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A RESOURCE-BASED APPROACH TO THE MULTIBUSINESS FIRM: EMPIRICAL ANALYSIS OF PORTFOLIO INTERRELATIONSHIPS AND CORPORATE FINANCIAL PERFORMANCE

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The resource-based view of the firm has provided important new insights into corporate strategy (Barney, 1991; Peteraf, 1993); however, there has been only limited empirical research linked to the theory (e.g., Farjoun, 1994). Although a great deal of work has been done on corporate diversification, the measures and data typically have a weak connection to resource-based theory. Empirical research on resource-based corporate strategy has been particularly difficult because key concepts such as tacit knowledge or capabilities resist direct measurement. This study is an effort to narrow the gap between theory and empirical research on the multibusiness firm. It develops a resource-based approach to modeling interrelationships among businesses and applies it to the analysis of corporate economic performance. This approach proves to be significant in explaining the financial performance of large manufacturing firms, and it promises to be an important source of insight into corporate strategy.

The impact of corporate strategy on the economic performance of firms has been a central concern of strategic management for three decades. From Chandler's (1962) pioneering work on strategy and structure to contemporary studies of the 'core competence' of the corporation (Prahalad and Hamel, 1990), researchers have examined the effect of combining multiple businesses within a single organization. Few topics have attracted as much attention as the effect of interrelationships among businesses on economic performance, and few issues have greater importance to the formulation of strategy.

Key words: resource-based strategy; corporate strategy; diversification; multi-business organization; corporate performance

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The relationship between the composition of a corporation's business portfolio and the firm's economic performance has become a particularly prominent issue in strategic management theory in recent years with the development of the resource-based view of the firm. Resource-based theory argues that interrelationships within corporate portfolios provide the economic foundation for multibusiness organization (Teece, 1982). Shared strategic assets or resources are critical to firm performance, and corporate strategy relies upon scope economies of that type among businesses (Peteraf, 1993).

Despite extensive empirical and theoretical work on this topic, the impact of portfolio composition on economic firm performance remains uncertain. Empirical studies have exam-

ined the effects of related and unrelated diversification, but results have been mixed (see Hoskisson and Hitt, 1990; Ramanujam and Varadarajan, 1989 for reviews). Although theoretical work in strategy has provided important insights into the economic conditions for multibusiness organization (e.g., Teece, 1982; Peteraf, 1993), a great deal remains to be done in applying those ideas to empirical research. Empirical studies often employ measures that have only weak conceptual grounding, while important aspects of contemporary theories linking corporate strategy to economic performance remain essentially untested.

The research reported in this paper is an effort to narrow the gap between the theory of the multibusiness firm and empirical study of the link between 'relatedness' in corporate portfolios and performance. Concepts drawn from the resource-based view of the firm (Barney, 1991; Mahoney and Pandian, 1992; Peteraf, 1993) provide a basis for a new approach to measuring interrelationships among the businesses of firms. This resource-based approach avoids a number of methodological and substantive problems associated with current techniques for analyzing interrelationships in corporate portfolios, and it proves to be significant in explaining the financial performance of large manufacturing firms. The resource-based approach promises to be an important new source of empirical insights into the link between the corporate strategy and economic performance.

The paper is organized in three sections. The first section provides a brief review of recent research on the relationship between types of diversification and the economic performance of firms. This is not intended to be a comprehensive review of the topic; it is meant to highlight the need for improved approaches to empirical research on the multibusiness firm.

The second part of the paper outlines a new method for analyzing interrelationships among the businesses of a firm. Although the idea of 'relatedness' has been central to research on corporate strategy, measures of interrelationships among businesses often exhibit important weaknesses. Concepts drawn from resource-based theory serve as a foundation for an approach to operationalizing 'relatedness' among businesses that avoids many of the substantive and methodological pitfalls associated with current techniques.

The final part of the paper uses this new approach to examine the financial performance of a sample of large manufacturing firms. The resource-based measure of portfolio 'relatedness' proves to be significant in explaining differences among corporations in financial performance, and the approach appears to be a promising step forward in linking theory and empirical research on corporate strategy.

RESEARCH ON PORTFOLIO STRATEGY AND FIRM PERFORMANCE

Empirical evidence on portfolio interrelationships and performance

Interest in the multibusiness firm within the field of strategic management can be traced to Chandler's (1962) seminal work *Strategy and Structure*. Chandler introduced the idea of looking at patterns of business activity as corporate strategies and suggested that different types of portfolio strategies might have important implications for the organization and management of firms. Based on the history of several very large firms, Chandler (1962) argued that expansion into new areas of business creates organizational complexity that poses new managerial problems for firms and requires new organizational structures for efficient control. In Chandler's view, matching structure to strategy becomes critical to operational efficiency as firms expand into multiple businesses.

The direct link between portfolio composition and economic performance emerged as a key topic for research on corporate strategy a decade later with Rumelt's (1974) pioneering study *Strategy, Structure and Performance*. Rumelt carried out a quantitative study of one of the central hypotheses underlying Chandler's research: the idea that different strategy/structure configurations had different implications for the economic performance of firms. Using a typology based on Wrigley's (1970) work, Rumelt (1974) classified a sample of large firms by type of diversification and corporate structure and examined ways in which patterns of diversification and structure affected corporate financial performance. One of the most influential findings of Rumelt's research proved to be the fact that firms with interrelated business portfolios appeared to outperform firms with unrelated

portfolios, independent of the type of corporate structure adopted.

The relationship between the composition of corporate business portfolios and the economic performance of firms quickly became a major issue in the study of strategic management; however, empirical research on the topic during the two decades since Rumelt's (1974) work has produced equivocal results. Studies have lent some support to Rumelt's finding (e.g., Bettis, 1981), but a substantial body of research also has challenged it. Industry structure (Christensen and Montgomery, 1981; Lecraw, 1984; Montgomery, 1985) and firm characteristics (Bettis, 1981; Grant and Jammine, 1988; Montgomery, 1985) have been found to play important roles in explaining performance, and 'relatedness' in corporate portfolios appears to have little effect net of these factors in many cases. Montgomery (1985), for example, found that industry profitability and market share should explain about 12 percent of variance in firm performance, but portfolio relatedness had no explanatory power once these other factors had been taken into account. Similarly, Grant and Jammine (1988) explained more than 20 percent of variance in performance based on longitudinal effects and industry structure, but portfolio composition added only about 3–6 percent to explained variance. Neither Grant and Jammine (1988) nor Amit and Livnat (1988) were able to find significant differences between firms with related and unrelated business portfolios. Overall, the research linking the composition of corporate business portfolios to firm performance has produced few strong findings of any sort, and results have been divided on the significance of relatedness among the businesses of a firm (Hoskisson *et al.*, 1993).

Theoretical work on portfolio interrelationships and performance

Although the empirical research has been equivocal, powerful arguments for the expectation that firms in related businesses will outperform firms with unrelated portfolios have been developed in the theoretical work on corporate strategy during the last decade. A detailed logic for the relationship between portfolio composition and economic performance has emerged as part of the development of the resource-based view of the firm (Barney, 1991; Wernerfelt, 1984). Resource-based strategy uses a logic from Coase (1937) and Penrose (1959) to argue that the rationale for multibusiness organizations ultimately lies in sharing strategic capabilities among businesses (Mahoney and Pandian, 1992; Peteraf, 1993; Teece, 1982; Teece, Pisano, and Schuen, 1991). In the absence of shared firm-specific strategic assets (Winter, 1987), a corporation can be expected to perform less well than the sum of its separate businesses (Coase, 1937; Robins, 1992; Teece, 1984). Scope economies (Teece, 1984) or subadditivities (Panzer and Willig, 1981) that result from these inseparabilities among businesses make a critical contribution to the value of the firm. The resource-based view of the corporation argues that strategic interrelationships among businesses have a direct positive effect on firm performance.

At first glance, the empirical evidence described above appears to provide relatively little support for the resource-based view. However, closer scrutiny suggests that the empirical research may have only a limited connection to the theory. Many of the prevailing approaches to analysis of relatedness are subject to substantial problems of measurement error, and it is questionable whether they measure the types of relationships among businesses that are important in resource-based strategy.

Operationalization of relatedness within corporate portfolios

Two general approaches to operationalizing the concept of relatedness have been common in research on strategic management: categorical and continuous measures (Davis and Duhaime, 1992). Categorical measures typically involve classification of a firm in terms of one of several characteristic types of diversification, while continuous measures position a firm on a scale that indicates its relative degree of related or unrelated diversification. The categorical measures are built on the earlier typological work of Wrigley (1970) and Rumelt (1974), while continuous measures are derived from the Standard Industrial Classification (SIC) system.

Categorical measures continue to enjoy some currency in strategy research (e.g., Grant and Jammine, 1988), but continuous measures have gained popularity in recent years. The continuous

measures offer a number of features that make them very attractive for quantitative research. They provide variables at a higher level of measurement, thereby allowing researchers a wider range of techniques for analysis. Perhaps more important, they employ data classified according to standard categories. This helps to make research replicable and cumulative, and it allows researchers to use the broad range of data that are reported using the SIC system (Hoskisson *et al.*, 1993).

The two continuous measures of relatedness that currently are most widely used are the entropy index and the concentric index (Davis and Duhaime, 1992). Although these measures differ in detail, they share certain important features that create doubt about their appropriateness for research on resource-based strategy. The manner in which the concentric index (e.g., Caves, Porter, and Spence, 1980; Montgomery and Hariharan, 1991; Montgomery and Wernerfelt, 1988) and the related component of the entropy index (e.g., Davis and Duhaime, 1992; Jacquemin and Berry, 1979) are constructed raises serious questions about their validity as measures of strategic interrelationships within corporate portfolios.

Concentric index

The concentric index is an adaptation of the Herfindahl index that Caves *et al.* (1980) developed for work on industrial organization. Montgomery and her colleagues (e.g., Montgomery and Hariharan, 1991; Montgomery and Wernerfelt, 1988) adapted that measure for research on corporate strategy, calculating it in the following manner (Montgomery and Hariharan, 1991: 80):

$$FDIVERS_k = \Sigma P_{ki} \; R \; P_{kl} \; d_{il}$$

Where:

- P_{ki} = percentage of sales for firm 'k' in industry 'i'
- P_{kl} = percentage of sales for firm 'k' in industry 'l'
- d_{il} = variable weighting factor such that d_{il} = 0 where i and l belong to the same 3-digit SIC category, d_{il} = 1 where i and l belong to the same 2-digit SIC group but different 3-digit SIC groups, and d_{il} = 2 where i and l are in different 2-digit SIC categories.

One of the major problems associated with this measure is the fact that it imposes extremely difficult assumptions on the SIC system. In constructing the measure, the 2, 3, and 4-SIC digit levels of classification implicitly are treated as points on an underlying scale of 'relatedness' among businesses, and arithmetic values are assigned to the distances between the points. This procedure requires two very strong and deeply problematic assumptions about the SIC system: the assumption that industries are homogeneous within category levels, and the assumption that the assigned 'relatedness' scale accurately reflects quantitative distinctions between category levels (Rumelt, 1982). The failure to meet either of these assumptions can be an important source of error.

Related component of the entropy index

Although the related component of the entropy index is derived in a somewhat different fashion than the concentric index, it involves similar assumptions about the SIC system. Jacquemin and Berry (1979) compute the basic entropy index as $E = \Sigma P_i \; 1n(1/P_i)$, where E is an entropy measure and P_i is the proportion of a firm's sales in SIC industry i. This measure can be calculated using the distribution of sales across 4, 3, or 2-digit SIC levels. The 4-digit SIC level typically is treated as total diversification, while the measure based on 2-digit SIC classifications is treated as unrelated diversification. The 'related' portion of the measure is derived by taking the difference between total and unrelated diversification:

$$E_R = E_T - E_U = \Sigma P_T \; 1n(1/P_T) - \Sigma P_U \; 1n(lP_U)$$

Where:

- E_R = related component of entropy
- E_T = entropy defined at the 4-digit SIC level
- E_U = entropy defined at the 2-digit SIC level
- P_T = percentage of sales in each 4-digit SIC industry
- P_U = percentage of sales in each 2-digit SIC industry.

Although this calculation does not employ an explicit weighting factor for SIC levels—such as the weight d_{il} in the concentric index—it uses distinctions among SIC levels in a similar fashion. SIC levels are treated as homogeneous, and all 4-digit SIC categories effectively are treated as if they were equidistant from all 2-digit SIC categories on some underlying quantitative scale of relatedness.

Problematic assumptions of this sort are an unavoidable feature of the attempt to extract fine quantitative distinctions from the relatively coarse classification scheme of the SIC system. These assumptions can be relaxed only by going beyond the SIC system and employing additional sources of information. Without a broader information base than the SIC codes, continuous measures of relatedness inevitably will require extremely difficult assumptions and result in high levels of measurement error.

Limitations of the SIC system as an information source

The use of the SIC system as a basis for measuring interrelations among areas of business suffers from additional problems with regard to validity. The SIC system is a weak source of information on substantive relationships among industries. The SIC system was developed to facilitate collection of establishment data for macroeconomic analysis, and it employs a set of reporting standards that have evolved over time based on a variety of considerations ranging from similarities in materials to product-market linkages (Machinery and Allied Products Institute, 1974). This has created categorizations that may place close substitutes such as glass and plastic bottles in different groupings while combining very different goods or services in common categories. In consequence, SIC codings offer only limited information on the types of strategic interrelationships that are important in the theory of the multibusiness firm (Teece, 1982). When the very strong assumptions required by the concentric and entropy indices are applied to this weak source of information, the resulting measures have little validity as indicators of strategic interrelationships within corporate portfolios.

The problems of validity created by the use of measures such as the entropy or concentric indices primarily are of the type described by psychometricians (e.g., Nunnally, 1978) as weaknesses in 'content validity'. Content validity refers to the fundamental logical connection between a measure and the concept it is intended to indicate. In the words of Hoskisson *et al.* (1993: 217): 'Content validity refers to the extent to which empirical measurement reflects a specific domain of content'.

Content validity is a conceptual issue rather than a matter for empirical verification (e.g., Hoskisson *et al.*, 1993; Nunnally, 1978; Venkatraman and Grant, 1986).[1] The strength of the deductive syllogism that links indicator to underlying concept determines the content validity of an indicator. This also is the most fundamental determinant of whether empirical research addresses the theoretical concerns of science (Russell, 1948). As indicated above, the interrelations among businesses that can be examined using the information embodied in the SIC codes have a tenuous conceptual linkage to the shared strategic assets that are critical in resource-based theory.

The validity of indicators of related diversification for research on resource-based strategy also suffers from the fact that they are measures of diversification type rather than relatedness (Hoskisson *et al.*, 1993). Neither continuous nor categorical measures clearly differentiate extent of diversification from relatedness within corporate business portfolios. Resource-based theory argues that strategic interrelationships among the businesses of a firm should have an effect on performance that is independent of the extent of the firm's diversification (Teece, 1982; Peteraf, 1993). Although indicators that combine the measurement of relatedness and extent of diversification may be appropriate for other types of theoretical concerns (Hoskisson and Hitt, 1990; Pitts and Hopkins, 1982; Reed and Luffman,

[1] Hoskisson *et al.* (1993) respond to the question of the content validity of SIC-based measures primarily by comparing the SIC-based measures with other indicators of diversification type. They note that both Montgomery (1982) and Ramanujam and Varadarajan (1989) found that diversification–performance relationships could be reproduced using alternative measures. This comparison speaks to issues of convergent or predictive validity, but it does not address content validity. Measures of related diversification may be consistent with each other at the same time that none serves as an indicator of the type of portfolio interrelationships that are important in resource-based theory.

1986), they have limited content validity in research that addresses the resource-based view of the firm.

The weaknesses of SIC-based indicators have begun to turn the attention of researchers to measures based on other sources of data. Recent works on merger activity (Brumagim, 1992; Klavans, 1990) and strategic groups (Farjoun, 1994) have used the distribution of occupations across industries as an indicator of potential strategic interrelationships among businesses. In these studies, occupational data have provided indirect indicators of less measurable linkages among businesses due to shared skills and expertise (Farjoun, 1994).

Indicators of this type have the advantage of preserving the ability to utilize SIC-coded data while incorporating a broader base of information about characteristics of industries that may have strategic importance. Information of that sort is necessary in order to give measures a stronger conceptual linkage to the underlying strategic assets or capabilities that are critical in resource-based approaches to corporate strategy. The use of additional information about substantive similarities among industries can also provide a means of avoiding measurement problems associated with transforming the categorical distinctions of the SIC system into quantitative measures of relationships between industries.

A RESOURCE-BASED APPROACH TO MEASURING INTERRELATIONSHIPS AMONG THE BUSINESSES OF A FIRM

The first step in developing any alternative approach to measuring the 'relatedness' of industries is to identify the types of interrelationships among businesses that have strategic importance. Teece (1986), Barney (1986a), Winter (1987) and others have argued that certain forms of managerial or technical knowledge play a particularly important part in creating a rationale for the multibusiness firm. In contrast to the types of physical assets that can be readily transferred between enterprises, these forms of productive knowledge are difficult to formalize and reproduce (Winter, 1987). Because they are both valuable and difficult for competitors to copy, capabilities of this kind can serve as 'strategic assets' that offer important sources of competitive advantage (Barney, 1991). The efficient utilization of these strategic assets may require the combination of businesses within a corporation (Peteraf, 1993; Teece, 1982).

This resource-based view of synergies or scope economies argues for measures of 'relatedness' that are at least indirectly linked to underlying forms of knowledge or capability that can create competitive advantage for multibusiness firms. Because these types of knowledge or capability often are incompletely understood or articulated (Teece, 1984; Winter, 1987), direct measurement may be difficult or impossible. However, as Farjoun (1994) and others have argued, it may be possible to develop indirect indicators of these types of underlying similarities among SIC industries based on secondary data about industrial activity. Industries that employ similar types and quantities of measurable inputs such as skilled personnel or specialized equipment may also utilize common forms of less measurable technical and managerial knowledge in production and exchange. Although it may not be possible to measure those forms of knowledge or capability directly, patterns of activity associated with different industries may provide useful indirect indicators of underlying commonalities among those industries.

One of the strongest potential indicators of this type is the pattern of technology flows among industries.[2] Two industries that import a similar mix of technology may also rely upon common underlying capabilities or knowledge in utilizing technological inputs. It is important to bear in mind the fact that patterns of technology imports serve as an *indirect* indicator of underlying strategic capabilities in this approach. Critical scope economies or synergies are not a consequence of sharing inputs; they are due to underlying shared know-how or capabilities (Teece, 1982). Underlying forms of shared knowledge or capability are likely to be more systemic and less well articulated than the

[2] Unfortunately, relatively few potential indicators of underlying capabilities or knowledge exist at the industry level. The problem is essentially sociological; it involves identifying macrolevel patterns of activity that are plausible indicators of underlying social phenomena such as shared knowledge that can make a distinctive contribution to economic productivity. Patterns in the employment of human capital or technologies are two of the most credible indicators for which data are available.

measurable technological inputs that these tacit capabilities help firms to utilize (Winter, 1987). The systemic, tacit character of these capabilities helps to give them strategic importance (Teece, 1984; Winter, 1987), but it also makes their direct measurement difficult or impossible.

An approach to estimating portfolio interrelationships of this type was developed using technology flows among manufacturing industries. This operationalization of 'relatedness' involved two steps: creation of measures of strategic similarity among industries, and derivation of a firm-level index of interrrelationship among the businesses of specific corporate portfolios. Patterns of technology inflows to industries served as indirect indicators of strategic similarity among the industries. Interindustry similarity measures were then combined with data on the distribution of corporate activity across industries to create a summary index of the degree of interrelationship within corporate portfolios. The resulting index is not a measure of transfers or sharing of physical assets among the businesses of a corporation; it is an indicator of the potential for synergies or scope economies due to shared underlying capabilities or know-how within the corporate portfolio.

Measures of interindustry similarity

Measures of similarity among industries were derived by examining patterns of technology flows among SIC-based industry groups. Technology inflows and outflows among major groups of industries within the manufacturing sector of the United States economy have been estimated by Scherer (1982). Scherer combined information on patent filings with input–output data to construct a matrix of R & D flows between major groups of industries. The flow of technology from an industry of origin to a destination industry was estimated by Scherer (1982) from data on the proportion of patents filed in the origin industry that were used in the destination industry and data on interindustry economic transfers drawn from the input–output tables (see Scherer, 1982, for details of the estimating procedures).

Scherer's estimation procedures involve some important potential sources of error, including both error in the underlying data and error introduced by the use of proxies for technology transfer such as the cross-licensing of patents. However, Scherer's estimates do offer the best available overview of general patterns of technology transfer within the manufacturing sector of the U.S. economy. The effects of errors in the underlying estimates of flows between individual industries also tend to be mitigated by the methods that were used in this research to derive measures of similarity.

Scherer (1982) reported technology flows in a 48 by 40 rectangular matrix, with 3-digit SIC industries aggregated into more general categories. The matrix reported by Scherer was edited to create a 37-category square matrix of inflows and outflows between groups of industries in the manufacturing sector. Coefficients of similarity for each pair of these 37 manufacturing industry categories were estimated from the matrix using techniques developed for sociometric modeling.

A form of structural equivalence modeling (Burt, 1976; Lorraine and White, 1971) similar to the approach adopted by Farjoun (1994) was used to generate the coefficients of similarity between industries. In the structural equivalence approach, similarity or dissimilarity is not based on direct connections among actors; it is a property of the position of actors within groups. Two actors are alike if the patterns of their relationships with all other actors in the group are similar (Burt, 1976).

In this case, the 'actors' were categories of industry, and relationships were defined by inflows of technology. Two categories of industry were similar to the degree that they imported technology in similar patterns from other industry categories. The similarity—or structural equivalence—of industries in this model is an indication of the relative positions of those industries in the overall flow of technology within the manufacturing sector of the United States economy.

The analysis began by extracting 'profiles' of technology inflows to industries from the data in the square matrix described above. A profile vector of technology inflows was formed for each of the categories of manufacturing industry. The profile vector for any given industry was the distribution of technology inflows to that category from the full set of 37 categories of manufacturing industry. The data included estimates of internal transfer for categories, and within-category flows were treated as technology importations in the profile vector for any given category.

Following the structural equivalence approach (e.g., Burt, 1976), measures of similarity between categories of industry were derived from these profiles of intercategory technology flows. Pearson correlation coefficients were calculated for each pair of profile vectors to form a triangular matrix of interindustry correlations. This matrix of correlations between industry categories is a structural equivalence model of the manufacturing sector of the United States economy, based on technology flows. The correlation between any two industry categories is a direct measure of similarity in patterns of technology inflow from the entire sector to each of the two categories. A perfect correlation of 1.0 would indicate that a pair of industries imported technology from the same categories in precisely the same proportions. A zero correlation would indicate no similarity in patterns of technology imports, and a negative correlation would indicate inverse profiles of technology imports. The triangular matrix of intergroup correlations and descriptive information about group definitions are reported in Appendix 1.

This methodology tends to reduce the impact of errors in Scherer's underlying estimates of interindustry technology flows. The use of profile vectors to characterize industries attenuates the effect on similarity coefficients of errors in the estimates of technology flow between specific pairs of industries. An error in the estimate of inflow from an individual origin industry will alter just one of the 37 observations that define the profile vector for a destination industry. If errors of this sort are randomly distributed across categories of industry, they may reduce the average magnitude of correlations between profile vectors without altering the pattern of interindustry correlations.

Once similarity coefficients for pairs of industries had been derived, the methodology diverged from the approach employed in sociometric analysis (e.g., Burt, 1976) and adapted for analysis of strategic groups by Farjoun (1994). Farjoun (1994) used coefficients of interindustry similarity as input to a clustering routine in order to form a block model of the economy for the purposes of examining strategic groupings among firms. The analysis reported here was concerned with the portfolio strategies of individual firms rather than strategic groupings among firms, and coefficients of interindustry similarity were used for the derivation of firm-level measures of relatedness rather than patterns of interrelationship among firms.

Firm-level measures of portfolio interrelationships

In order to analyze the impact of these similarities at the level of the firm, it was necessary to create a summary measure of portfolio interrelationship for individual firms. An index of this type was constructed using the measures of structural–equivalence similarity between pairs of industries described above. For each combination of two different industry categories 'i' and 'j' in a firm's portfolio, a sales-weighted measure of interrelationship R_{ij} was calculated as:

$$R_{ij} = P_i r_{ij} + P_j r_{ij}$$

Where:

P_i = percentage of sales in industry category i

P_j = percentage of sales in industry category j

r_{ij} = structural equivalence similarity (correlation) of i and j

These weighted measures of similarity between paired industries (R_{ij}) were summed over all combinations of two industries that could be formed from the business portfolio of the firm, resulting in an aggregate index of interrelationship of the businesses of the firm $M_k = \Sigma R_{ij} = \Sigma r_{ij} (P_{ki} + P_{kj})$, where i and j represent any two different industries in which firm k is active. A correction was introduced for the fact that the possible range of this index varies with the total number of industries in which a firm is active, as described in Appendix 2. The adjusted index has a range from +1.0 to −1.0, with a positive score indicating that a firm has a positively interrelated portfolio of businesses and a negative score indicating a negatively interrelated portfolio.

Although this index bears a substantial resemblance to the concentric or entropy measures, it differs in very important ways. The most significant difference is its stronger conceptual linkage to the underlying strategic theory of the multi-

business firm. The use of additional data on the position of SIC industries within the overall structure of the manufacturing sector substantially increases the information incorporated into the index, and patterns of technology usage have good content validity as indirect indicators of less transferable capabilities or know-how. By moving away from the use of the SIC hierarchy to determine interrelationship among businesses, this approach also avoids problems associated with transforming the categorical scheme of the SIC into a set of quantitative measures. At the same time, it preserves the ability to analyze economic activity that is reported in SIC categories.

THE IMPACT OF PORTFOLIO INTERRELATIONSHIPS ON CORPORATE FINANCIAL PERFORMANCE

Regression models

This resource-based approach was used to analyze the impact of portfolio interrelationships on firm performance in a sample of large manufacturing corporations. Models of the relationship between resource-based relatedness and financial performance were tested with controls for a number of industry and firm-specific factors suggested by prior research. The explanatory power of the resource-based approach was also compared with two of the popular SIC-based measures—the related component of the entropy index and the concentric index—by estimating separate models for each of the three approaches.

Two general models were examined for each of the three approaches. The first model represents a cross-sectional analysis of current firm performance as a function of industry and firm characteristics as follows:

$$\text{Current Firm Performance} = \alpha + \beta_i\ (\text{Industry profitability}) + \beta_2\ (\text{Industry concentration}) + \beta_3\ (\text{Industry asset intensity}) + \beta_4\ (\text{Firm market share}) + \beta_5\ (\text{Firm size}) + \beta_6\ (\text{Firm relatedness}) + \epsilon$$

The second model analyzes continuing performance of firms over a 6-year period as a function of initial industry and firm characteristics, as follows:

$$\text{Continuing Firm Performance} = \alpha + \beta_1\ (\text{Industry profitability}) + \beta_2\ (\text{Industry concentration}) + \beta_3\ (\text{Industry asset intensity}) + \beta_4\ (\text{Firm market share}) + \beta_5\ (\text{Firm size}) + \beta_6\ (\text{Firm relatedness}) + \epsilon$$

These models were designed to address basic issues of corporate strategy. Research on economic performance in the field of strategic management characteristically is motivated by underlying concern about factors that influence the performance of individual firms. This objective is fundamentally different from the more general concern in fields such as economics or industrial-organization economics with analyzing variability in profits in order to identify structural impediments to free competition (Teece, 1984). Firm-level effects are critical in strategy research, and an important consideration in choosing variables is the fact that they may have implications for managerial decision making.

Industry-level independent variables

The industry characteristics that were used as independent variables in the models described above were chosen with these strategic concerns in mind. Industry structure has a strong theoretical and empirical relationship to firm profitability. The link between the structure of industries and their average profitability has been a central concept of industrial-organization economics since the early work of Bain (1956) and Mason (1957), and the impact of structure on industry profitability has been documented in an extensive body of empirical research (e.g., Long and Ravenscraft, 1984; Ravenscraft and Wagner, 1991; Schmalensee, 1985). Opportunities for individual firms to earn profits are strongly influenced by the structural factors that affect the average profitability of industries (Grant, 1991; Porter, 1980).

Three industry-level independent variables were used in the study: industry concentration, asset intensity, and industry profitability. Concentration and asset intensity have proved significant in prior research, and they are plausible indicators of entry and exit barriers that may have significance for strategy formulation. Industry average profitability was added to the models to control for industry effects on firm profitability that were not captured by concentration or asset intensity.

Industry concentration has been treated as one of the basic indicators of barriers to entry in industrial-organization research (Bain, 1956). In highly concentrated industries, large scale economies or other sources of market power may protect incumbents from new competitors. The market power enjoyed by firms operating under those conditions may allow them to sustain high levels of profitability. Evidence for this type of relationship between industry concentration and firm profitability has been found in empirical research on strategy and industrial organization (Montgomery, 1985; Weiss, 1974). Industry concentration was expected to have a positive effect on firm performance.

A high level of asset intensity in an industry has been viewed as an indicator of exit barriers created by substantial resource commitments that may not be fully recoverable. Bettis (1981) found that industry asset intensity was positively related to firm performance and argued that sunk investment poses a risk that would be assumed by firms only if profitability also were high. Following Bettis (1981), we expected industry asset intensity to be positively related to firm performance.

A measure of the profitability of the industries in which a firm operates was used to control for industry effects not captured by concentration or asset intensity. Control for other, unspecified industry effects on firm profitability is vital in attempting to evaluate the link between relatedness and performance. Resource-based theory suggests that interrelationships among the businesses of a corporate portfolio may have an impact on performance independent of the profitability of the different industries represented in the portfolio and control for industry profitability was introduced in order to evaluate this type of net effect of relatedness on firm performance. Industry performance has been found to have a positive effect on firm performance in prior empirical research (Christensen and Montgomery, 1981; Lecraw, 1984; Montgomery, 1985), and we anticipated a positive relationship with firm performance in the models analyzed here.

Firm-level independent variables

Market share probably has a more reliable relationship to firm performance than any other firm-level variable that has been analyzed in research in strategy, marketing, or industrial organization (e.g., Bass, Cattin, and Wittink, 1978; Buzzell, Gale, and Sultan, 1975; Gale, 1971; Shepherd, 1972). A number of different explanations have been proposed for this relationship, including possible cost advantages due to scale economies or learning effects (see Lieberman and Montgomery, 1988, for a review). We anticipated a positive relationship between market share and firm performance.

Firm size was also used as an independent variable in the models. Firm size has been viewed as an indicator of scale economies and market power, and empirical evidence exists linking size to firm profitability (Bettis, 1981; Grant and Jammine, 1988). Cost advantages due to scale economies or control over pricing created by market power may enable large firms to achieve unusually high levels of profitability. We expected firm size to be positively related to firm performance.

Variable definitions

Firm performance

Performance was measured using a firm's return on assets (ROA). ROA is one of the most widely employed measures of performance, and it has been shown to be related to a variety of other indicators of financial performance for firms (e.g., Keats and Hitt, 1988). Current firm performance was measured as the firm's 3-year average ROA for 1976–1978. Continuing firm performance was measured as the 6-year average ROA for 1976–1981.

Although there is a good deal of debate over the use of accounting measures of performance in strategy research, ROA offers a desirable measure for a study of this type for a number of reasons. Accounting indicators of asset performance maintain a close connection to the decision variables controlled by managers at the same time that they have well-documented relationships to the market value of firms (e.g., Ball and Brown, 1968; Gonedes, 1973). Perhaps most important, the use of ROA helps to preserve consistency with other research that has been carried out in strategic management and industrial-organization economics. The majority of studies on topics such as diversification and performance have used accounting measures of

firm performance, and much of the work on performance in industrial-organization economics has also relied upon accounting information (see Ravenscraft and Wagner, 1991, for a review of FTC-based work). The use of ROA as a performance measure allows the results of the analysis to be directly compared with a substantial body of work on related topics in strategy, and it helps to make the research replicable and cumulative.

Measures of relatedness

Three different measures of interrelationship among a firm's businesses were used: the resource-based measure described in the second part of this paper, the 'related' component of the entropy measure, and the concentric index. The derivation of the resource-based measure, the related component of the entropy measure, derived using Jacquemin and Berry's (1979) methodology, and the concentric index measure of a firm's diversification have been described earlier in this article.

Industry profitability

Industry profitability was a summary measure weighted to reflect a firm's relative sales in the different industries in which it was active. FTC Line of Business data were used to estimate the profitability of industries in 1977. The average profitability of each 4-digit SIC industry in which a firm participated was multiplied by the proportion of firm sales in the industry and aggregated for the firm as follows:

$$\text{Industry Profitability} = \Sigma\ ROA_i\ P_i$$

Where ROA_i is the average return on assets for industry 'i', and P_i is the proportion of a firm's sales in SIC 'i'.

Industry concentration

Industry concentration was also a summary measure weighted to reflect a firm's relative sales in different industries. Data from the Census of Manufactures were used to estimate concentration ratios for industries in 1977. The concentration ratio of each industry in which a firm participated was multiplied by the proportion of firm sales in the industry and aggregated for the firm as follows:

$$\text{Industry Concentration} = \Sigma\ CR4_iP_i$$

Where $CR4_i$ is the four-firm concentration ratio for industry 'i', and P_i is the proportion of a firm's sales in SIC 'i'.

Industry asset intensity

Industry asset intensity was also a summary measure weighted to reflect a firm's relative sales in different industries. Data from the Census of Manufactures were used to estimate average asset intensity for industries in 1977. The asset intensity of each industry in which a firm participated was multiplied by the proportion of firm sales in the industry and aggregated for the firm as follows:

$$\text{Industry Asset Intensity} = \Sigma\ AI_iP_i$$

Where AI_i is the asset intensity for industry 'i', and P_i is the proportion of a firm's sales in SIC 'i'.

Firm market share

A firm's average market share was also a measure weighted to reflect the firm's relative sales across the industries in which it was active. Information from the TRINET EIS data base was used to estimate a firm's 1977 market share in each of the industries in which it was active. A firm's market share in each industry in which it participated was multiplied by the proportion of firm sales in that industry and aggregated for the firm as follows:

$$\text{Firm Market Share} = \Sigma\ MS_iP_i$$

Where MS_i is a firm's market share in each of its industries 'i', and P_i is the proportion of sales in SIC 'i'.

Firm size

Firm size is represented by the log of a firm's revenue in 1977 as reported by COMPUSTAT.

Scherer's (1982) estimates of interindustry technology flows and the FTC line of business

data were available only for the late 1970s. All independent variables were measured for the year 1977 in order to preserve consistency among the data.

Data

A sample of 120 firms was randomly selected from the 500 largest manufacturing firms in the United States, as listed by *Fortune*. Single business firms were dropped from the sample, reducing the number to 100. The sample was reduced to 88 firms because TRINET data were unavailable for 12 of the firms. The average firm size was $1,550 million, with six lines of business.

Data were drawn from a number of sources. Firm performance and firm size were derived from COMPUSTAT data, while industry data came from the Census of Manufactures and the FTC line of business data base. Data on revenues and market share for the 4-digit SIC code in which firms participated were gathered from the TRINET/EIS Large Establishment Data Base. This data base allows for the aggregation of establishment (plant level) data to the 4-digit SIC level for each firm. The data on the distribution of firm revenues across SICs provided the basis for estimation of the weights (P_i) that were used in constructing the independent variables, as described above.

Davis and Duhaime (1992) have noted that the choice between the TRINET/EIS and COMPUSTAT data bases for information on business-level activity involves a number of trade-offs. They suggest that the most important issue for research on relatedness is the level of aggregation of business data (Davis and Duhaime, 1992). COMPUSTAT data are reported for business segments, while TRINET/EIS data are based on establishment reporting.

Davis and Duhaime (1992) argue that the higher level of aggregation of COMPUSTAT data offers advantages for research on relatedness. The assignment of business activities to COMPUSTAT segments is carried out by respondents in firms, and the data can be expected to embody some information about managers' views of relationships among businesses. The use of COMPUSTAT data thus provides a means of capturing additional information about the perceptions of managers (Davis and Duhaime, 1992).

As Davis and Duhaime (1992) suggest, this additional information in the COMPUSTAT data may be valuable in research that employs measures such as the entropy or concentric indices. It is likely to be less useful in work that goes beyond the SIC system to use additional data sources for estimation of potential interrelationships among businesses. The classification of businesses into segments by respondents may become a source of error in research of that type. If managers do not employ criteria that map underlying shared strategic assets such as tacit knowledge or capabilities when they aggregate data into segments, the pooling of establishment data into business segments can increase error in the measurement process and reduce the validity of measures (Hoskisson *et al.*, 1993). This error may be exacerbated by variations among respondents in the manner in which they conceptualize relationships among businesses. The consistent application of a single set of externally defined measures of relatedness to disaggregated data can be expected to produce a more reliable measure under those circumstances.

Methods

The impact of relatedness on firm financial performance was examined using least squares regression. Two sets of analyses were conducted. The first set of models analyzed current firm performance as a function of industry and firm characteristics. The second set of models examined the continuing performance of firms over a 6-year period as a function of industry and firm characteristics at the beginning of the period.

The analysis did not produce evidence of heteroscedasticity, and the distribution of the residuals gave no indications of underidentification in our models. However, the analyses did prove to be sensitive to the effects of a few extreme cases. Like Kessides (Ravenscraft and Wagner, 1991), we found that the proportion of variance in performance explained by firm-specific factors was substantially reduced by the effects of a few outliers in the sample. In consequence, we estimated the models using a reduced data set with outliers removed.

A set of four separate regression equations were estimated for each of the two dependent

variables. The four models estimated for each dependent variable were: (1) control variables only, (2) control variables and related diversification as measured by the related component of the entropy measure, (3) control variables and related diversification as measured by the concentric index, and (4) control variables and the resource-based relatedness measure. Four separate models were estimated in order to facilitate comparison of the explanatory power of the three measures of portfolio interrelationship. Higher order models and effects of interactions between measures of relatedness and control variables were estimated and tested for significance based on incremental contributions to explained variance in the dependent variable. Linear, additive models proved to be the best fit to the data.

Results: Current firm performance

Table 1 presents means, standard deviations, and intercorrelations for all variables for the analysis examining current firm performance. Table 2 presents the results of the regression analysis of current firm performance on industry and firm characteristics.

Model 1

Regression of current firm performance on the control variables (industry profitability, industry concentration, industry asset intensity, firm market share, and firm size) in Model 1 indicated that industry structure and firm level factors had significant effects on firm performance. The overall model was significant, explaining 16 percent of the variance in ROA (adjusted R^2 = 0.10). Slopes for industry profitability and firm market share both were significant and positive as anticipated. Contrary to expectations, the slope coefficient for industry concentration proved to be negative and significant. These results suggested that firms operating in highly concentrated industries were likely to perform less well than firms in other types of industries, controlling for overall industry performance and firm market share and firm size.

Models 2 and 3

The regression of current firm performance on control variables and related diversification as measured by the related component of the entropy index is shown in Model 2. The overall model was significant and explained 19 percent

Table 1. Descriptive statistics and correlation matrix: Current ROA

	Mean	S.D.	1	2	3	4	5	6	7	8	9
1. Current firm performance	6.7	2.7	1.000								
2. Industry profitability	0.11	0.04	0.113	1.000							
3. Industry concentration	0.51	0.13	−0.231**	0.066	1.000						
4. Industry asset intensity	0.61	0.19	−0.122	0.435***	0.117	1.000					
5. Market share	0.05	0.06	0.133	−0.046	0.388***	−0.041	1.000				
6. Firm size	6.24	1.34	0.002	−0.081	0.410***	−0.110	0.614***	1.000			
7. Related diversification entropy	1.85	0.74	−0.185*	0.058	0.026	−0.021	−0.136	0.397***	1.000		
8. Related diversification concentric	0.15	0.17	−0.229**	0.116	0.050	0.034	−0.181*	0.279**	0.924***	1.000	
9. Resource-based relatedness	0.72	0.19	0.320**	−0.004	0.063	−0.035	−0.088	−0.093	−0.059	−0.063	1.000

n = 84, * $p < 0.10$, ** $p < 0.05$, ***$p < 0.001$

Table 2. Regression of current firm performance on industry structure, firm characteristics, related diversification, and resource-based relatedness

	1 Control variables	2 Control + related diversification − entropy measure	3 Control + related diversification − concentric measure	4 Control + resource-based relatedness
Industry profitability	0.22*	0.24**	0.25**	0.22*
Industry concentration	−0.32**	−0.34**	−0.32**	−0.37***
Industry asset intensity	−0.17	−0.17	−0.17	−0.15
Market share	0.29**	0.15	0.15	0.32**
Firm size	−0.05	0.14	0.11	0.00
Related diversification—entropy		−0.23*		
Related diversification—concentric			−0.24**	
Resource-based relatedness				0.37***
Constant	0.03	0.03	0.02	0.03
R^2	0.16	0.19	0.20	0.29
Adjusted R^2	0.10	0.13	0.14	0.23
F statistic	2.91**	2.97**	3.16**	5.18***

n = 84. Note: Standardized beta-weights reproted. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

of the variance in ROA (adjusted R^2 = 0.13). The slope coefficient of the related component of the entropy index was negative and significant, but comparison of this model to Model 1 indicated that the incremental increase in explained variance (0.03) due to inclusion of the entropy measure was not significant. Firm performance appears to be unaffected by a firm's level of 'relatedness' on the entropy index once the impact of industry and firm-level variables has been taken into account.

The regression of current firm performance on control variables and related diversification as measured by the concentric index is shown in Model 3. The overall model was significant and explained 20 percent of the variance in ROA (adjusted R^2 = 0.14). The slope coefficient of the concentric index was also negative and significant, and comparison of this model to Model 1 indicates that the incremental increase in explained variance (0.04) due to related diversification was significant. When the effects of industry and firm-level controls are taken into account, firm performance does appear to be affected by related diversification as measured by the concentric index. However, the increment to explained variance due to the effect of related diversification is relatively modest.

Model 4

Model 4, which examined the effect of control variables and the resource-based relatedness measure, proved to be the most powerful of the three models in explaining current firm performance. The full model explained 29 percent of the variance in ROA (adjusted R^2 = 0.23). Comparison to Model 1 indicated that the addition of the resource-based relatedness measure created a significant increase in the explained variance in current firm performance. The slope of the resource-based measure was significant and positive, indicating that interrelationship among the businesses of a firm is associated with higher financial performance.

Results: Continuing firm performance

Table 3 presents means, standard deviations, and intercorrelations for all variables for the analysis examining continuing firm performance. Table 4 presents the results of the regression analysis of continuing firm performance on industry and firm characteristics.

Model 1A

Regression of continuing firm performance on the control variables (industry profitability, industry

Table 3. Descriptive statistics and correlation matrix: Continuing ROA

	Mean	S.D.	1	2	3	4	5	6	7	8	9
1. Continuing firm performance	6.49	2.33	1.000								
2. Industry profitability	0.11	0.05	0.020	1.000							
3. Industry concentration	0.51	0.14	−0.295**	0.064	1.000						
4. Industry asset intensity	0.62	0.20	−0.071	0.438***	0.107	1.000					
5. Market share	0.05	0.06	0.020	−0.041	0.368***	−0.049	1.000				
6. Firm size	6.27	1.34	−0.183	−0.077	0.396***	−0.119	0.608***	1.000			
7. Related diversification—entropy	1.82	0.75	−0.206*	0.041	0.069	−0.021	−0.130	0.409***	1.000		
8. Related diversification—concentric	0.71	0.20	−0.182	0.092	0.115	0.030	−0.159	0.316***	0.931***	1.000	
9. Resource-based relatedness	0.14	0.17	0.289**	−0.032	0.121	−0.028	−0.064	−0.050	−0.050	−0.057	1.000

$n = 80$, $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.001$

Table 4. Regression of continuing firm performance on industry structure, firm characteristics, related diversification, and resource-based relatedness

	1A Control variables	2A Control + related diversification − entropy measure	3A Control + related diversification − concentric measure	4A Control + resource-based relatedness
Industry profitability	0.07	0.08	0.07	0.08
Industry concentration	−0.30**	−0.30**	−0.29**	−0.36**
Industry asset intensity	−0.08	−0.08	−0.08	−0.07
Market share	0.27**	0.21	0.24	0.30**
Firm size	−0.24	−0.16	−0.20	−0.21
Related diversification—entropy		−0.10		
Related diversification—concentric			−0.05	
Resource-based relatedness				0.34***
Constant	11.40	11.18	11.45	10.77
R^2	0.14	0.15	0.15	0.26
Adjusted R^2	0.09	0.08	0.08	0.20
F statistic	2.48**	2.13*	2.07*	4.20***

$n = 80$. Note: Standardized beta-weights reported. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

concentration, industry asset intensity, firm market share, and firm size) in Model 1A indicated that the combination of industry structure and firm level factors had significant effects on continuing firm performance. The overall model was significant, explaining 14 percent of the variance in firm ROA (adjusted $R^2 = 0.09$). The slope coefficient for firm market share was significant and positive as anticipated. Once again, the slope coefficient for industry concentration proved to be negative and significant, suggesting that firms operating in highly concentrated industries in 1977 were likely to experience lower firm performance on a continuing basis.

Models 2A and 3A

The regression of continuing firm performance on control variables and related diversification as measured by the related component of the entropy index is shown in Model 2A. The overall model was significant and explained 15 percent of the variance in ROA (adjusted $R^2 = 0.08$). However, comparison of this model to Model 1A indicates that the related component of the entropy index did not make a significant contribution to explained variance.

The regression of continuing firm performance on control variables and related diversification as measured by the concentric index is shown in Model 3A. The overall model was significant and explained 15 percent of the variance in ROA (adjusted $R^2 = 0.08$). Comparison of this model to Model 1A indicates that the concentric index also did not make a significant contribution to explained variance in continuing firm performance.

Model 4A

Model 4A, which examined the effect of control variables and the resource-based relatedness measure, again proved to be the most powerful of the three models. The full model explained 26 percent of the variance in ROA (adjusted $R^2 = 0.20$). Comparison to Model 1A indicates that the addition of the resource-based relatedness measure creates a significant increase in the explained variance in continuing firm performance. The slope of the resource-based measure was significant and positive, again indicating that the interrelationship among the businesses of a firm is associated with higher financial performance.

DISCUSSION AND CONCLUSION

The most important finding of the research is that the resource-based approach to modeling interrelationships among businesses developed in this study appears to provide real insight into the multibusiness firm. Indirect indicators of underlying shared strategic assets can help to explain variability in corporate financial performance. Corporations with more highly interrelated business portfolios outperform firms with lower levels of portfolio 'relatedness'.

This finding is particularly important when viewed in the context of research on strategic management. One of the distinctive features of strategy research is an underlying normative interest in the performance of the firm—an orientation not generally shared by other fields where economic performance is a key issue, such as economics and industrial-organization economics (Teece, 1984). As indicated above, firm-level variables examined in prior research typically have explained only a small proportion of variance in economic performance. The explanatory power of the resource-based measure of 'relatedness' is comparable to virtually any firm-level factor that has been studied to date, and it is superior to other measures of corporate portfolio composition.

The reconceptualization of 'relatedness' in terms of shared strategic assets such as capabilities or know-how, rather than linkages among businesses based on operations or facilities, is particularly important. Recent strategic theories of the firm have argued for a behavioral orientation of this type (e.g., Barney, 1986b, 1991; Mahoney and Pandian, 1992; Teece, 1984; Teece *et al.*, 1991), but macrolevel operationalization of many of the key concepts of those theories has proved to be difficult. Resource-based theory enriches the analysis of corporate strategy by giving a central position to ideas such as know-how and tacit knowledge, but those ideas also create obstacles to empirical research. Many of the strategic characteristics of firms identified by resource-based theory cannot be measured directly. Operationalization of the theory requires approaches rooted in the

behavioral sciences, such as the sociometric modeling of relatedness developed in this study. Approaches of this type are not a substitute for microlevel behavioral research on resource-based strategy, but they can offer large scale findings that are a valuable complement to intensive research carried out within firms.

The resource-based index of relatedness appears to be genuinely different from measures of related diversification such as the related component of the entropy index or the concentric index. There is little correlation between the resource-based and SIC based measures of relatedness (see Tables 1 and 3) and they have significantly different effects in models of financial performance (Tables 2 and 4). The resource-based index not only has a stronger grounding in theory, it also appears to measure different underlying phenomena than the concentric index or the related component of the entropy index.

The unexpected finding that industry concentration is negatively related to performance suggests that concentration may not be a strong indicator of entry barriers in this case. Assuming contestability of industries, Porter's (1980) view that industry concentration may be associated with high levels of rivalry among firms may be a more appropriate interpretation of these findings. It is also possible that measures based on domestic data overstate levels of concentration in industries that are open to global competition. The presence of strong foreign competitors in those industries may have a substantial impact on the performance of domestic firms as well. In common with many other areas of strategy research, our understanding of these issues might be strengthened considerably by extensions of the work to international settings.

This study has important implications both for work on corporate portfolio strategies and for the general development of strategic theory and research. It provides new support for the link between portfolio interrelationships and corporate financial performance, and it suggests that stronger measurement techniques might eliminate much of the current ambiguity in empirical work on relatedness. The evidence provided here that portfolio interrelationships have a positive effect on performance also lends support to the resource-based view of the multibusiness firm. The fact that measurement techniques grounded in a resource-based view of the firm are successful in linking portfolio interrelationships to corporate performance argues that weaknesses in measurement rather than weaknesses in theory may have been the source of ambiguous findings in the past. Although resource-based approaches to corporate strategy are still in an early stage of development, the research reported here represents a real advance in the process of building empirical foundations for a very important contemporary body of theoretical work on strategic management.

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GUIDE TO APPENDIX 1

Category	*SIC codes included*	*Category*	*SIC codes included*
1	0090–0900	20	3410–3499
2	0999–1500	21	3500–3519
3	2000–2199	22	3520–3529
4	2209–2299	23	3530–3539
5	2309–2399	24	3540–3549
	3110–3119	25	3550–3568
	3130–3179		3572–3593
	3190–3199		3598–3599
6	2410–2459	26	3569–3571
	2490–2499		2572–2574
7	2500–2599	27	3610–3629
8	2609–2669		3640–3649
9	2709–2799		3690–3699
10	2809–2819	28	3630–3639
	2870–2899	29	3650–3679
11	2820–2829	30	3710–3719
12	2830–2839	31	3720–3729
13	2859–2870	32	3760–3769
14	2840–2859	33	3730–3759
15	2900–2999		3790–3799
16	3009–3049	34	3810–3879
	3060–3079	35	3910–3919
17	3210–3299		3930–3969
18	3310–3329		3990–3999
19	3330–3335	36	5009–5999
	3338–3369	37	4000–4999
	3390–3399		

APPENDIX 1

Category	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13	V14
1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	1.00	−0.04	−0.04	0.00	−0.04	−0.05	−0.05	−0.04	−0.05	−0.10	−0.03	−0.05	−0.15
3	0.00	−0.04	1.00	−0.04	−0.10	−0.03	0.02	0.88	0.13	−0.05	−0.05	−0.00	−0.04	0.37
4	0.00	−0.04	−0.04	1.00	1.00	−0.04	−0.05	−0.04	−0.04	−0.04	0.27	−0.05	0.02	0.10
5	0.00	0.00	−0.10	1.00	1.00	−0.13	0.15	0.02	0.00	−0.16	0.09	−0.08	−0.10	−0.11
6	0.00	−0.04	−0.03	−0.04	−0.13	1.00	−0.01	−0.04	−0.04	−0.05	−0.06	−0.04	−0.05	−0.03
7	0.00	−0.05	0.02	−0.05	0.15	−0.01	1.00	0.08	0.04	−0.06	−0.09	−0.07	−0.08	−0.03
8	0.00	−0.05	0.88	−0.04	0.02	−0.04	0.08	1.00	0.00	−0.02	−0.00	0.02	−0.03	0.34
9	0.00	−0.04	0.13	−0.04	0.00	−0.04	−0.04	0.00	1.00	−0.05	−0.06	−0.04	−0.06	0.01
10	0.00	−0.05	−0.04	−0.04	−0.16	−0.05	−0.06	−0.01	−0.05	1.00	0.02	−0.05	0.98	−0.07
11	0.00	−0.10	−0.05	0.26	0.09	−0.06	−0.09	0.00	−0.06	0.02	1.00	−0.05	0.66	0.01
12	0.00	−0.03	0.00	−0.05	−0.08	−0.04	−0.07	0.02	−0.04	−0.05	−0.05	1.00	−0.05	0.93
13	0.00	−0.5	−0.04	0.02	−0.10	−0.05	−0.08	−0.03	−0.06	0.98	0.66	−0.05	1.00	−0.05
14	0.00	−0.15	0.37	0.10	−0.11	−0.03	−0.03	0.34	0.01	−0.07	0.01	0.94	−0.05	1.00
15	0.00	−0.03	−0.03	−0.04	0.71	−0.03	−0.01	−0.03	−0.03	0.05	−0.06	−0.04	−0.01	0.02
16	0.00	−0.03	0.05	0.12	0.70	0.12	0.07	0.02	−0.03	−0.06	0.88	−0.04	0.02	0.33
17	0.00	−0.05	−0.05	−0.05	−0.18	−0.03	−0.01	−0.02	−0.05	−0.05	−0.01	−0.05	−0.05	−0.05
18	0.00	−0.05	−0.05	−0.05	−0.40	−0.04	−0.03	−0.06	−0.04	0.20	−0.08	−0.04	−0.07	−0.04
19	0.00	−0.04	−0.03	−0.05	−0.13	−0.04	−0.05	−0.05	−0.04	−0.03	−0.03	−0.04	−0.05	−0.05
20	0.00	−0.05	0.12	−0.06	−0.11	−0.03	0.05	0.01	−0.04	−0.05	−0.10	−0.07	−0.07	0.10
21	0.00	−0.00	−0.03	−0.06	−0.09	−0.04	0.12	−0.01	−0.02	−0.04	−0.11	−0.04	−0.07	0.06
22	0.00	−0.03	0.00	−0.03	−0.09	−0.03	−0.02	0.02	−0.03	−0.04	−0.06	0.39	−0.04	0.94
23	0.00	0.93	0.00	−0.07	−0.05	0.04	0.05	−0.04	−0.05	−0.05	−0.12	−0.08	−0.08	−0.08
24	0.00	−0.12	−0.10	−0.13	−0.25	0.01	−0.06	−0.10	−0.12	−0.10	−0.10	−0.06	−0.16	0.18
25	0.00	−0.06	0.44	0.02	−0.10	−0.04	0.36	0.26	0.29	0.00	−0.09	−0.09	−0.01	0.10
26	0.00	−0.07	0.04	−0.05	−0.09	−0.05	0.66	0.11	0.08	0.03	−0.09	−0.08	−0.05	−0.03
27	0.00	−0.06	−0.04	−0.07	−0.23	−0.05	0.09	−0.01	−0.04	−0.05	−0.10	−0.07	−0.08	0.01
28	0.00	−0.06	−0.01	−0.01	0.23	0.01	0.49	0.05	−0.03	−0.06	−0.08	−0.07	−0.08	−0.04
29	0.00	−0.04	−0.04	−0.05	−0.07	−0.04	0.07	−0.05	−0.02	−0.06	−0.08	−0.06	−0.05	0.01
30	0.00	−0.03	0.06	−0.06	0.31	−0.01	0.60	0.09	0.05	−0.05	−0.09	−0.01	−0.08	0.18
31	0.00	−0.03	−0.05	−0.04	−0.08	−0.03	−0.01	−0.05	−0.02	−0.06	−0.07	−0.05	−0.06	−0.02
32	0.00	−0.04	−0.05	−0.04	−0.10	−0.04	−0.06	−0.05	−0.04	−0.14	−0.07	−0.04	−0.11	−0.09
33	0.00	0.00	−0.04	−0.04	0.00	−0.03	0.04	−0.04	−0.02	−0.06	−0.07	−0.05	−0.07	0.01
34	0.00	−0.08	0.00	−0.07	−0.13	−0.06	0.27	0.03	−0.01	−0.01	−0.10	−0.07	−0.02	−0.02
35	0.00	−0.04	−0.03	−0.03	0.71	−0.03	0.01	−0.03	0.03	−0.05	−0.04	−0.04	−0.06	−0.07
36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

APPENDIX 1 (continued)

Category	V15	V16	V17	V18	V19	V20	V21	V22	V23	V24	B25	B26	V27	V28
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	−0.03	−0.03	−0.06	−0.05	−0.04	−0.05	−0.00	−0.04	0.93	−0.12	−0.06	−0.07	−0.06	−0.06
3	−0.04	0.05	−0.06	−0.05	−0.04	0.12	−0.03	−0.01	0.00	−0.10	0.44	0.04	−0.04	−0.01
4	−0.04	0.12	−0.06	−0.05	−0.05	−0.06	−0.06	−0.03	−0.07	−0.14	0.03	−0.05	−0.07	−0.01
5	0.71	0.70	−0.18	−0.40	−0.14	−0.11	−0.09	−0.09	−0.05	−0.25	−0.10	−0.09	−0.23	0.23
6	−0.03	0.12	−0.03	−0.04	−0.04	−0.03	−0.04	−0.03	0.04	0.00	−0.04	−0.05	−0.05	0.02
7	−0.01	0.07	−0.01	−0.03	−0.05	0.05	0.12	−0.02	0.05	−0.06	0.36	0.66	0.09*	0.49
8	−0.03	0.02	−0.02	−0.06	−0.05	0.01	−0.01	0.02	−0.04	−0.10	0.26	0.11	−0.01	0.05
9	−0.03	−0.03	−0.05	−0.04	−0.04	−0.04	−0.02	−0.03	−0.05	−0.12	0.29	0.08	−0.04	0.03
10	0.05	−0.06	−0.05	0.20	−0.03	−0.05	−0.04	−0.04	−0.05	−0.10	0.00	−0.03	−0.05	−0.06
11	−0.06	0.88	−0.01	−0.08	−0.03	−0.10	−0.10	−0.06	−0.12	−0.10	−0.09	−0.09	−0.10	−0.08
12	−0.04	−0.04	−0.05	−0.04	−0.04	−0.07	−0.04	0.39	−0.08	−0.06	−0.09	−0.08	−0.07	−0.07
13	−0.01	0.017	−0.05	−0.07	−0.05	−0.07	−0.07	−0.04	−0.08	−0.16	0.01	−0.05	−0.08	−0.08
14	0.02	0.329	−0.05	−0.04	−0.05	0.10	0.06	0.94	−0.08	0.18	0.10	−0.03	0.01	−0.04
15	1.00	−0.02	0.02	0.10	−0.03	0.01	0.06	−0.02	0.21	−0.12	0.05	0.05	0.013	−0.01
16	−0.02	1.00	−0.01	−0.05	−0.03	0.03	0.05	0.02	−0.04	−0.05	0.10	0.10	0.04	0.04
17	0.02	0.01	1.00	0.01	−0.06	−0.03	−0.01	−0.05	0.01	−0.04	0.06	0.01	0.57	−0.04
18	0.10	−0.05	0.01	1.00	−0.02	0.08	0.07	−0.03	−0.02	0.45	0.26	0.32	0.12	−0.06
19	−0.03	−0.03	−0.06	−0.02	1.00	−0.00	−0.03	−0.03	−0.05	0.26	−0.02	−0.05	0.00	−0.06
20	0.01	0.03	−0.03	0.08	−0.00	1.00	0.71	−0.04	0.03	0.28	0.36	0.22	0.67	0.01
21	0.06	0.05	−0.02	0.07	−0.03	0.71	1.00	0.05	0.08	−0.11	0.36	0.34	0.77	0.09
22	−0.02	0.02	−0.05	−0.03	−0.03	−0.04	0.05	1.00	−0.04	0.11	0.04	−0.03	−0.00	−0.02
23	0.21	−0.04	0.01	−0.02	−0.05	0.03	0.08	−0.04	1.00	−0.10	0.08	0.08	0.04	0.02
24	−0.12	−0.05	−0.04	0.56	0.26	0.28	−0.11	0.11	−0.10	1.00	0.20	−0.03	0.07	−0.10
25	0.05	0.10	0.06	0.26	−0.02	0.36	0.36	0.04	0.08	0.20	1.00	0.56	0.38	0.32
26	0.05	0.10	0.01	0.32	−0.05	0.22	0.34	−0.03	0.08	−0.03	0.56	1.00	0.30	0.58
27	0.01	0.04	0.57	0.12	0.00	0.67	0.77	−0.00	0.04	0.06	0.38	0.30	1.00	0.10
28	−0.01	0.04	−0.04	−0.06	−0.06	0.01	0.09	−0.02	0.02	−0.10	0.32	0.58	0.11	1.00
29	−0.00	0.02	0.01	−0.04	−0.03	0.57	0.67	−0.04	0.02	−0.09	0.22	0.24	0.62	0.02
30	0.04	0.12	0.02	−0.03	−0.04	0.45	0.58	0.14	0.14	0.09	0.63	0.82	0.54	0.52
31	0.00	0.03	−0.01	−0.04	−0.03	0.73	0.81	−0.04	0.02	−0.09	0.23	0.19	0.75	−0.03
32	−0.06	−0.05	−0.05	−0.04	−0.04	−0.05	−0.05	−0.04	−0.07	−0.11	−0.12	−0.06	−0.07	−0.06
33	0.96	0.05	−0.00	1.00	−0.02	0.78	0.92	−0.04	0.33	−0.13	0.37	0.53	0.85	0.00
34	0.06	0.05	0.02	−0.02	−0.05	0.52	0.63	−0.03	0.03	−0.03	0.42	0.51	0.59	0.23
35	−0.02	−0.03	−0.05	−0.04	−0.04	−0.04	−0.03	0.04	−0.06	−0.07	−0.06	0.01	−0.05	−0.00
36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
37	0.00	0.00	0.00	0.00	0.00	0.006	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

APPENDIX 1 (continued)

Category	V29	V30	V31	V32	V33	V34	V35	V36	V37
1	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.00
2	−0.04	−0.03	−0.03	−0.04	0.00	−0.08	−0.04	0.00	0.00
3	−0.04	0.06	−0.05	−0.05	−0.04	0.00	−0.03	0.00	0.00
4	−0.05	−0.06	−0.05	−0.05	−0.04	−0.08	−0.03	0.00	0.00
5	−0.07	0.31	−0.08	−0.10	0.00	−0.13	0.71	0.00	0.00
6	−0.04	−0.01	−0.03	−0.04	−0.03	−0.06	−0.03	0.00	0.00
7	0.07	0.60	−0.01	−0.06	0.04	0.27	0.01	0.00	0.00
8	−0.05	0.09	−0.05	−0.05	−0.04	0.03	−0.03	0.00	0.00
9	−0.02	0.05	−0.02	−0.04	−0.02	0.12	−0.03	0.00	0.00
10	−0.06	−0.05	−0.06	−0.14	−0.06	−0.01	−0.05	0.00	0.00
11	−0.08	−0.09	−0.07	−0.07	−0.07	−0.10	−0.04	0.00	0.00
12	−0.06	−0.01	−0.05	−0.04	−0.05	−0.07	−0.04	0.00	0.00
13	−0.05	−0.08	−0.06	−0.11	−0.07	−0.02	−0.06	0.00	0.00
14	0.01	0.18	−0.02	−0.09	0.01	−0.02	−0.07	0.00	0.00
15	−0.00	0.04	0.00	−0.06	0.96	0.06	−0.02	0.00	0.00
16	0.02	0.12	0.03	−0.05	0.05	0.05	−0.03	0.00	0.00
17	0.01	0.02	−0.01	−0.05	−0.00	0.02	−0.05	0.00	0.00
18	−0.04	−0.03	−0.04	−0.04	1.00	−0.02	−0.04	0.00	0.00
19	−0.03	−0.04	−0.03	−0.04	−0.02	−0.05	−0.04	0.00	0.00
20	0.57	0.45	0.73	−0.05	0.78	0.52	−0.04	0.00	0.00
21	0.67	−0.58	0.81	−0.05	0.92	0.63	−0.03	0.00	0.00
22	−0.04	0.14	−0.04	−0.04	−0.04	−0.03	0.04	0.00	0.00
23	0.02	0.14	0.02	−0.07	0.33	0.03	−0.06	0.00	0.00
24	−0.09	0.09	−0.09	−0.11	−0.13	−0.03	−0.07	0.00	0.00
25	0.22	0.63	0.23	−0.12	0.37	0.42	−0.06	0.00	0.00
26	0.24	0.82	0.19	−0.06	0.53	0.51	0.01	0.00	0.00
27	0.62	0.54	0.75	−0.07	0.85	0.59	−0.05	0.00	0.00
28	0.02	0.52	−0.03	−0.06	0.00	0.23	0.00	0.00	0.00
29	1.00	0.40	0.68	−0.04	0.75	0.59	−0.03	0.00	0.00
30	0.40	1.00	0.42	−0.06	0.95	0.62	0.02	0.00	0.00
31	0.68	0.42	1.00	−0.02	0.91	0.60	−0.03	0.00	0.00
32	−0.04	−0.06	−0.02	1.00	−0.03	−0.06	−0.04	0.00	0.00
33	0.75	0.95	0.91	−0.03	1.00	0.71	−0.02	0.00	0.00
34	0.59	0.62	0.60	−0.06	0.71	1.00	−0.04	0.00	0.00
35	−0.03	0.02	−0.03	−0.04	−0.02	−0.04	1.00	0.00	0.00
36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00

APPENDIX 2: ADJUSTMENT PROCEDURE FOR THE RESOURCE-BASED INDEX OF PORTFOLIO INTERRELATEDNESS

When sales-weighted measures of interrelatedness between businesses are summed for a firm, the resulting index varies with the total number of industries in which a firm is active. This is a consequence of the fact that the index is summed over all combinations of two SICs that can be formed from the portfolio of a firm, and sales weights are subejct to multiple counting. For example, if the sales-weighted measure of interrelationship for any pair of industries i_1 and i_2 is:

$$R_{12} = P_1 r_{12} + P_2 r_{12} = r_{12} (P_1 + P_2)$$

then the sum of these measures for a firm active in three industries will be:

$$M_k = \Sigma R = R_{12} + R_{13} + R_{23}$$
$$= r_{12} (P_1 + P_2) + r_{13} (P_1 + P_3) + r_{23} (P_2 + P_3)$$

This sum will attain its maximum value when all measures of interindustry similarity are at their maxima, i.e., $r_{12} = r_{13} = r_{23} = 1.0$, therefore:

$$\max (M_k) = (P_1 + P_2) + (P_1 + P_3) + (P_2 + P_3)$$
$$= 2 (P_1 + P_2 + P_3)$$

By definition, the sales weights for a firm sum to unity,

$$\text{i.e. } P_1 + P_2 + P_3 = 1.0, \text{ therefore, } \max (M_k) = 2.0$$

Evaluating this expression at its minimum, where $r_{12} = r_{13} = r_{23} = -1.0$, then:

$$\min (M_k) = -2.0$$

For a firm active in four industries, the maximum and minimum will be +3.0 and −3.0. In general, the theoretical maximum and minimum values for the measure are determined by the number of times each industry is counted in the summation process. For a firm active in N industries, the number of combinations of two industries that can be formed will be:

$$\frac{N!}{2(N-2)!} = \frac{N(N-1)}{2}$$

Each industry P_i will appear a total of $N - 1$ times in these combinations. The theoretical maximum and minimum values of the measure therefore will be $+(N-1) \Sigma P_i$ and $-(N-1) \Sigma P_i$. Because $\Sigma P_i = 1.0$ by definition, the theoretical maximum and minimum for a firm active in N industries will be $+(N-1)$ and $-(N-1)$. The sum $M_k = \Sigma r_{ij} (P_{ki} + P_{kj})$ therefore was divided by the absolute value $|N-1|$ to form an adjusted index that ranged from +1.0 to −1.0.