THE MEASUREMENT OF CORPORATE PORTFOLIO STRATEGY: ANALYSIS OF THE CONTENT VALIDITY OF RELATED DIVERSIFICATION INDEXES

JAMES A. ROBINS[1] and MARGARETHE F. WIERSEMA[2]*
[1] Department of Management, City University of Hong Kong, Hong Kong
[2] Graduate School of Management, University of California, Irvine, California, USA

Measures developed for the analysis of corporate diversification have become fundamental to a broad range of strategy research. This paper examines the content validity of the two most widely used continuous measures of related diversification—the related component of the entropy index and the concentric index—and raises fundamental questions about their validity as indicators of portfolio relatedness. These questions are not driven by the use of SIC data for estimation of the indexes; they involve validity problems intrinsic to the construction of the measures. The related component of entropy and the concentric index are sensitive to features of corporate portfolio composition that may not be directly linked to portfolio relatedness. These sensitivities can create important ambiguities in strategy research. Copyright © 2002 John Wiley & Sons, Ltd.

Some of the most important measures of related diversification may involve serious ambiguities not previously discussed by researchers. This paper examines the content validity (Nunnally, 1978) of the two types of continuous measures most widely used in strategy research—the related component of the entropy index and the concentric index—and argues that important questions exist about the validity of these measures as indicators of portfolio 'relatedness.' We find that the measures are strongly influenced by dimensions of corporate strategy other than relatedness such as focus on a dominant business or the number of businesses in the corporate portfolio. The sensitivity of the related diversification measures to these more basic elements of portfolio composition suggests caution in the interpretation of research and the selection of measures.

The validity problems examined in the paper are independent of questions about the SIC system.

Although the related component of the entropy index and the concentric index typically are calculated using SIC data, the problems identified here would exist even if those measures were computed using a different type of data. There are important ambiguities associated with the measures that are due to basic features of their construction. This issue is particularly important because most efforts to improve the measurement of related diversification have focused on problems associated with the SIC system (e.g., Brush, 1996; Farjoun, 1994, 1998; Robins and Wiersema, 1995).

The paper examines four major questions:

- What do the related diversification indicators actually appear to measure; i.e., how do the measures characterize different types of corporate portfolios and changes in corporate portfolios?
- Why do the measures operate in these ways?
- Are these sensitivities likely to be significant when measures are used in empirical research on diversified corporations?
- What are the implications of these sensitivities for existing and future research on corporate strategy?

The first three of these questions focus on the problem of understanding the content of related diversification measures; the fourth examines issues of content validity in research that has used these measures. It is necessary to address the first three questions before the fourth can be adequately explored. The empirical content of the related entropy and concentric indexes has not been systematically examined in prior research, and it is not possible to assess the validity of the measures without first having a better understanding of what they actually measure.

The paper begins by looking at the sensitivities of the related diversification indexes to some fundamental features of portfolio composition. The first two parts of the paper use simple simulations and basic mathematics to develop a general picture of how and why the measures respond to certain types of changes in stylized corporate portfolios and why they may exhibit these sensitivities. The analysis in this part of the paper suggests important concerns about the related diversification measures, but it is based on stylized conditions and may not reflect the sensitivities of the measures in practice.

The paper then looks at these issues in an empirical context using data on the corporate portfolios of a sample of large diversified firms. This empirical analysis underscores the concerns raised by the exploratory simulations. It suggests that measures of related diversification may be driven by features of portfolio composition that are not tightly linked to the concepts that the measures are intended to capture.

The final part of the paper reviews a few of the seminal studies that have used the related entropy and concentric measures and asks basic questions about the appropriate interpretation of research findings. The studies examined in this section include some of the most influential empirical research on corporate strategy—studies that helped to establish the methodological and conceptual directions taken by empirical work on diversification during the last two decades.

CONCERNS ABOUT THE VALIDITY OF RELATED DIVERSIFICATION MEASURES

The measurement of related diversification is important to a broad range of strategy research.

Measures developed for the analysis of corporate portfolio strategy are used in many areas of research on strategy, economics, and financial economics. Studies of strategic management have used diversification measures as independent variables, dependent variables, and control variables in work on topics such as restructuring, refocusing, governance, merger, divestiture, top management team turnover, and strategic change (Barker and Duhaime, 1997; Bergh and Holbein, 1997; Bergh, 1997; Bethel and Liebeskind, 1998; Markides, 1992; Wiersema and Bantel, 1992). Diversification measures have been particularly significant in work linking portfolio strategy and financial performance, and they have figured prominently in recent studies of corporate focus and shareholder wealth. They played an important part in earlier studies of diversification complementarity (Bettis, 1981; Palepu, 1985; Rumelt, 1974, 1982; Varadarajan, 1986; Wernerfelt and Montgomery, 1988) and they have been vital to analysis of the 'diversification discount' implied by the finding that focused firms outperform highly diversified corporations (Berger and Ofek, 1995; Comment and Jarrell, 1995; Davis and Thomas, 1993; Fan and Lang, 2000; Lang and Stulz, 1994; Rajan, Servaes, and Zingales, 2000; Scharfstein and Stein, 2000; Servaes, 1996; Shin and Stulz, 1998).

In the course of these various studies, certain specific types of measures have become part of the standard tool kit used in empirical research. Continuous or 'product count' measures of related diversification such as the entropy and concentric indexes are used particularly widely in contemporary research (e.g., Barker and Duhaime, 1997; Bergh, 1997). These indicators are popular for a number of reasons, including the fact that they are readily derived from secondary data and can be measured at an interval level.

Widespread use of these measures also has created concern about their validity, and a number of studies have examined the validity of related diversification indexes with mixed results (e.g., Acar and Sankaran, 1999; Chatterjee and Bloucher, 1992; Davis and Duhaime, 1992; Hall and St John, 1994; Hoskisson *et al.*, 1993; Lubatkin, Merchant, and Srinivasan, 1993; Robins and Wiersema, 1995). Hoskisson *et al.* (1993), for example, argued that the related component of the entropy index shows a high level of validity on several dimensions including convergence and prediction. Lubatkin *et al.* (1993) also found evidence of

convergent validity when comparing continuous and categorical measures. However, Hall and St John (1994) raised questions about the convergent validity of continuous and categorical measures, arguing that choice of a diversification measure may influence research results.

Researchers' concerns about the related diversification measures are well founded. Measures that are used to indicate similar concepts may respond to empirical data in different or contradictory ways. Two major problems arise with these measures: indicators may not represent a single construct or dimension, and measures may be driven by different underlying dimensions of portfolio strategy.

An illustrative example

A simple example based on stylized conditions helps to illustrate the point. Consider the case of a hypothetical firm such as the Consolidated Electric (CE), with the business portfolio in the year 1988 that is illustrated by Figure 1.

Consolidated Electric is involved in four distinct businesses in 1988: power transformers (3612); switchgear apparatus (3613); household cooking equipment (3631); and household refrigerators and freezers (3632). Each represents 25 percent of the corporation's total sales. Two of these businesses fall within one 3-digit SIC, electric transmission equipment (361), and the other two are in a different 3-digit SIC group, household appliances (363). All are part of a single 2-digit SIC major area of business, electronic and electrical equipment (36). Figure 1 illustrates this hypothetical corporate portfolio.

The related component of the entropy index and the concentric index can readily be computed for the Consolidated Electric. The related component of the entropy index can be derived by a partition of total entropy into its related and unrelated parts (Jacquemin and Berry, 1979). Total entropy (DT) is given by:

$$DT = \sum_{i=1}^{N} P_i \ln(1/P_i)$$

where P_i = Proportion of business activity (sales) in SIC code i, for a corporation with N different 4-digit SIC businesses.

Unrelated entropy (DU) is computed in a similar fashion using 2-digit SIC data:
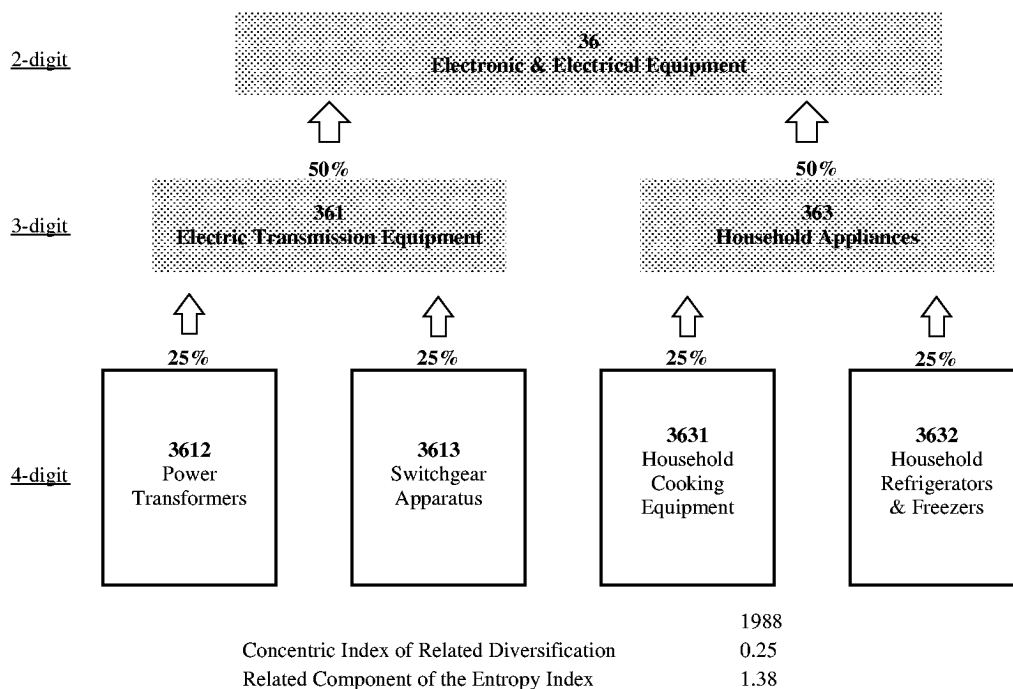
$$DU = \sum_{i=1}^{N} P_i \ln(1/P_i)$$

Figure 1. Consolidated Electric 1988

	1988
Concentric Index of Related Diversification	0.25
Related Component of the Entropy Index	1.38

where P_i = Proportion of business activity (sales) in SIC code i, for a corporation with N different 2-digit SIC businesses.

Related entropy (DR) therefore can be estimated as DT − DU = DR. For Consolidated Electric in Figure 1, this value would be DR = 1.38.

The concentric index can be calculated as (Montgomery and Hariharan, 1991: 80):

$$\text{FDIVERS}_k = \sum_{i=1}^{N} \sum_{k=1}^{N} P_{ki} P_{kl} d_{il}$$

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.[1]

_____

[1] The formula in the text has been edited from the original provided by Montgomery and Hariharan (1991) in order to provide more precise algebraic notation. The formula provided in the text corresponds to the description of the operational derivation of the measure provide by Montgomery and Hariharan.

As indicated in Figure 1, the concentric index of related diversification has a value of 0.25 for Consolidated Electric in 1988.

Five years later, Consolidated Electric has undertaken a significant change in its portfolio. By 1993, the corporation has expanded from four businesses to seven businesses. Two of Consolidated Electric's original businesses remain essentially unchanged; power transformers (3612) and switchgear apparatus (3613) each still represents 25 percent of corporate activity. However, other aspects of the portfolio have changed significantly. Household cooking equipment (3631) and household refrigerators and freezers (3632) now represent only 10 percent of corporate activity each, and three new areas of business have been added: electric light bulbs (3641), audio records, tapes, and disks (3652), and radio and TV broadcasting equipment (3663). Each of these new businesses also represents 10 percent of the firm's activity. The three new businesses are in distinct 3-digit SICs, but all businesses of the corporation still lie within the same major 2-digit SIC area of business. This portfolio is illustrated in Figure 2.

The measures of related diversification for Consolidated Electric also have changed between 1988

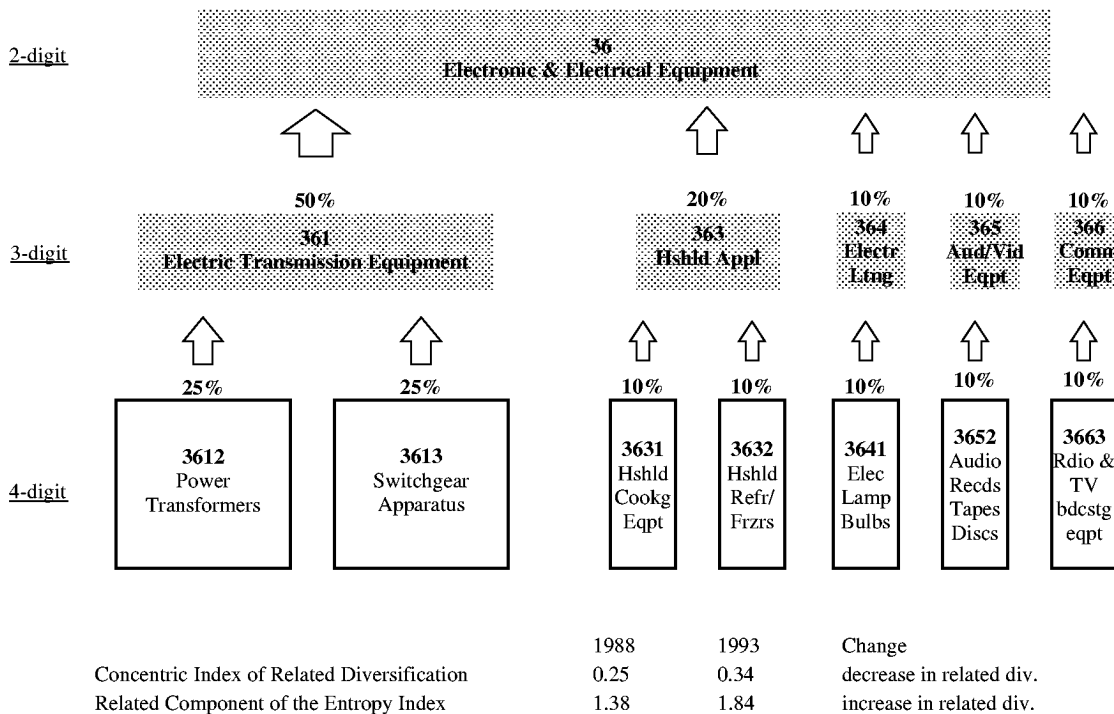|	1988	1993	Change
Concentric Index of Related Diversification	0.25	0.34	decrease in related div.
Related Component of the Entropy Index	1.38	1.84	increase in related div.

Figure 2.   Consolidated Electric 1993

and 1993. The concentric index is 0.34 in 1993, and related entropy is 1.84. Since a larger value of the concentric index designates less related diversification, the change in the concentric index from 0.25 in 1988 to 0.34 in 1993 shows a *decrease* in related diversification. The entropy measure, on the other hand, increases with greater related diversification. The change in the related component of the entropy index from 1.38 in 1988 to 1.84 in 1993 indicates that related diversification has *increased* during that period. The shift in Consolidated Electric's business portfolio between 1988 and 1993 produced opposing results in the concentric and related entropy measures. One measure indicates that the firm increased its related diversification; the other indicates a decrease.

Now consider additional changes in the CE portfolio after 1993. Imagine that Consolidated Electric's increased diversification in 1993 was followed by a focusing strategy in the later 1990s. During the 5 years from 1993 to 1998, the firm exited from the three new businesses that had been added between 1988 and 1993. The four original businesses from 1988 remained in the corporate portfolio in 1998, but power transformers (3612) grew to account for 70 percent of all corporate

activity, while switchgear apparatus (3613), household cooking equipment (3631), and household refrigerators and freezers (3632) each represented only 10 percent of activity. This new 1998 portfolio is illustrated in Figure 3.

The concentric and entropy indexes for Consolidated Electric have changed again. The concentric index is 0.16 in 1998 and the related component of the entropy index is 0.94. Compared to the original 1988 portfolio, the value of the concentric index indicates an increase in related diversification; it has changed from 0.25 in 1988 to 0.16 in 1998. The value of the related entropy index, on the other hand, now indicates a decrease in related diversification, from 1.38 in 1988 to 0.94 in 1998.

The measures again produce contradictory results. These results pose an important dilemma for research. Which measure is believable and why are the measures contradictory?

The answers lie in the fact that the measures do not capture exactly the same dimensions of portfolio strategy. Although they often have been viewed as alternative approaches to the common problem of measuring related diversification, the measures can produce contradictory results because they differ in their sensitivity to underlying dimensions of portfolio strategy. Neither the concentric nor
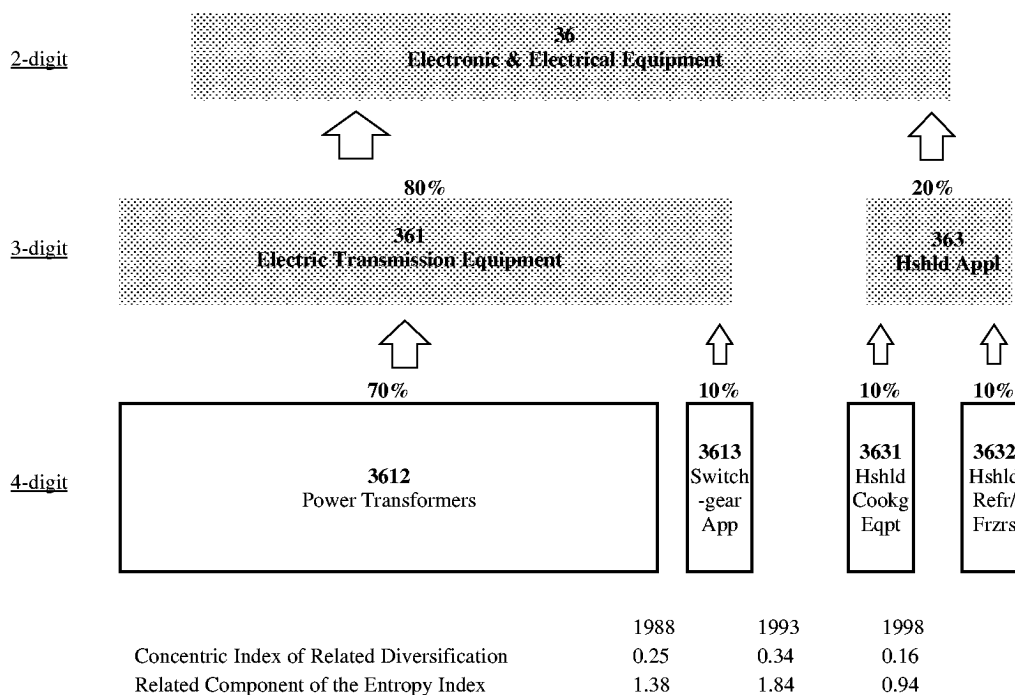

Figure 3. Consolidated Electric 1998

the related entropy index necessarily is incorrect or invalid for analysis of the changes in Consolidated Electric's corporate strategy between 1988 and 1998. The validity of these measures ultimately depends on the theoretical concerns that drive researchers to examine Consolidated Electric and the substantive interpretation placed on the change in strategy undertaken by Consolidated Electric.

Content validity

It is important to recognize that the ambiguities associated with analysis of Consolidated Electric are not a result of the fact that SIC data were used to calculate the related diversification measures. Although popular diversification measures may suffer from weaknesses associated with use of the SIC system (Robins and Wiersema, 1995), the validity of these measures would remain questionable even if an alternative data source or data coding scheme were employed. The way in which the measures are constructed they are not unidimensional since they reflect two or more different constructs in a single measure.

The Consolidated Electric example highlights questions about a form of validity that psychometricians such as Nunnally (1978) or Zeller and Carmines (1980) have termed *content validity*. Zeller and Carmines (1980: 78) describe content validity in this way:

> Fundamentally, content validity concerns the extent to which a set of items taps the content of some domain of interest. To the degree that the items reflect the full domain of content, they are said to be content-valid.

Content validity—also sometimes called the 'face validity' of an indicator—relies on the logic that connects indicator to underlying concept. The evaluation of content validity therefore must be addressed primarily through theory rather than empirical analysis (e.g., Hoskisson *et al.*, 1993; Nunnally, 1978; Venkatraman and Grant, 1986; Zeller and Carmines, 1980). The fact that there is no standard methodology for evaluating content validity makes content validity one of the most problematic areas of inquiry; however, content validity also is one of the most fundamental determinants of whether empirical work speaks to the theoretical concerns of research (Blalock, 1982; Russell, 1948; Zeller and Carmines, 1980).

The fact that there is no rote method for analyzing content validity also may help to explain why little attention has been given to the subject in recent validation studies. As Lubatkin *et al.* (1993) have observed, the few studies that have dealt with content validity of diversification measures generally have approached the issue by looking at convergence between current continuous measures and earlier categorical approaches. The earlier measures used for this purpose have been based on the categorical analysis of diversification patterns developed by Rumelt (1974) nearly 30 years ago for investigation of questions raised by Chandler (1962) and Wrigley (1970). Although Rumelt's (1974) measures may have content validity for important questions about strategy and structure, the measures have a more ambiguous relationship to the concerns that drive current research on corporate strategy. Convergence with Rumelt's typology may provide little information about the content validity of a measure that is used in research based on theories such as the resource-based or knowledge-based views of the firm.

One other stream of research on content validity has appeared in the last few years, but it has looked primarily at problems associated with the SIC classifications. Robins and Wiersema (1995) raised questions of this type about the validity of the entropy and concentric indexes for research on 'relatedness' within corporate portfolios. They argued that the SIC classification used to assess relationships among businesses has a weak connection to the forms of relatedness that are important in contemporary strategy theory, and they proposed an alternative measure based on interindustry technology flows. Similar efforts to move away from SIC-based approaches to measurement of relatedness also have been presented by Farjoun (1994, 1998) and Brush (1996). However, all of these studies have examined content validity in terms of inherent weaknesses of the coding of data in the SIC system. Important questions that go beyond the quality and coding of data have been left unexplored, and those questions are the focus of the analysis here.

The limitations of prior assessments of content validity also may reflect the fact that researchers rarely articulate a rationale for their approaches to measuring related diversification. As Acar and Sankaran (1999) have pointed out, certain measures tend to be routinely adopted without systematic consideration of their validity for the problems

under analysis. The logic that links measures to constructs often is left implicit, with the result that researchers may not recognize problems of content validity that arise as older measures are applied to newer research problems.

The concept of related diversification

Advances in the theory of corporate strategy during the last two decades have given increasing importance to these types of concerns about content validity. Research on corporate portfolio strategy has shifted from emphasis on the link between strategy and organizational structure to questions that grow out of theories such as the resource-based and knowledge-based views of the firm. These recent research approaches to the corporation emphasize relationships within corporate portfolios rather than diversification as a basis for corporate advantage (Collis and Montgomery, 1998; Grant, 1996; Kogut and Zander, 1996). Problems of understanding portfolio relatedness, and the impact of relatedness on firm performance, have emerged as central concerns of corporate strategy (Hoskisson and Hitt, 1990; Mahoney and Pandian, 1992; Nayyar, 1992; Palich, Cardinal, and Miller, 2000).

The contemporary concept of related diversification is the result of almost three decades of evolution. Although Rumelt's (1974) pathbreaking work *Strategy, Structure and Performance* did not introduce the concept of related diversification, it first focused attention on the idea that portfolio interrelationships might be analytically distinguished from questions about costs and benefits of diversification. In the 1980s, introduction of the idea that the corporation serves as a repository for nonmarketable assets created a broader foundation for the concept of relatedness among businesses (Panzar and Willig, 1981; Teece, 1982). Building on this foundation, the resource-based view of the firm focused the analysis of diversification directly on the issue of relatedness. In the resource-based view, relatedness among businesses is more than just a necessary condition for successful diversification; it is the motive force behind diversification (Barney, 1988; Penrose, 1959). Profitable growth relies on achieving scope in the exploitation of scarce resources, and 'relatedness' thus defines the potential for corporate growth. More recent developments in the knowledge-based view of the firm have carried this concept further while retaining

the key idea that strategic interrelationships among the businesses of a corporate portfolio may be more important to performance than the number or size of those businesses.

This contemporary view of related diversification might be summarized by the idea that '... the rationale for multi-business organizations ultimately lies in sharing strategic capabilities among businesses. In the absence of shared firm-specific strategic assets, a corporation can be expected to perform less well than the sum of its separate businesses' (Robins and Wiersema, 1995). This idea captures the common foundation for the contemporary concept—the idea that a portfolio of businesses is bound together by some shared strategic resources or capabilities. A measure that is to be valid for this type of research must capture this common element 'relatedness.'

Operationalization and measurement of relatedness and diversification have lagged behind the theory in important ways. Diversification measures that were developed in prior decades for different research purposes are routinely used to analyze relatedness in contemporary studies. This growing disjunction between theory and method has opened the door to problems of content validity that are only beginning to attract the attention of researchers.

Methods for analysis of content validity

As indicated above, analysis of content validity involves issues of research design and interpretation that are essentially theoretical, and there is no single established approach to the problem. This difficulty is compounded by the fact that most discussions of content validity by statisticians have been strictly in the context of experimental work (Zeller and Carmines, 1980).

Blalock's (1985) classic work on measurement presents one of the most extensive examinations of validity in nonexperimental social research. Blalock draws a key distinction between the primary theory that defines the model tested in a research study and the 'auxiliary theories' that link concepts to measures. Those auxiliary theories determine the content validity of measures, and they must pass logical scrutiny before findings from analysis of the primary causal model can be interpreted (Blalock, 1985). Any ambiguities with regard to the connections between indicators

and concepts inescapably translate into uncertainties about the meaning of research results. Meaning becomes uncertain if a measure may be a function of some phenomenon other than the concept under analysis—regardless of whether that measure can be used to consistently reproduce results (Blalock, 1985; Zeller and Carmines, 1980).

Two broad questions must be answered in order to assess the strength of the auxiliary theories that connect measures to concepts (Stinchcombe, 1968; Wunsch, 1988):

● Are these auxiliary theories preferable to alternative theories that might connect the measures to different concepts?
● Which auxiliary theories are supported by evidence?

The simplest standard for answering the first question probably lies in the logic of 'Occam's razor'—the most parsimonious explanation that covers the facts is best (Stinchcombe, 1968). If the empirical phenomenon captured by these measures can be grounded in simpler concepts than 'related diversification,' then the prevailing interpretation of the measures becomes questionable.

Empirical evidence also can aid in the evaluation of auxiliary theories. Empirical analysis of the sensitivity of related diversification measures to more basic dimensions of portfolio composition is used for that purpose in this study. It provides a basis for evaluating the claim that a simpler dimension of portfolio strategy—and thus a more parsimonious auxiliary theory—might be substituted for the complex construct and complex auxiliary theories required for interpretation of these measures as indexes of relatedness.

Two specific underlying dimensions of portfolio structure are examined here: the number of businesses in the portfolio, and the relative size of the dominant business. These dimensions are termed 'pure diversification' and 'dominant business focus' for the purposes of this analysis. Although they are not the only dimensions of portfolio structure that may influence the related diversification indices, they are particularly important because they are among the most basic features of corporate portfolios. Virtually any change in corporate portfolio strategy is likely to have an impact on pure diversification, dominant business focus, or both. If these basic factors can explain findings derived from related diversification measures, then

the validity of research that uses the related diversification measures is questionable. The effects of dominant business focus and pure diversification may offer explanations for research findings that are more parsimonious than the concept of related diversification.

DIVERSIFICATION MEASURES: A STYLIZED ANALYSIS

The example of the Consolidated Electric above offers a good starting point for examining the content of corporate diversification measures. The basic change that occurred in Consolidated Electric's business portfolio between 1988 and 1993 was an expansion of the portfolio into a larger number of loosely related businesses. In 1988, Consolidated Electric was involved in four businesses of equal size. By 1993, the firm had moved into three new businesses within the same major area, and two of the firm's existing businesses had come to represent smaller proportions of the total portfolio. The principal change in the corporate strategy was pure diversification into a larger number of businesses, each of which accounted for smaller proportions of total activity.

The related component of the entropy index increased by 33 percent in response to this change, signifying an *increase* in related diversification. The value of the concentric index went up by about 36 percent, signifying a *decrease* in related diversification. The two indicators of related diversification exhibited substantial changes in the opposite directions in response to greater pure diversification.

This suggests that the related component of the entropy index might have a significant positive sensitivity to pure diversification; it appears to measure higher levels of related diversification with increase in the number of businesses in a corporate portfolio. However, pure diversification does not appear to affect the concentric index in the same way. When the Consolidated Electric portfolio is analyzed using the concentric index, pure diversification is negatively associated with related diversification.

Pure diversification

Closer examination of the measures suggests that the construction of each of the indexes creates

potential sensitivities to pure diversification. As indicated below, these are only 'potential' sensitivities because they rely upon a number of assumptions about corporate portfolios that may not be met in the real world. Although the assumptions generally are reasonable, it is also possible that a specific group of real corporations might deviate substantially from these stylized models.

Sensitivity of the related component of the entropy index to pure diversification

The derivation of the related component of the entropy index has been briefly described earlier in the article. Pure diversification—the number of businesses in the corporate portfolio—can influence all of the entropy measures: total, unrelated, and related. The related component of the entropy index is sensitive to three different aspects of the distribution of activity within a corporate portfolio: the number of 4-digit SIC businesses in a corporate portfolio, the number of 2-digit SIC businesses in the portfolio, and the distribution of 4-digit SIC categories within 2-digit SIC categories. The manner in which these different factors interact to determine the value of the related entropy measure may be quite complex.

Total entropy will have a positive relationship to pure diversification, holding everything else constant. This can be seen most readily by considering the case where all businesses in a portfolio are the same size. In that case,

$$P_i = 1/N$$

where N = number of businesses in the portfolio.

$$DT = \sum_{i=1}^{N} P_i \ln(1/P_i) \tag{1}$$

Substituting for P_i, $DT = N(1/N)\ln(N) = \ln(N)$.

Total entropy thus is an increasing logarithmic function of the number of businesses in the portfolio, in the case where all businesses are equal in size.

For simplicity, we can also assume that each 2-digit SIC contains an equal number of 4-digit SICs, = Z. Therefore, the corporation will have N/Z 2-digit SIC divisions, each of which contains a proportion of activity = Z/N. Unrelated entropy

(DU) therefore will be

$$DU = \sum_{k=1}^{N/Z} P_k \ln(1/P_k)$$

Substituting for P_k, $DU = (N/Z)(Z/N)\ln(N/Z) = \ln(N/Z)$
The related component therefore will be

$$DT - DU = \ln(N) - \ln(N/Z)$$
$$= \ln(N) - \ln(N) + \ln(Z) = \ln(Z)$$

In this case, the related component of the entropy index would be a direct logarithmic function of the number of 4-digit SIC businesses within each 2-digit SIC division. If a corporation simply increased the number of 4-digit businesses in its portfolio with no reallocation of activity at the 2-digit level, the related component of entropy would increase. By the same token, a firm with a greater number of smaller 4-digit businesses would register greater relatedness than one with fewer businesses, holding structure at the 2-digit level constant. This type of result also can be expected in many cases where 2-digit SICs are not equal in size and number.[2]

Sensitivity of the concentric index to pure diversification

As indicated by the example of Consolidated Electric above (Figures 1 and 2), pure diversification also may affect the concentric index. A closer look at the derivation of the index can shed some light on that issue as well. As indicated earlier

[2] Since unrelated entropy is calculated in the same fashion as total entropy, it will be an increasing logarithmic function of the number of 2-digit SIC businesses. In the case where all 2-digit SIC businesses are the same size, related entropy is equal to the difference between total and unrelated entropy, and it is therefore affected by both the number of 4-digit SICs and the number of 2-digit SICs in a portfolio. The effect of increase in the number of 4-digit businesses is potentially quite complex, but a few broad observations can be made about its likely direction. Firms often diversify by entering new 4-digit SICs that lie within their existing 2-digit SICs. When that takes place, the number of 4-digit SICs increases more than the number of 2-digit SICs. If the number of 4-digit SICs in a portfolio grows faster than the number of 2-digit SICs in the portfolio, then total entropy also will increase faster than unrelated entropy. This implies that the related entropy index also is likely to grow, since the related component of the entropy index is the difference between total and unrelated entropy. Pure diversification therefore may increase the related component of the entropy index in a broader range of cases, *ceteris paribus*.

in this article, the construction of the concentric index is fundamentally different from the entropy measures. Although the concentric index also was originally derived from measures of industrial concentration, it relies upon pairwise evaluation of relationships between the businesses of a portfolio in order to assess relatedness.

The sensitivity of the concentric index to pure diversification is a function of the distribution of business activity at the 3-digit and 2-digit SIC levels. The number of 4-digit SICs in a corporate portfolio affects the concentric index only inasmuch as the number of 4-digit SICs is correlated with the number of 3-digit or 2-digit SICs. An expansion or contraction of the number of 4-digit SIC businesses within a single 3-digit SIC would have no effect on the concentric index for a firm. However, the number of 3-digit SICs in a corporate portfolio can be expected to have some positive correlation with the number of 4-digit SIC businesses. Under those circumstances, greater pure diversification would affect the concentric index indirectly, through influence on the number of 3-digit SICs.

Increase in the number of 3-digit SICs in a corporate portfolio will raise the value of the concentric index and thus reduce the estimate of related diversification, *ceteris paribus*. This can be seen most easily by again looking at the case where all businesses in a corporate portfolio are the same size. For the sake of simplicity, we can assume that all businesses are identical in size and that there is a perfect correlation between 3-digit and 4-digit SIC activity; i.e., every 4-digit business is in a unique 3-digit SIC. To simplify the case, we can also assume that the firm has only one 2-digit SIC. Variability in the concentric index will be entirely due to the number of businesses in the corporate portfolio under those circumstances. Thus, $d_{il} = 1$ for all pairs of businesses.

As indicated above, the concentric index is based on the set of all pairs of businesses that can be formed from a portfolio. A product term is created by multiplying the proportion of activity in each of the two businesses of a pair together. The products of pairs are weighted (as described earlier in this article), and the summation of the weighted products is the concentric index.

In the case where all businesses are the same size,

$$P_{ki} = P_{kl} = 1/N$$

where N = number of businesses in portfolio.

$$\text{FDIVERS} = \sum_{i=1}^{N}\sum_{k=1}^{N} P_{ki}P_{kl}d_{il} \qquad (2)$$

However, $d_{il} = 1$; therefore

$$\text{FDIVERS} = \sum_{i=1}^{N}\sum_{k=1}^{N} P_{ki}P_{kl}$$

The number of possible pairs of businesses in a portfolio will be

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

Substituting in $P_{ki} = P_{kl} = 1/N$ for all k and l, the concentric index is

$$\text{FDIVERS}_k = \frac{N(N-1)}{2}*\frac{1}{N^2} = \frac{N-1}{N}*\frac{1}{2}$$

As the number of businesses in a firm becomes very large:

$$(N-1)/N \rightarrow 1$$

and

$$\text{FDIVERS} = \frac{N-1}{N}*\frac{1}{2} \rightarrow \frac{1}{2}$$

As N shrinks toward unity:

$$(N-1)/N \rightarrow 0$$

and

$$\text{FDIVERS} = \frac{N-1}{N}*\frac{1}{2} \rightarrow 0$$

The concentric index therefore will be zero for a single business firm and have an upper bound of 1/2 as the number of businesses in a corporate portfolio becomes very large—in the stylized case where all businesses are the same size and all are in different 3-digit SICs. In this case, $d = 1$ for all pairs of businesses due to the assumption that all businesses are in different 3-digit SICs and the same 2-digit SIC. The concentric index

therefore would approach a limit of 0.5 as pure diversification increases in this special case.

The same logic holds for increase in the number of 2-digit SICs, although $d = 2$ for all pairs of businesses in that case, and the concentric index therefore would approach 1.0 with increasing N. The value of concentric index thus may be an increasing function of pure diversification, if the number of 4-digit SIC businesses in the portfolio is correlated with the number of 3-digit or 2-digit SICs. Higher values of the concentric index signify lower levels of related diversification, so the concentric index is likely to measure less related diversification for portfolios with higher levels of pure diversification, under those assumptions.

Sensitivity to dominant business focus

The potential sensitivities of these measures to dominant business focus can be seen in the changes that took place in the Consolidated Electric portfolio between 1993 and 1998. Consolidated Electric undertook a focusing strategy during this period, and the major change in the CE portfolio was an increase in the size of the dominant business. The number of businesses in the portfolio remained unchanged between 1993 and 1998. As indicated above, these changes again produced contradictory results in the concentric index and related component of the entropy index. The concentric index indicated an increase in related diversification, while the related component of entropy indicated a decrease.

The changes in the two measures suggest a basic difference in their sensitivities to dominant business focus. The concentric index appears to be sensitive to focus, with the existence of a large, dominant business raising estimates of relatedness. On the other hand, estimates based on the related entropy index appear to decline with the relative size of the dominant business. A decrease in the entropy estimate of relatedness was associated with an increase in the size of the dominant business rather than a reduction in pure diversification.

A more detailed examination of the construction of the indexes can provide some insight into the possible bases of these sensitivities as well. Again, this analysis must be treated as only hypothetical because it relies upon key assumptions about corporate portfolios that may or may not be relevant to real firms.

Sensitivity of the related component of the entropy index to dominant business focus

A rough analysis of the special case of a firm with a two-business portfolio can provide some insight into the effects of dominant business size on the related component of the entropy index. The two-business case is simple from a mathematical standpoint, and it can be generalized to portfolios that include a larger number of businesses. The two businesses are designated '1' and '2' and their shares in total firm activity P_1 and P_2. Assume that P_1 is the dominant business, i.e., $P_1 > P_2$.

$$P_1 + P_2 = 1$$

Therefore

$$P_2 = (1 - P_1)$$

The index of total entropy for this firm will be

$$\mathrm{DT} = \sum_{i=1}^{N} P_i \ln(1/P_i) = P_1 \ln(1/P_1) + P_2 \ln(1/P_2) \tag{3}$$

Substituting for P_2 in Equation 3, we get

$$\mathrm{DT} = P_1 \ln(1/P_1) + (1 - P_1) \ln[1/(1 - P_1)] \tag{4}$$

We can examine the effects of dominant business size on each of the two terms that compose the total entropy index (Equation 4) for this hypothetical two business firm:

As $P_1 \to 1$, the expression $1/P_1 \to 1$

Therefore

$$\ln(1/P_1) \to 0,$$

and

$$P_1 \ln(1/P_1) \to 0$$

The expression $P_1 \ln(1/P_1)$ is therefore a decreasing function of P_1.

The second term of the entropy measure also will be a decreasing function of P_1, as follows:

As $P_1 \to 1$, the expression $(1 - P_1) \to 0$

and $1/(1 - P_1)$ becomes very large. Therefore $\ln[1/(1 - P_1)]$ also becomes large.

However, as $P_1 \rightarrow 1$, the expression $(1-P_1)$ decreases as a linear function of P_1. The rate of increase of the logarithmic function $\ln[1/(1-P_1)]$ is smaller than the rate of decrease in the linear function $(1-P_1)$. The product of the two, $(1-P_1) * \ln[1/(1-P_1)]$, therefore will also be a decreasing function of P_1.

If both terms of the entropy measure are decreasing functions of P_1, their sum—total entropy—also will be a decreasing function of P_1. Entropy therefore will be greatest for the smallest value of P_1. The minimum value that P_1 can assume for a firm with two businesses is $P_1 = 0.50$, and entropy therefore will be greatest when the business units of a two-business firm are the same size. This result generalizes to portfolios with multiple businesses; entropy can be expected to be greatest where there is the least variation in the size of businesses within a portfolio, i.e., where $P_i = 1/N$ for all businesses, *ceteris paribus*.

Related entropy is the difference between total and unrelated entropy, so it is again necessary to consider the likely relationship between changes in the portfolio at the 4-digit and 2-digit SIC levels. In theory, the proportions of activity within specific 4-digit and 2-digit SICs can vary independently—within the limit that no 4-digit SIC can be larger than the largest 2-digit SIC. However, it is common for firms to have several 4-digit SICs that fall within the same 2-digit SIC and relatively rare for a corporation to be entirely composed of unrelated businesses. This leads to the following observations.

Define the set of n 4-digit SICs subsumed within a single 2-digit SIC, D_m as

$$D_m = \{P_1, P_2 \ldots P_n\}$$

where the 2-digit SIC actually contains more than one business (i.e., $n > 1$), then $D_m > P_i$ by definition.

If P_i increases by some amount q, then the proportional increases in D_m and P_i will be

$$\frac{D_m + q}{D_m} < \frac{P_i + q}{P_i}$$

Increase in the proportion of activity in any one 4-digit SIC business therefore will produce a smaller proportional increase at the 2-digit level,

if the 2-digit SIC contains more than one 4-digit SIC.

This suggests that increase in the size of a dominant business is likely to alter the proportions of activity across 4-digit categories more than it alters the proportions of activity in 2-digit categories. In that case, total entropy would decrease more than unrelated entropy as a result of the change. If DT decreases more than DU, then DR = DT − DU also will decrease. Related entropy therefore would tend to decrease as the size of the dominant business in a portfolio grows, assuming that the 2-digit SICs of a corporate portfolio typically subsume multiple 4-digit SIC businesses.

Sensitivity of the concentric index to dominant business focus

The concentric index also may be sensitive to dominant business focus. The index is affected only by 3-digit and 2-digit SIC distribution of business activity, so dominant business focus again will have an effect only inasmuch as 4-digit SIC business size is correlated with 3-digit or 2-digit SIC size. As indicated in the discussion of the entropy index above, it is reasonable to assume some correlation between the relative magnitudes of corresponding 4-digit and 3-digit SICs. A weaker relationship probably would be found between 4-digit and 2-digit activity in many cases.

Another stylized analysis can help to illustrate the possible effects of dominant business size on the concentric index. Imagine a firm such as Consolidated Electric in 1988, in which all 4-digit SIC businesses fall within two separate 3-digit SICs and one 2-digit SIC. We can designate the two 3-digit SICs T_1 and T_2 and define the sets of 4-digit businesses within those SICs as $T_1 = \{P_1, P_2 \ldots P_n\}$ and $T_2 = \{Q_1, Q_2 \ldots Q_m\}$. The full set of businesses in the corporation would be

$$T_1 \cup T_2 = \{P_1, P_2 \ldots P_n; Q_1, Q_2 \ldots Q_m\}$$

As indicated above, the product terms for all pairs of businesses from within any 3-digit SIC are given the weight $d = 0$ in the concentric index. The effects on the concentric index of pairs of businesses from within 3-digit SICs can thus be ignored. For pairs that cross 3-digit SIC categories,

$d = 1$. In this example, therefore

$$\text{FDIVERS} = [(P_1 + P_2 \ldots + P_n)$$
$$* (Q_1 + Q_2 \ldots + Q_m)] * d$$
$$= \sum_{i=1}^{N} P_i * \Sigma Q_k * 1 \tag{5}$$

However

$$\sum_{i=1}^{N} P_i + \sum_{k=1}^{M} Q_k = 1$$

Therefore

$$\sum_{k=1}^{M} Qk = 1 - \sum_{i=1}^{N} P_i$$

and substituting in Equation 5

$$\text{FDIVERS} = \sum_{i=1}^{N} P_i \left(1 - \sum_{i=1}^{N} P_i\right) \tag{6}$$

Since $T_1 = \sum_{i=1}^{N} P_i$, the concentric index depends entirely on the relative size of the 3-digit SICs in this case. The distribution of activity within the sets of 4-digit SIC businesses $\{P_1, P_2 \ldots P_n\}$ and $\{Q_1, Q_2 \ldots Q_m\}$ has no effect on the index; only the aggregate size of each set (T_i) matters.

The effect of the size of a 3-digit SIC, T_1, on the concentric index can be evaluated in a relatively simple fashion. The concentric index can be expressed as a function of $\sum_{i=1}^{N} P_i = T_1$ as follows:

$$\text{FDIVERS} = \sum_{i=1}^{N} P_i \left(1 - \sum_{i=1}^{N} P_i\right)$$
$$= T_1(1 - T_1) = T_1 - (T_1)^2 \tag{7}$$

Differentiating for the effect of change in T_1

$$\frac{\delta \text{ FDIVERS}}{\delta T_1} = 1 - 2T_1$$

We can solve for the value of T_1 that will maximize FDIVERS by setting the first derivative equal to zero, i.e., $1 - 2T_1 = 0$.

Therefore, $T_1 = 0.50$ will maximize the concentric index, FDIVERS.

The concentric index thus will be largest when the two 3-digit SIC businesses are the same size.

This result generalizes by multivariate analysis to cases where the firm has more than two 3-digit areas of business; the concentric index will assume its largest value where 3-digit SICs are identical in size. The same logic applies to distribution of activity across 2-digit SICs for firms with multiple 2-digit areas of business; the concentric index will be largest where SICs are the same size. Conversely, the concentric index will decrease in magnitude with disproportion among 3-digit or 2-digit areas of business, *ceteris paribus*. Since smaller values of the concentric index denote higher levels of related diversification, we can expect dominant business size to be positively associated with related diversification as measured by the concentric index—assuming some correlation between 4-digit business focus and 3-digit or 2-digit SIC size.

We can see this effect in the comparison between Consolidated Electric's portfolio in 1988 and 1998. The increase in dominant business focus at the 4-digit level increased the relative size of one of the 3-digit SICs from 50 percent to 80 percent of corporate activity. This created an increase in the level of related diversification, as measured by the concentric index.

Uncertainties about the behavior of measures

The arguments above are essentially speculative. They can be shown to apply to the measures under a limited set of stylized conditions; however, it is uncertain whether those conditions approximate the real characteristics of corporations. This uncertainty is compounded by the fact that different factors—such as dominant business focus and pure diversification—are likely to be interrelated in the portfolios of real firms. Since some of these features of portfolio composition can have opposed effects on the measures, the sensitivities of measures to pure diversification and dominant business focus are uncertain in practice.

The uncertainties associated with these assumptions can be readily illustrated. Two additional stylized examples indicate the ways that the generalizations above may break down if assumptions about portfolio composition are not met. Instead of the portfolio in Figure 3, imagine that by 1998 Consolidated Electric had exited the businesses it entered—electric light bulbs (3641), audio records, tapes, and disks (3652), and radio and TV broadcasting equipment (3663)—and diversified

into two new related businesses: household laundry equipment (3633) and electric housewares and fans (3634). The relative sizes of businesses in this example have also changed: power transformers (3612) has grown to be the dominant business with 70 percent of activity, switchgear apparatus (3613) continues to account for 10 percent, while the other four businesses—household cooking equipment (3631); household refrigerators and freezers (3632); household laundry equipment (3633); and electric housewares and fans (3634)—each represent 5 percent of corporate activity in 1998. This alternative scenario for 1998 is illustrated in Figure 4.

The value of the concentric index would be 0.16 for this portfolio, indicating a high level of related diversification. The related component of the entropy index would be 1.07.

If we compare this portfolio to the original firm in 1988 (Figure 1), we see that Consolidated Electric has undergone an increase in the number of businesses from four to seven; however, the entropy estimate of related diversification has decreased from 1.38 to 1.07. Increase in the size of the dominant business appears to have had a negative effect on related entropy

that outweighs the positive effects of increase in number of businesses.

The concentric index, on the other hand, has been consistent in signaling a higher level of related diversification with increase in the relative magnitude of the dominant business. The concentric index for Consolidated Electric in 1988 was 0.25, and it is 0.16 for this portfolio. However, like the related entropy index, the concentric index also cannot be relied upon to be consistent in all cases.

Another possible scenario for Consolidated Electric illustrates the type of uncertainties that may be associated with the concentric index. Instead of shifting toward the very strong dominant business focus between 1993 and 1998 illustrated in Figure 3, Consolidated Electric might have undertaken a more moderate focusing strategy. Power transformers (3612) might have grown to 40 percent of activity, and switchgear apparatus (3613) diminished to 10 percent of corporate activity, while the rest of the firm remained essentially the same as the 1993 portfolio. In that case, Consolidated Electric would have become seven businesses grouped within two 3-digit SICs in 1998. Six of the businesses would have been equal in size, while the seventh would have been a dominant business with 40 percent of all

	1988	1998
Concentric Index of Related Diversification	0.25	0.16
Related Component of the Entropy Index	1.38	1.07

Figure 4. Consolidated Electric 1998

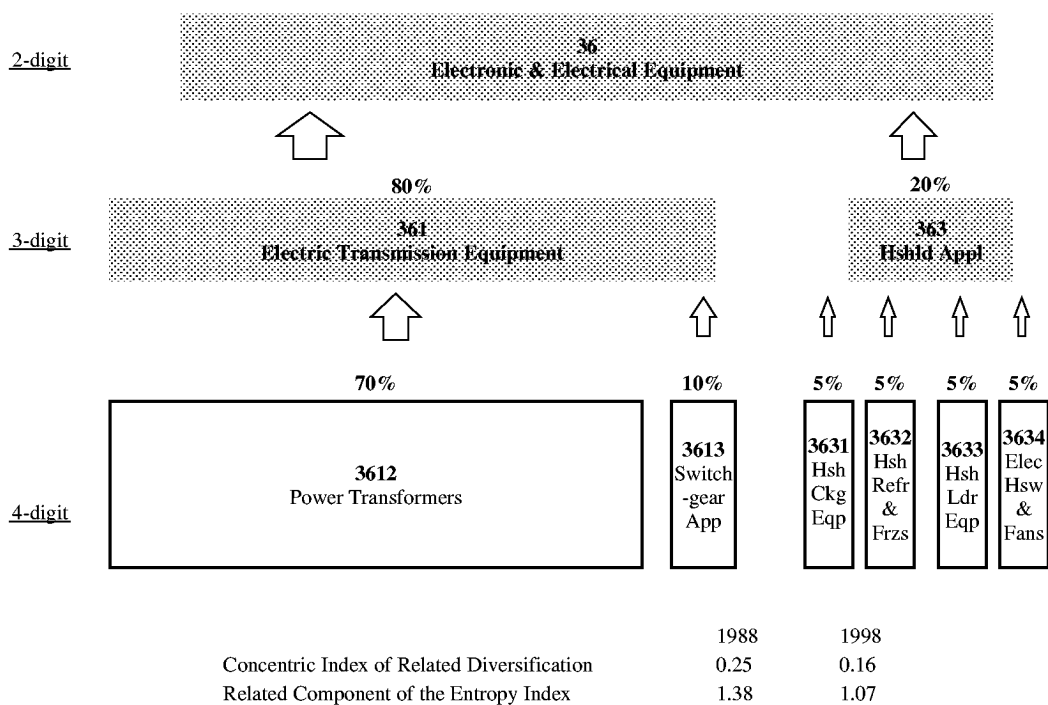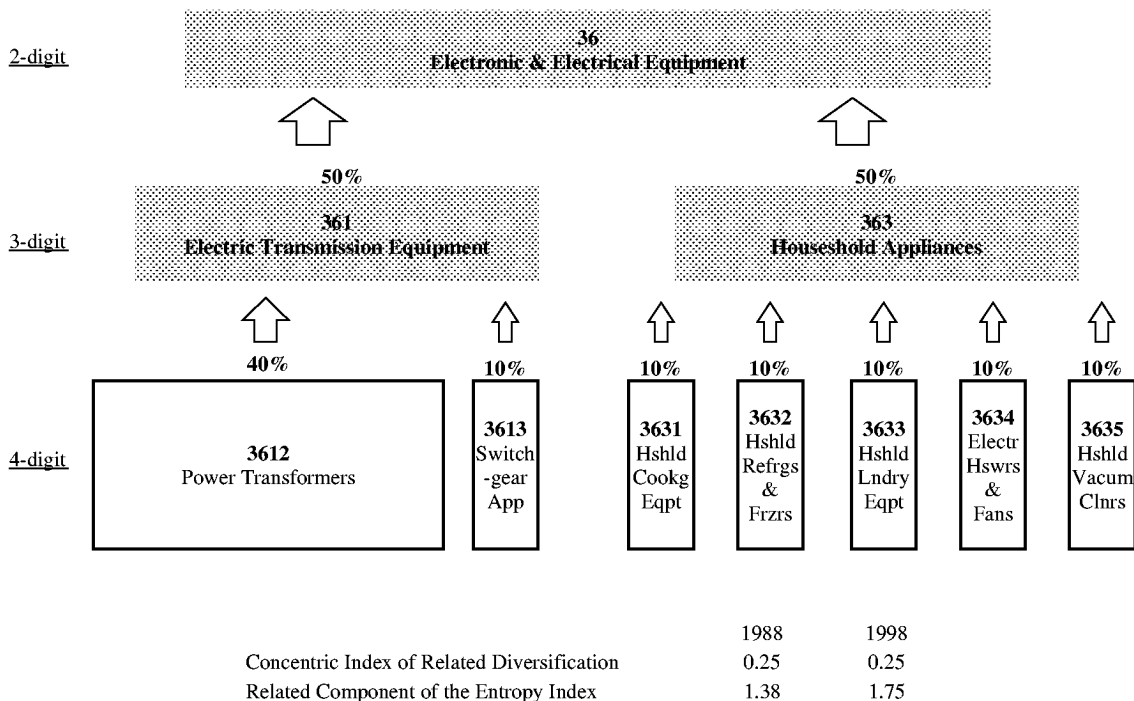|	1988	1998
Concentric Index of Related Diversification	0.25	0.25
Related Component of the Entropy Index	1.38	1.75

Figure 5. Consolidated Electric 1998

corporate activity. This portfolio is illustrated in Figure 5.

The concentric index for this portfolio is 0.25—identical to the original 1988 portfolio. Despite the fact that the firm has shifted from a portfolio with four equal-sized businesses to one that has a 40 percent dominant business, the concentric index estimate of related diversification is the same as the original 1988 level—increased focus has had no effect on the concentric index in this case.

On the other hand, this shift has affected the related component of the entropy index. The related entropy index is 1.75 in this new sce-nario—which represents a substantial increase from the 1988 level of 1.38. An increase in the number of businesses in the portfolio appears to have had a greater effect on related entropy than the shift toward a dominant business in this case, and the entropy index measures an increase in relatedness.

As these examples suggest, it is not possible to determine *ex ante* what sensitivities the measures will exhibit for a given population of firms. The examples and mathematical observations about the construction of measures are suggestive, but they cannot prove that the hypothesized sensitivities

actually will be found in practice. Real firms might be similar to Figures 1–3, or they might have a greater resemblance to Figures 4 and 5. The analysis above suggests reasonable grounds for expecting specific types of sensitivities, but the mathematical explorations cannot actually estab-lish whether those sensitivities exist in practice. It is necessary to carry out empirical analysis of sensitivities using data on the types of firms that researchers in corporate strategy actually study in order to determine whether to anticipate these types of responses from measures in practice.

SENSITIVITY OF MEASURES: EMPIRICAL EVIDENCE

The analysis above leads to a set of straightfor-ward expectations for the related diversification measures. The concentric index can be expected to be positively associated with the size of the dominant business in a corporate portfolio and it may be negatively associated with the number of businesses in the portfolio. Conversely, the related component of the entropy index can be expected to increase with the number of businesses in a firm's portfolio and shrink with dominant business size.

The simplest and most straightforward approach to analyzing whether these expectations are likely to hold up for the types of firms that are typically studied in strategy research is to examine the empirical association between the measures of related diversification and underlying dimensions of portfolio strategy—dominant business focus and pure diversification. If the portfolios of real firms are structured in ways that result in sensitivity to these underlying factors, then the related diversification measures should show significant correlations with dominant business size and number of businesses in a portfolio. These correlations also would provide some indication of the potential power of these underlying factors to explain apparent changes in related diversification.

Data and sample

An analysis of this type was carried out using COMPUSTAT line of business data for the year 1995. A total of 8307 firms were listed with line of business data in COMPUSTAT in 1995. Because diversification measures are not relevant to single business firms, corporations with only one business segment were dropped from the sample, reducing the total to 1707 firms. The majority of studies that use diversification measures to examine corporate strategy focus on very large firms; the sample was refined further to reflect that fact. Firms with sales less than $400 million were removed from the sample, leaving a final sample of 840 firms.

Data on revenues and the distribution of sales within the portfolios of firms were gathered from the COMPUSTAT database. The proportions of firm revenues within 4-digit SICs provided the basis for the weights (P_i) that were used in constructing both the related diversification measures and the measures of pure diversification and dominant business focus.

Variables

As indicated above, pure diversification is defined in terms of the number of businesses or industries in which a firm is active (Jacquemin and Berry, 1979; Pitts and Hopkins, 1982). Pure diversification was operationalized here as the number of 4-digit SIC activities in which a firm was listed as participating by the COMPUSTAT LOB database in 1995. The mean number of 4-digit SIC

industries for the firms in this sample was 3, with a range of 2–10.

Dominant business focus was operationalized as the relative size of the largest business within each corporation's portfolio. Information from COMPUSTAT was used to identify the 4-digit SIC industry that accounted for the greatest proportion of sales for each firm, and dominant business focus was represented as the percentage of total firm sales in the largest 4-digit SIC. The mean size of the largest 4-digit SIC business for the firms in the sample was 64 percent of firm sales, with a range from 20 percent to 95 percent.

Results

Bivariate correlations for the related diversification measures, dominant business size, and number of businesses are presented in Table 1. For clarity in presentation, the concentric index was recoded to reverse its sign. Higher values of concentric index signify greater related diversification in this table, and a positive correlation with the concentric index implies a positive association with related diversification as measured by the index.

As indicated in Table 1, the underlying dimensions of portfolio strategy proved to be significantly associated with both the related component of the entropy index and the concentric index. The sensitivity of the two diversification measures to these features of portfolio strategy differed substantially. Dominant business size was positively linked to related diversification as measured by the concentric index ($r = 0.73$), and it had a negative effect on the entropy measure of related diversification ($r = -0.42$). The associations are reversed for pure diversification; the number of businesses

Table 1. Correlation of related diversification measures with dominant business size and number of businesses

	Related component of entropy index	Concentric index
Size of dominant business	−0.42***	0.73***
Number of businesses	0.35***	−0.49***

$n = 840$; $p < 0.001$

in a portfolio is positively linked to the entropy measure of related diversification ($r = 0.35$), and has a negative effect on the concentric index ($r = -0.49$).

These empirical results suggest that the related diversification measures are likely to exhibit sensitivities similar to the hypothetical examples above when they are used for research on large diversified corporations. As indicated, these sensitivities may differ among different populations of firms. However, they appear to be important for the types of firms most commonly examined in empirical research on corporate strategy.

IMPLICATIONS FOR RESEARCH

These features of the diversification measures have important implications for interpretation and design of research on corporate strategy. The analysis above suggests that a researcher can expect significant differences in the content of the related entropy and concentric indexes. The measures appear to be driven in differing degrees by pure diversification and dominant business focus—and neither index necessarily measures portfolio relatedness. This raises important questions about the meaning of research that employs these measures. The ambiguity that these measures introduce into the interpretation of research can be most readily seen by examining some of the classic studies in corporate strategy that have relied upon the concentric index or related entropy measure.

Table 2 summarizes a group of seminal studies that used either the concentric index or the related component of the entropy index to analyze corporate strategy. The interpretations of findings offered by the original authors were based

Table 2. Empirical studies utilizing the concentric index and related component of the entropy index

Study	Research issue	Construct and measure	Findings
Montgomery and Wernerfelt (1988)	Diversification and performance Firms' diversity in response to excess capacity of factors. Firms that elect to diversify most widely should expect the lowest average rents	Construct: diversification described as wide (less similar) vs. narrow (more similar) Measure: concentric index	As firms diversify widely their returns decline
Wernerfelt and Montgomery (1988)	Are widely diversified (less-focused) firms less able to transfer their competencies to different markets? Does a firm's return decrease as they diversify further afield?	Construct: firm focus Described as wide vs. narrow diversification Measure: concentric index	More focused (narrow diversified) firms outperform less focused firms
Palepu (1985)	Examines diversification-performance relationships distinguishing between related and unrelated diversification. Hypothesizes that related will outperform unrelated	Construct: related vs. unrelated diversification Measure: related component of the entropy index	Firms with related diversification (related entropy) outperform firms with unrelated diversification (unrelated entropy)
Jacquemin and Berry (1979)	Relative comparison of entropy and concentric measures of diversification Analyzes growth rates by related vs. unrelated diversification	Construct: diversification—related vs. unrelated Measure: related component of the entropy index	Firms pursuing related diversification have higher growth rates than firms pursuing unrelated diversification

on the assumption that the concentric and related entropy measures provided valid indicators of related diversification. However, the influence of dominant business focus or pure diversification offer a variety of alternative explanations for the research findings. The empirical evidence presented in the original studies does not provide a basis for discriminating among these competing interpretations.

Interpretation of research with the concentric index

The studies by Montgomery and Wernerfelt (Table 2) broke new ground in linking corporate portfolio strategy to success in financial markets, and they are among the most influential works on diversification and firm performance. These studies represented an important response to the debate over 'defensive diversification' among researchers in strategic management. They continue to influence research in the fields of strategy, financial economics, and industrial-organization economics (Berger and Ofek, 1995; Comment and Jarrell, 1995; Davis and Thomas, 1993; Lang and Stulz, 1994).

The most important finding reported in these papers was that firms with wider (less related) diversification perform less well than firms with more related portfolios. This finding raised serious questions about the idea that diversification commonly represents a move from less attractive to more attractive industries, and it was hailed as empirical evidence that portfolio 'relatedness' has a key role in diversification. It has been widely cited in subsequent strategy research dealing with diversification, and questions raised by these studies about portfolio composition and market performance have been influential in the field of finance as well.

However, a variety of alternative explanations are plausible when we consider the fact that the concentric index can be driven by dominant business focus rather than related diversification. For example, the differences in firm performance observed by Montgomery and Wernerfelt might be based on market power. Firms with large dominant businesses may, on average, have greater market power in their core industries and enjoy higher performance as a consequence. Signaling effects offer another plausible explanation. Corporations with large dominant businesses may have

greater visibility within the investment community, and the superior market performance observed by Montgomery and Wernerfelt might be driven by information or signaling effects.

An explanation that reverses causality also is possible. Firms with a strong history of performance in dominant businesses may have had less incentive to invest resources in new businesses. This could be true regardless of whether the foregone diversification opportunities might have resulted in wide diversification into a number of new areas or narrower investment in related areas.

Montgomery and Wernerfelt's empirical findings do not provide a basis for choosing among these competing explanations. Different research designs employing different variables and different data would have been required in order to address many of these issues. These ambiguities raise important questions about content validity in the substantial body of subsequent research that has relied upon Montgomery and Wernerfelt's findings.

Interpretation of research with the related component of the entropy index

Similar problems can be seen in interpretation of research that has used the related component of the entropy index. The two studies that played the greatest role in introducing the measure into strategy research are Jacquemin and Berry's (1979) seminal work on diversification and Palepu's (1985) study of diversification and performance. Jacquemin and Berry (1979) pioneered the decomposition of the index into components representing related and unrelated diversification and provided an important early empirical statement about the implications of related diversification for firm growth. Palepu's (1985) work served to popularize the related component of the entropy index in strategy research, and it is one of the most widely cited studies of the link between related diversification and performance.

Jacquemin and Berry (1979) found a broad association between related diversification—measured as the related component of the entropy index—and firm growth. This was interpreted as evidence for the impact of related diversification on firm performance. However, the interpretation of the related component of the entropy index as a measure of relatedness raises important questions about

the findings. The sensitivity of the related component to pure diversification opens the possibility that a firm may have a higher level of related entropy solely because it has a greater number of businesses within the corporate portfolio. We would expect to see an association between related entropy and growth if the firms in Jacquemin and Berry's (1979) sample typically grew by entering new businesses. The observed link between related entropy and firm growth may simply indicate a pattern of growth through new business formation or acquisition.

The link found by Palepu (1985) between the related component of the entropy index and firm performance also may indicate the effects of pure diversification rather than relatedness. Higher levels of related entropy may be driven by larger portfolios. In that case, the association between related entropy and performance might simply indicate that higher performing firms are expanding more rapidly.

One of the most striking problems introduced by the ambiguity of these indexes is the fact that findings which previously appeared to support the same position may actually contradict each other. These studies of related diversification and performance are a case in point. The findings by Montgomery and Wernerfelt (1988) or Wernerfelt and Montgomery (1988) might actually stand in direct opposition to Palepu's (1985) work. Palepu's (1985) study may have documented a positive relationship between pure diversification and performance, while the Montgomery and Wernerfelt (1988) study may indicate that firms with activity concentrated in a dominant business outperform firms with more diversified portfolios. We cannot determine whether or not this contradiction exists because problems of content validity make it difficult to support a definite interpretation. Uncertainties about the measures give rise to these ambiguities in interpretation of the research.

This is the type of validity problem that Blalock (1985) signals in his discussions of the 'auxiliary theories' that link measures to concepts. The auxiliary theories that define the concentric and related entropy indexes as measures of related diversification exhibit basic weaknesses. The logic linking measure and concept is tenuous, and we can find empirical evidence that supports plausible alternative theories about the content of the measures.

Implications for research design

The validity problems associated with these measures pose important challenges to students of strategic management. As noted above, measures of relatedness have come to play a vital part in research on a wide variety of topics in strategic management, financial economics, and industrial-organization economics. The fact that the most widely used indicators of related diversification cannot be treated as reliable measures of 'relatedness' within corporate portfolios creates a real dilemma for researchers.

It may be important for researchers to test the sensitivity of findings to underlying dimensions of portfolio strategy such as dominant business focus and pure diversification in studies where ambiguities in the meaning of measures have significant implications for the interpretation of results. And it also is important for researchers to recognize that the selection of a measure of related diversification may play a role in research design. Measures vary in their suitability for specific research problems, and both the related entropy and concentric indexes must be used with caution.

Sensitivity testing

Researchers sometimes face situations in which theory is equivocal about elements of portfolio strategy such as focus and diversification. For example, firms may respond to certain types of economic pressures by either expanding their portfolios or focusing, and researchers may be interested in the conditions that differentiate the two types of responses (Kochhar and Hitt, 1998; Lane, Cannella, and Lubatkin, 1998). A prudent approach to research design under those circumstances might involve testing whether findings based on the use of either the related entropy or concentric measures are also significantly affected by dominant business focus or pure portfolio diversification. Sensitivity testing may help researchers evaluate the validity of findings, and it may inform decisions about model specification.

Selection of measures

The selection of measures is another area in which strategy research can benefit from greater attention to the content validity of diversification indexes. The importance of pure diversification and dominant business focus may vary for different research

topics, and the choice of a related diversification measure has the potential to influence the outcome of research.

The observations above suggest that the related component of the entropy index may be preferable in situations where sensitivity to dominant business focus could affect the substantive interpretation of research. Conversely, the concentric index may be more suitable if pure diversification has the potential to produce confounding results. Measure selection cannot serve as a substitute for sensitivity testing and caution in the interpretation of findings, but it may contribute to the validity of individual studies and improve consistency of results across studies.

CONCLUSION

The content validity of the related entropy and concentric measures has serious implications for strategy research. Although questions about content validity have been largely neglected by researchers, content validity reaches to the core of empirical work in strategy. The measures of related diversification analyzed in this paper are mainstays of strategy research, but their empirical content remains little understood and even less discussed. The analysis presented here indicates that the measures can be expected to behave in different ways, and that links between the measures and the concept of portfolio 'relatedness' are uncertain. Those ambiguities may have important consequences for the interpretation of prior research and the design of future studies. Explicit consideration of these issues may help researchers understand why past research has been equivocal on many key issues of corporate strategy, and it may provide a means of achieving stronger and more valid empirical findings in the future. It may also guide the continuing efforts of researchers to develop new approaches to measurement of corporate portfolio composition that can improve the validity of research on strategy.

REFERENCES

Acar W, Sankaran K. 1999. The myth of the unique decomposability: specializing the Herfindahl and Entropy measures. *Strategic Management Journal* **20**(10): 969–976.

Barker V, Duhaime I. 1997. Strategic change in the turnaround process: theory and empirical evidence. *Strategic Management Journal* **18**(1): 13–38.
Barney J. 1988. Returns to bidding firms in mergers and acquisitions: reconsidering the relatedness hypothesis. *Strategic Management Journal*, Summer Special Issue **9**: 71–78.
Berger P, Ofek E. 1995. Diversification's effect on firm value. *Journal of Financial Economics* **37**: 39–65.
Bergh D. 1997. Predicting divestiture of unrelated acquisitions: an integrative model of ex ante conditions. *Strategic Management Journal* **18**(9): 715–731.
Bergh D, Holbein G. 1997. Assessment and redirection of longitudinal analysis: demonstration with a study of the diversification and divestiture relationship. *Strategic Management Journal* **18**(7): 557–571.
Bethel JE, Liebeskind JP. 1998. Diversification and the legal organization of the firm. *Organization Science* **9**(1): 49–67.
Bettis R. 1981. Performance differences in related and unrelated diversified firms. *Strategic Management Journal* **2**(4): 379–393.
Blalock HM. 1982. *Conceptualization and Measurement in the Social Sciences*. Sage: Beverly Hills, CA.
Blalock HM. 1985. *Measurement in the Social Sciences: Theories and Strategies*. Aldine: Chicago, IL.
Brush TH. 1996. Predicted change in operational synergy and post-acquisition performance of acquired businesses. *Strategic Management Journal* **17**(1): 1–24.
Chandler AD Jr. 1962. *Strategy and Structure*. MIT Press: Cambridge, MA.
Chatterjee S, Bloucher JD. 1992. Measurement of firm diversification: Is it robust? *Academy of Management Journal* **35**(4): 874–888.
Collis DJ, Montgomery CA. 1998. Creating corporate advantage. *Harvard Business Review* **76**(3): 70–83.
Comment R, Jarrell G. 1995. Corporate focus and stock returns. *Journal of Financial Economics* **37**: 67–87.
Davis R, Duhaime I. 1992. Diversification, vertical integration, and industry analysis: new perspectives and measurement. *Strategic Management Journal* **13**(7): 511–524.
Davis R, Thomas LG. 1993. Direct estimation of synergy: a new approach to the diversity–performance debate. *Management Science* **39**(11): 1334–1346.
Fan J, Lang L. 2000. The measurement of relatedness: an application to corporate diversification. *Journal of Business* **73**(4): 629–660.
Farjoun M. 1994. Beyond industry boundaries: human expertise, diversification and resource-related industry group. *Organization Science* **5**(2): 185–199.
Farjoun M. 1998. The independent and joint effects of the skill and physical bases of relatedness in diversification. *Strategic Management Journal* **19**(7): 611–630.
Grant RM. 1996. Toward a knowledge-based theory of the firm. *Strategic Management Journal*, Winter Special Issue **17**: 109–122.

Hall EH Jr, St John CH. 1994. A methodological note on diversity measurement. *Strategic Management Journal* **15**(2): 153–168.

Hoskisson RE, Hitt MA. 1990. Antecedents and performance outcomes of diversification: a review and critique of theoretical perspectives. *Journal of Management* **16**(2): 461–509.

Hoskisson RE, Hitt MA, Johnson RA, Moesel DD. 1993. Construct validity of an objective (entropy) categorical measure of diversification strategy. *Strategic Management Journal* **14**(3): 215–235.

Jacquemin AP, Berry CH. 1979. Entropy measure of diversification and corporate growth. *Journal of Industrial Economics* **27**: 359–369.

Kochhar R, Hitt MA. 1998. Linking corporate strategy to capital structure: diversification strategy, type and source of financing. *Strategic Management Journal* **19**(6): 601–610.

Kogut B, Zander U. 1996. What firms do? Coordination, identity, and learning. *Organization Science* **7**(5): 502–518.

Lane PJ, Cannella AA Jr, Lubatkin MH. 1998. Agency problems as antecedents to unrelated mergers and diversification: Amihud and Lev reconsidered. *Strategic Management Journal* **19**(6): 555–578.

Lang L, Stulz R. 1994. Tobin's q, corporate diversification, and firm performance. *Journal of Political Economy* **102**(6): 1248–1280.

Lubatkin M, Merchant H, Srinivasan N. 1993. Construct validity of some unweighted product-count diversification measures. *Strategic Management Journal* **14**(6): 433–449.

Mahoney JT, Pandian JR. 1992. The resource-based view within the conversation of strategic management. *Strategic Management Journal* **13**(5): 363–380.

Markides C. 1992. Consequences of corporate refocusing: ex ante evidence. *Academy of Management Journal* **35**(2): 398–412.

Montgomery CA, Hariharan S. 1991. Diversified expansion by large established firms. *Journal of Economic Behavior* **15**(1): 71–89.

Montgomery C, Wernerfelt B. 1988. Diversification, Ricardian Rents, and Tobin's q. *Rand Journal of Economics* **19**(4): 623–633.

Nayyar PR. 1992. On the measurement of corporate diversification strategy: evidence from large U.S. service firms. *Strategic Management Journal* **13**(3): 219–235.

Nunnally JC. 1978. *Psychometric Theory*. McGraw-Hill: New York.

Palepu K. 1985. Diversification strategy, profit performance and the entropy measure. *Strategic Management Journal* **6**(3): 239–255.

Palich LE, Cardinal LB, Miller CC. 2000. Curvilinearity in the diversification–performance linkage: an examination of over three decades of research. *Strategic Management Journal* **21**(2): 155–174.

Panzar J, Willig R. 1981. Economies of scope. *American Economic Review* **71**(2): 268–273.

Penrose E. 1959. *The Theory of the Growth of the Firm*. Wiley: New York.

Pitts RA, Hopkins HD. 1982. Firm diversity, conceptualization and measurement. *Academy of Management Review* **7**: 620–629.

Rajan R, Servaes H, Zingales L. 2000. The cost of diversity: the diversification discount and inefficient investment. *Journal of Finance* **55**(1): 35–80.

Robins J, Wiersema MF. 1995. A resource-based approach to the multi-business firm: empirical analysis of portfolio interrelationships and corporate financial performance. *Strategic Management Journal* **16**(4): 277–299.

Rumelt RP. 1974. *Strategy, Structure, and Economic Performance*. Harvard University Press: Cambridge, MA.

Rumelt R. 1982. Diversification strategy and profitability. *Strategic Management Journal* **3**(4): 359–369.

Russell B. 1948. *Human Knowledge: Its Scope and Limits*. Routledge: London.

Scharfstein DS, Stein J. 2000. The dark side of internal capital markets: divisional rent-seeking and inefficient investment. *Journal of Finance* **55**(6): 2537–2564.

Servaes H. 1996. The value of diversification during the conglomerate merger wave. *Journal of Finance* **51**: 1201–1225.

Shin H, Stulz RM. 1998. Are internal capital markets efficient? *Quarterly Journal of Economics* **113**(2): 531–552.

Stinchcombe AL. 1968. *Constructing Social Theories*. Harcourt, Brace & World: New York.

Teece DJ. 1982. Towards an economic theory of the multiproduct firm. *Journal of Economic Behavior and Organization* **3**: 39–63.

Varadarajan P. 1986. Product diversity and firm performance: an empirical investigation. *Journal of Marketing* **50**(3): 43–57.

Venkatraman N, Grant JH. 1986. Construct measurement in organizational strategy research: a critique and proposal. *Academy of Management Review* **11**: 71–87.

Wernerfelt B, Montgomery C. 1988. Tobin's q and the importance of focus in firm performance. *American Economic Review* **78**(1): 246–250.

Wiersema MF, Bantel K. 1992. Top management team demography and corporate strategic change. *Academy of Management Journal* **35**(1): 81–121.

Wrigley L. 1970. Divisional autonomy and diversification. Doctoral dissertation, Harvard Business School.

Wunsch G. 1988. *Causal Theory and Causal Modeling*. Leuven University Press: Leuven.

Zeller RA, Carmines EG. 1980. *Measurement in the Social Sciences: The Link between Theory and Data*. Cambridge University Press: Cambridge, UK.