A SET-THEORETIC APPROACH TO

ORGANIZATIONAL CONFIGURATIONS*

PEER C. FISS

Queen's School of Business

143 Union Street

Kingston, ON, Canada K7L 3N6

phone: (613) 533 6797

fax: (613) 533 2325

fiss@business.queensu.ca

A SET-THEORETIC APPROACH TO

ORGANIZATIONAL CONFIGURATIONS*

ABSTRACT

I argue that research on organizational configurations has been limited by a mismatch between theory and methods. While configurational theory stresses nonlinearity, synergistic effects, and equifinality, empirical research has largely drawn on methods that assume linearity, additive effects, and unifinality. I introduce set-theoretic methods as a viable alternative for overcoming this mismatch. Set-theoretic methods conceptualize cases as combinations of attributes and use Boolean algebra to derive simplified expressions of combinations that lead to a specific outcome. I demonstrate the value of such methods for studying organizational configurations and discuss their applicability for examining equifinality and limited diversity among configurations, as well as their relevance to other research fields such as complementarities theory, complexity theory, and the resource-based view.

The study of organizational configurations, broadly defined as "any multidimensional constellation of conceptually distinct characteristics that commonly occur together" (Meyer, Tsui & Hinings, 1993: 1175), has occupied an important and central role in both organization theory and strategy research (e.g. Bensaou & Venkatraman, 1995; Dess & Davis, 1984; Doty & Glick, 1994; Hambrick, 1984; Ketchen et al., 1997; Miller, 1986; Miller & Friesen, 1984; Mintzberg, 1979, 1980). In essence, a configurational approach suggests that organizations are best understood as clusters of interconnected structures and practices rather than as modular or loosely coupled entities whose components can be understood in isolation. Configurational analysis thus takes a systemic and holistic view of organizations, where patterns or profiles rather than individual independent variables are related to an outcome such as performance (Delery & Doty, 1996). Due to its multidimensional nature, the configurational approach is particularly relevant to the study of strategic management (Amburgey & Dacin, 1994; Dyas & Thanheiser, 1976; Inkpen & Choudhury, 1995; Ketchen, Thomas & Snow, 1993; Miller, 1996). A core theme of strategy concerns how firms can achieve a match between structures, activities, and the environment, suggesting that configuration itself is the very essence of strategy (cf. Miller, 1996). Likewise, different typologies of configurations, such as those suggested by Miles and Snow (1978), Mintzberg (1983), and Porter (1980), have occupied a central place in the strategy literature.

While a configurational approach presents a very attractive perspective, the progress of empirical research has been less than satisfying. To establish and measure configuration membership, authors have used a variety of clustering algorithms (e.g. Bensaou & Venkatraman, 1995; Cool & Schendel, 1987; Fiegenbaum & Thomas, 1990;

Hambrick, 1983; Ketchen et al., 1993), interaction effects (Baker & Cullen, 1993; Dess, Lumpkin & Covin, 1997), and deviation score approaches (Delery & Doty, 1996; Drazin & Van de Ven, 1985) to identify configurations and their effects, typically on performance as the key outcome variable. However, evidence on the relationship between configurations and performance has been equivocal. While some reviews of previous studies cast doubt the existence of such a relationship (Barney & Hoskisson, 1990; Thomas & Venkatraman, 1988), a meta-analysis of configurational studies by Ketchen et al. (1997) nevertheless suggests that configuration membership does predict performance. Other research has proposed that the inability to find a reliable link between configurations and performance may be due to insufficient statistical power in previous studies (Ferguson & Ketchen, 1999). In reviewing these results, Delery & Doty (1996) conclude that while the configurational approach holds promise, additional testing is necessary to validate the efficacy of a configurational perspective.

In this paper, I suggest that many of the problems of empirical research on organizational configurations derive from a mismatch between methods and theory. In terms of its theory, configurational theory suggests a clean break with the predominant linear paradigm. Rather than implying singular causation and linear relationships, a configurational approach assumes complex causality and non-linear relationships where "variables found to be causally related in one configuration may be unrelated or even inversely related in another" (Meyer et al., 1993: 1178). As a result, relationships between variables need not be symmetric (Black & Boal, 1994) and tend to involve synergistic effects that go beyond traditional bivariate interaction effects (Delery & Doty, 1996). Furthermore, configurational analysis stresses the concept of *equifinality*, which

4

refs to a situation where "a system can reach the same final state, from different initial conditions and by a variety of different paths" (Katz & Kahn, 1978: 30). While unifinality assumes that there exists one optimal configuration, equifinality assumes that two or more organizational configurations can be equally effective in achieving e.g. high performance, even if they are faced with the same contingencies (Galunic & Eisenhardt, 1994; Gresov & Drazin, 1997). However, these theoretical ideas have not been well translated into empirical models. For one thing, the suggestion that there are frequently multiple paths to an outcome stands in contrast to conventional methods of multivariate regression analysis which estimate a single path for all cases under examination. Similarly, the use of cluster analysis and deviation scores to detect distinct groups of firms may often not allow the researcher to examine just *how* different design elements work together (Whittington, Pettigrew, Peck, Fenton & Conyon, 1999).

The primary purpose of this paper is to offer a fresh view of these methodological issues by introducing set-theoretic methods for studying cases as configurations. Set-theoretic methods are uniquely suitable for configurational theory as such methods explicitly conceptualize cases as *combinations* of attributes and emphasize that it is these very combinations that give cases their unique nature (Ragin, 1987, 2000). As such, set-theoretic methods differ from conventional, variable-based approaches in that they do not disaggregate cases into independent, analytically separate aspects but instead *treat configurations as different types of cases*. To examine these different configurations of attributes, set-theoretic methods use Boolean algebra, a notational system that permits the algebraic manipulation of logical statements. Such an approach in many ways offers a better fit with a configurational understanding of organizations and also allows for a

sophisticated assessment of just how different causes combine to affect relevant outcomes such as performance. Furthermore, set-theoretic methods contribute to theory-building by providing a rigorous way for combining verbal statements with logical relationships that differs from the conventional correlational view, allowing for the expression of complex causal relations in ways that generate new insights for organizational theory and strategy research. While I focus here mainly on the field of organizational configurations, I also expand the discussion to the implications of set-theoretic methods for a number of other research areas, including theories of complementarities, complexity, the field of human resource management, and the resource-based view.

THE MISMATCH BETWEEN CONFIGURATIONAL THEORY AND METHODS

Configurational approaches to organization are based on the fundamental premise that patterns of attributes will exhibit different features and lead to different outcomes depending on how they are arranged. But while theoretical discussions of configurational theory thus stress nonlinearity, synergistic effects, and equifinality, empirical research has so far largely drawn on econometric methods that by their very nature tend to imply linearity, additive effects, and unifinality. This mismatch has caused problems. For example, the classic linear regression model treats variables as competing in explaining variation in outcomes, rather than showing how variables combine to create outcomes. By focusing on the relative importance of rival variables, a correlational approach has difficulties treating cases as configurations and examining combinations of variables. This becomes particularly evident in the fact that regression analysis focuses on the

6

unique contribution of a variable while holding the values of all other variables in the equation constant. Holding other values constant, of course, stands in direct opposition to the fundamental assumption of a configurational approach, namely that it is the presence or absence of particular other factors that gives a variable meaning or not. In other words, a correlational approach can answer with precision questions relating to the average, net effect of a variable on an outcome; it is much less adept at answering under what specific conditions a variable influences an outcome.

Interaction effects are one attempt to overcome this characteristic of regression analysis, and both two- and three-way interactions have thus been used to study organizational configurations (e.g. Baker & Cullen, 1993; Dess et al., 1997; Miller, 1988). However, interactions that go beyond two-way effects are exceedingly difficult to interpret. Theoretically, there is no reason why configurations should be limited to three variables only, but empirically three-way interactions currently represent the boundaries of interpretable regression analysis, and questions about their interpretation and stability persist (c.f. Dess et al., 1997; Drazin & Van de Ven, 1985; Ganzach, 1998).

The situation becomes even more challenging when we turn to the issue of equifinality. Standard regression methods are essentially unable to take equifinality into account (Van de Ven & Drazin, 1985). While interaction effects aim to estimate non-linear relationships, they nevertheless assume that this relationship is relevant for all cases under examination, thus contrasting with the idea of different paths to the same outcome. As a result, equifinality remains an underdeveloped construct (Gresov & Drazin, 1997).

To overcome some of the limitations of regression analysis for studying configurations, a number of studies have instead employed cluster analysis (e.g. Bensaou & Venkatraman, 1995; Cool & Schendel, 1987; Dess & Davis, 1984; Fiegenbaum & Thomas, 1990; Hambrick, 1983; Ketchen et al., 1993). Typically, these studies use clustering algorithms to identify distinct groups of firms and then employ ANOVA or MANOVA to examine whether the distinct groups show differences in their performance. Clustering is attractive for studying configurations because it provides an established technique for discovering cases that are similar to each other along a variety of characteristics. However, cluster analysis also has a number of known limitations. For example, cluster analysis tends to treat each configuration as a black box insofar as only differences between constellations of variables can be detected (Whittington et al., 1999). The grouping analysis does not extend to the contribution of individual elements to the whole or to an understanding of just how these elements combine to achieve the outcome. It is usually assumed that the presence of a component in some way contributes to the outcome, but whether this is actually the case is largely impossible to establish. This is a considerable issue, since it makes cluster analysis insensitive to the fact that cases may be very similar regarding a few causally important characteristics, but may be different along a number of other characteristics that are irrelevant for this configuration. While such cases causally and analytically belong to the same configuration, cluster analysis would usually place them in different clusters because they differ on many, albeit irrelevant characteristics. Consequently, empirical groupings often do not reflect causal relations.

Furthermore, cluster-analytic methods have been criticized for their extensive reliance on researcher judgment (e.g. Ketchen & Shook, 1996). For example, the choice of a stopping rule which determines the cutoff point for clustering is largely at the discretion of the investigator. Since the number of clusters usually affects subsequent findings, this is a considerable concern. While previous studies have compared the results of different clustering algorithms, the basic issue remains that cluster analysis will always result in some clustering and there is not test statistic to guide the analysis. Results also strongly depend on the selection of the sample and variables, the scaling of the variables, and the choice of the similarity measure and clustering method (Ketchen & Shook, 1996; Ragin, 2000). As a result, cluster solutions for organizational configurations are often highly instable and their interpretation is frequently difficult (Miller 1996). Overall, these issues suggest that clustering may not be a promising path for studying how configurations combine to create outcomes (Barney & Hoskisson, 1990; Wiggins & Ruefli, 1995).

A final method that has been suggested for studying organizational configurations is the use of deviation scores (Delery & Doty, 1996; Drazin & Van de Ven, 1985). Here, the researcher theoretically defines an ideal type and then creates an empirical profile for this configuration. The researcher then calculates deviation scores that give the difference between these "ideal" profiles and the empirical profiles of organizations in the sample. Deviation scores can then be used to test hypotheses about the fit between profiles and how it affects e.g. performance, since greater deviation from the ideal profile should result in lower performance. While this approach is more theoretically rigorous than cluster analysis, it still raises similar challenges. By relying on a fit measure based

on a multidimensional profile, a deviation score approach allows the researcher only limited peeks into the black box of configurations. It often remains unclear which aspect of the misfit actually affects the outcome in question, as standard methods are not well suited to teasing apart the causal relations between different characteristics forming the profile. Furthermore, like cluster membership, deviation scores to a large extend depend on just how the "ideal" profile is initially defined. While theoretical guidance is of great importance here, previous studies have tended to define the ideal configuration using the empirically derived mean scores of their profiles (Drazin & Van de Ven, 1985) or by using plus or minus one standard deviation from the mean (e.g. Delery & Doty, 1996). Such approaches are again sample-dependent, and ideal types thus largely depend on just how the sample is composed, rather than on substantive theory about what an ideal configuration means and what makes it ideal. Furthermore, the obtained results may be quite sensitive to even minor errors in estimating the "ideal" configurations, and the reliability of deviation scores will often be very low because it is the product of the reliability of the original variables (Gupta & Govindarajan, 1993).

While a configurational approach thus seems to hold much promise for both organization theory and strategic management, the disconnect between configurational theory and empirical methods remains a significant hindrance to the further development of this approach. However, there is an alternative methodology available in the form of set-theoretic methods for studying causal complexity. These methods are premised on the idea that different conditions *combine* rather than compete with each other in creating an outcome, and that there may be different combinations of conditions that lead to the

same outcome, thus making them well-suited for studying configurations and equifinality.

A SET-THEORETIC APPROACH TO ORGANIZATIONAL CONFIGURATIONS

Instead of using either interaction effects, clustering algorithms, or deviation scores, a set-theoretical approach uses Boolean algebra to determine which combinations of organizational characteristics combine to result in the outcome in question (Boswell & Brown, 1999; Ragin, 1987, 2000). At the center of set-theoretical approaches lies the idea that relationships between different variables are often best understood in terms of *set membership*. Consider the simple case that A is a member in the set Z (formally: $A \subset Z$). For purposes of analyzing organizational configurations, let A be a firm with an efficient production system and Z the set of firms with high financial performance. Thus the statement that firms with an efficient production system tend to exhibit high performance may be restated as saying that such firms form a subset of high-performing firms.

At the same time, the overlap between both sets need not be absolute. For example, consider B, the set of firms with a high rate of product innovation. This characteristic may also result in high financial performance, thus making firms that rapidly innovate another subset of high-performing firms (formally: $B \subset Z$). Yet there may in fact be little overlap between the two subsets A and B; one can easily imagine a situation where an efficient production system and a high rate of product innovation may inhibit or even preclude each other, thus making both A and B non-overlapping subsets of Z. This may be expressed in the following logical statement:

11

$$A + B \rightarrow Z \qquad\qquad (1)$$

where "+" denotes the logical operator *or* while "→" denotes the logical implication

operator, as in "A or B implies Z." Both A and B thus present viable ways of attaining

high financial performance, yet the design features involved in attaining that outcome

may be quite different.

Now consider a somewhat more contingent statement: firms that exhibit an

efficient production system (A) will be high-performing *if* their environments are not

heterogeneous (~C). In logical terms, this statement may be expressed as follows:

$$A \cdot \sim C \rightarrow Z \qquad\qquad (2)$$

where "•" denotes the logical operator *and* while "~" denotes the logical *not*. In essence,

the above statement presents a set-theoretic reformulation of a classic contingency

hypothesis. Now let us extend the above by introducing another statement, namely that

firms with a high rate of product innovation (B) will be high-performing if they also

exhibit hierarchical control structures (D).[1] Combining this statement with the statement

(2) from above results in the following statement:

$$A \cdot \sim C + B \cdot D \rightarrow Z \qquad\qquad (3)$$

The Boolean statement above thus elegantly summarizes two contingency statements (or hypotheses) about the relationship of organizational characteristics, the nature of the environment, and firm performance.

To further understand a set-theoretic approach, let us now consider in more detail the nature of the set-subset relationships. Such relationships may be better understood in terms of necessity and sufficiency (Ragin, 1987), which describe the ability to generalize from a limited set of cases to larger populations. Consider again statement (3). According to this statement, there are at least two combinations of attributes that may allow a firm to attain high performance. If we take a necessary condition to denote that an outcome can be attained only if the attribute in question is present, then clearly neither of the combinations is necessary. On the other hand, if we take a sufficient condition to denote that an outcome will always be obtained if the attribute in question is present, then either of the combinations is sufficient. However, note that this finding applies only to combinations of attributes, not to individual attributes. In fact, of the individual attributes A, B, ~C, and D, none is either necessary or sufficient in that no attribute is present in all combinations and no attribute can by itself produce the outcome. In other words, statement (3) denotes a situation of considerable causal complexity: four attributes combine to create the outcome, but none is by itself necessary or sufficient. Note also that such situations of causal complexity are exceedingly difficult to capture using conventional linear regression, since necessity and sufficiency are outside the focus of correlational analysis.

To analyze which different configurations of organizational characteristics may cause a certain outcome, a researcher using a set-theoretic approach first constructs a

truth table that lists all possible configurations of characteristics, as well as whether these

configurations lead to the outcome in question. In this regard, selection of the

characteristics deemed important should be based on theoretical and substantive

knowledge about their relationship with the outcome. In a second step, the researcher

uses Boolean logic to determine commonalities among the configurations that lead to the

outcome and to generate logical statements such as those above that describe these

commonalities, thus allowing for the logical reduction of statements. This reduction

procedure uses the Quine-McCluskey algorithm, a common algorithm for simplifying

set-theoretic statements that is implemented in software packages such as QCA (Drass &

Ragin, 1992) and fs/QCA (Drass & Ragin, 1999). To illustrate how this algorithm works,

consider again the relatively simple situation of causal complexity described by statement

(3). The corresponding truth table for such a situation would be as follows:

Insert Table 1 about here

In this table, shaded cells for characteristics indicate cells corresponding to statement (3).

Furthermore, some of the cells in the outcome column show a question mark, indicating

that these combinations of conditions may show no empirical instances, a situation that is

frequently observed in empirical research and usually referred to as a situation of limited

diversity (Ragin 1987, 2000).

To find out whether any of the four conditions is necessary for causing the

outcome, we would examine whether the condition is always present in all cases where

the outcome is achieved. Clearly, this is not the case here. However, the truth table

14

shows that there are seven different configurations of the four individual organizational

characteristics that are sufficient for causing the outcomes. The combinations are listed

below:

1. A • B • C • D
3. A • B • ~C • D
4. A • B • ~C • ~D
7. A • ~B • ~C • D
8. A • ~B • ~C • ~D
9. ~A • B • C • D
11. ~A • B • ~C • D

While these combinations are all sufficient for causing high performance, the seven

combinations can be simplified since some combinations are logically redundant. For

example, firms with an efficient production system (A) that are not in heterogeneous

environments (~C) may or may not have a high rate of product innovation (B or ~B) and

may or may not exhibit a hierarchical control structure (D or ~D). Either way, the

combination of A and ~C will still be sufficient to cause the outcome. As a result, the

seven combinations may be logically reduced and simplified using the Quine-McCluskey

algorithm and simplifying assumptions (cf. Ragin 1987, 2000). In Boolean algebra, this

proceeds as follows for statements 3 and 4:

A • B • ~C • ~D + A • B • ~C • D   =
A • B • ~C (D + ~D)   =
A • B • ~C

Similarly, statements 7 and 8 can also be simplified:

$$A \cdot \sim B \cdot \sim C \cdot D + A \cdot \sim B \cdot \sim C \cdot \sim D =$$
$$A \cdot \sim B \cdot \sim C \, (D + \sim D) \qquad\qquad =$$
$$A \cdot \sim B \cdot \sim C$$

Finally, combining the results from both simplifications leads to the following:

$$A \cdot B \cdot \sim C + A \cdot \sim B \cdot \sim C \qquad\qquad =$$
$$A \cdot \sim C \, (B + \sim B) \qquad\qquad =$$
$$A \cdot \sim C$$

Using some very simple operations, we have thus arrived at a statement that by itself contains all four logical combinations involving A and ~C (3, 4, 7, and 8) that may lead to the outcome in question. The same operations can of course be applied to the four logical combinations involving B and D (1, 3, 9, and 11) that are also sufficient for producing high performance. The result is again a simple statement that contains all combinations that may cause the outcome:

$$A \cdot \sim C + B \cdot D \rightarrow Z \qquad\qquad (4)$$

From Crisp to Fuzzy Sets

The example I have used here to demonstrate a set-theoretic approach has employed crisp sets, i.e. the presence of attributes and thus the membership in sets of firms with such attributes has been defined using binary values (membership/non-

16

membership). However, in many situations researchers will be interested in more fine-grained measures of the attributes in question, and the information contained in varying levels of attributes will often be very important for studying how attributes combine. A common concern with methods employing Boolean algebra is therefore that they tend to require dichotomous variables, thus placing undue limitations on the task of categorizing cases.

Fortunately, recent developments now incorporate the equivalent of ordinal and continuous variables into set-theoretic methods.   This is accomplished by using "fuzzy" sets (Ragin 2000, 2004). With fuzzy sets, set membership is not restricted to binary values of 0 and 1, but may instead be defined using membership scores ranging from ordinal up to continuous values. Fuzzy sets therefore allow the researcher to exactly specify their constructs, such as the degree to which the organizational environment is turbulent or to what extent certain management practices are actually implemented in an organization. As in crisp sets, fuzzy sets also define a value of 0 as fully out of the relevant set and a value of 1 as full set membership. However, while crisp sets make no further distinctions, fuzzy sets use thresholds tied to substantive knowledge about a case to further partition set membership. For example, a simple, graded fuzzy set may contain the following six values:

1.00   = fully in
0.80   = mostly in
0.60   = more in than out
0.40   = more out than in
0.20   = mostly out
0.00   = fully out

Partitioning may be more fine-grained up to continuous fuzzy sets similar to ratio scales, but different in that such fuzzy sets contain both a meaningful floor and a meaningful ceiling (Ragin, 2000).

It is important to note here that fuzzy sets, and particularly continuous ones, should lead the researcher to go beyond a simple rescaling of variables. For example, a common way to measure of diversification is to count the number of four-digit SIC codes in which a firm operates and code these data into a continuous measure. To create measure of membership in the set of diversified firms, the researcher would infuse substantive knowledge into the measure about what it means to operate in any given number of different industries. For example, should firms that operate in 5, 10, or 15 different SIC codes be classified as fully diversified? If the firm operates in 20 different SIC codes, do operations in an additional SIC codes truly make a difference? A fuzzy set is a superior way of addressing such questions since it asks the investigator to provide meaningful thresholds for values. For instance, rather than merely controlling for prior performance in a regression analysis, a calibrated measure of performance would be based on substantive knowledge about the meaning of "high" or "medium" performance relative to e.g. other firms, stock market expectations etc. Calibration thus involves sinking stakes at a few critical points of the measure and basing this process on detailed knowledge of the context. In contrast, a mechanistic procedure such as standardizing, which relies on the sample mean as a reference point, tends to ignore the substantive meaning of variation that falls at the mean of the distribution, often giving a false sense of precision. The use of fuzzy sets thus accomplishes two things: it allows the researcher

to move from crisp to ordinal and continuous measures, and it forces the researcher to employ theoretical and substantive knowledge in the creation of the measure.

Set-theoretic Methods and Statistical Inference

Another important issue with set-theoretic methods is whether the Boolean algebra they employ makes them deterministic (e.g. Goldstone 1997; Lieberson 1994). Clearly, the social world contains a considerable element of randomness that needs to be accounted for. Furthermore, data frequently contain measurement or coding errors, resulting in further noise. An essential question therefore is how set-theoretic methods can account for the randomness and error of a stochastic world. Fortunately, set-theoretic methods have been modified to incorporate probabilistic criteria (e.g. Braumoeller & Goertz, 2000; Ragin 2000, 2004). For example, Ragin (2000) employs a z test to compare the proportion of cases exhibiting a combination to a specified benchmark proportion. This benchmark proportion can be varied depending on the nature of the data and the strength of the statement tested. For example, one might use a benchmark proportion of .90, suggesting that 90 percent of the cases with a specific combination need to exhibit the outcome for the combination to pass the significance test.

To illustrate the use of such probabilistic criteria, consider again the previous example about combinations of attributes that lead to high performance. After examining empirical data, we might find that out of 120 firms that show the combination A • ~C (an efficient production system and no heterogeneous environment), 115 do exhibit high performance. The observed proportion is therefore $115/120 = 0.958$. Can we be confident that this observed proportion is significantly higher than our benchmark

proportion of .90? A simple *z*-test can answer this question. With an observed proportion of .958, a benchmark proportion of .90, and an *N* of 120, we can calculate a *z*-value of 1.966. Using a significance level .05 and a one-tailed test, we find that this *z*-value exceeds the critical *z*-value of 1.65, confirming our assumption that at least 90 percent of all firms that show the combination A • ~C also exhibit high performance.[2] While this example has used standard binary sets, the same logic also applies to fuzzy sets. The main difference is that fuzzy sets are more finely calibrated and therefore posit more stringent requirements in terms of the consistency with the statement in question.

A second issue with set-theoretic methods relates to the selection of cases, and specifically whether set-theoretic methods select on the dependent variable. This is an important question and deserves an answer, since it is less of a problem than commonly assumed. Selecting on the dependent variable has been justly criticized since it often introduces bias that will attenuate causal estimates (Geddes, 1990; King, Keohane, & Verba, 1994). Clearly, some variation in the dependent variable is necessary to determine causes that lead to success and failure, and for most studies the sample of cases to be examined should be drawn using selection rules that are not correlated with the dependent variable and lead to some variation in both the predictor variable and the outcome (Shadish, Cook & Campbell, 2002). However, once the sample has been identified, selection on the dependent variable during the analysis is perfectly admissible to evaluate necessary conditions (Dion, 1998; Most & Starr, 1989). In fact, analysis of necessary conditions must only focus on cases showing the outcome; cases where the outcome is not present are irrelevant and including them would provide incorrect results for hypothesis tests (Braumoeller & Goertz, 2000).

Selecting on the dependent variable becomes a greater concern in the analysis of sufficient conditions, but there are several ways to address it. I have already mentioned the use of standard procedures to draw the original sample, thereby establishing variation in the dependent variable. This variation can be employed in a simple counterfactual analysis that compares whether conditions presumed to be sufficient are also present when the outcome is not observed.[3] For example, if the analysis suggested that the combination B • D (rapid product innovation and hierarchical control structures) was sufficient for high performance, then an examination of cases that do not exhibit high performance should equally show no cases with the combination B • D.

Variation in the dependent variable can furthermore be employed to examine what conditions are necessary or sufficient for the *absence* of the outcome. This could be done using simple negation of the outcome variable, or the analysis can be further refined, particularly with the use of fuzzy sets. For example, one might examine factors leading to the absence of high performance (simple negation of the high performance outcome) or one might create a new fuzzy set for the presence of low performance. This transformed negative outcome would not simply be the inverse of high performance, but might use quite different membership criteria based on substantive knowledge about what constitutes low performance. In combination, these approaches allow for a careful assessment of the factors that lead both to the presence and absence of the outcome in question, thereby addressing the selection issues.

A final issue that deserves mention relates to dealing with irrelevant or trivially necessary conditions. For example, while it is true that all armies require water and gravity to operate, such universals contribute little to causal explanations (Downs, 1989:

234; cf. also Braumoeller & Goertz, 2000). Trivially necessary conditions again highlight that necessity and sufficiency are not inherent in patterns of evidence, but instead involve the imposition of theoretical and substantive knowledge in examining imperfect evidence. All analysis needs to be guided by such knowledge. In this regard, set-theoretic methods are faced with the same issues of causal inference as all other methods that use non-experimental data (cf. Shadish et al., 2002)

In many cases, trivial conditions can be easily weeded out because they are obviously irrelevant, as was the case with gravity and water above. However, if questions remain about the trivialness of a specific condition, it is again useful to consider how the condition relates to variation in the outcome. A trivial condition can often be identified here because it does not vary regardless of the outcome. For the empirical assessment of trivialness, Braumoeller and Goertz (2000) have shown that a χ^2 test of homogeneity can be used to assess whether there are significant differences in the distribution of cases across the present/absent cells for causes and outcomes. The results of these authors confirm that trivialness is usually not an issue, suggesting further that the analysis of necessary conditions holds considerable promise for empirical research.

Set-theoretic Methods and Equifinality

Another major strength of set-theoretic methods is that they offer an attractive way of examining equifinality. While the concept of equifinality has received increasing attention for studying organizational configurations (Doty, Glick & Huber, 1993; Eisenhardt, 1988; Galunic & Eisenhardt, 1994, Gresov & Drazin, 1997; Pennings, 1992), the question of how to empirically examine equifinal outcomes is still largely

unanswered. Gresov and Drazin (1997) were among the first to describe a process by which equifinality research may proceed, moving from identifying different forms of equifinality to matching these forms with the appropriate methodology. For the identification process, Gresov and Drazin recommend qualitative research, surveys, and factor analysis as ways of assessing the degree of consistency or conflict between different functional demands faced by an organization. After gathering this information about the cases, equifinal configurations can then be classified using categories, scales, or deviation from profiles. However, both qualitative, case-oriented research and quantitative, variable-oriented methods for assessing equifinality face challenges, since these methods tend to either quickly exhaust the levels of complexity they can process or they tend to leave the actual processes by which equifinality emerges relatively unexamined, particularly if more than two variables combine to create equifinal outcomes. Set-theoretic methods are able to overcome both these limitations and are thus well-suited for examining equifinality. First, such methods allow the researcher to examine extensive numbers of different combinations of elements and detect the underlying commonalities of configurations that lead to a certain outcome. Second, set-theoretic methods allow a detailed assessment of causality, enabling the researcher to strip away elements that are not causally involved with the outcome.

Set-theoretic methods furthermore extend the analysis of equifinality by offering a technique for examining the relative importance of each path. Ragin (2003) refers to this relative importance as coverage, understood as the proportion of instances of the outcome that exhibit a certain causal combination or path. For example, while it may be true that the combinations $A \bullet \sim C$ and $B \bullet D$ are both equifinal in that both lead to high

performance, the number of cases showing each combination and thus the importance of each path may be quite different. Using simple calculations, it is possible to further partition path coverage in a manner that is roughly equivalent to partitioning explained variation in a conventional regression model (Ragin, 2003). Just like a factor may be statistically significant, but its explained R^2 may be very small, a characteristic or combination of characteristics may be sufficient to lead to the outcome, but its unique coverage may be very low since only few cases exhibit this path to the outcome. Measuring coverage thus allows for a very fine-grained analysis of equifinality by giving the researcher insights into the relative importance and unique contribution of different causal combination.

Limited Diversity in Organizational Configurations

Strategy researchers have frequently pointed out that not all possible configurations are realized, and that certain organizational elements show a tendency to appear together (Meyer et al., 1993; Miller, 1986; Mintzberg, 1980). In other words, within the multidimensional property space of organizational design features, there are certain cells that tend to be more crowded and certain cells that are empty. As I have mentioned, this phenomenon is known in set-theoretic research as limited diversity, defined as a situation where one or more of the logically possible combinations of causal conditions specified in the analysis do not exist empirically (Ragin, 1987, 2000).

While it is desirable to describe combinations of attributes that cover a large proportion of the target population of organizations (Miller & Friesen, 1984), it is also instructive to understand what combinations do not occur.[4] Recently, Inkpen and

Chowdhury (1995) have pointed out that most of the research on strategy has neglected to examine cases of strategic absence, i.e. those situations where strategy is expected but not observed. Examining the limited diversity of organizational configuration can likewise help the researcher understand not only whether a certain configuration is absent, but also *which* configurations are absent. Thus, if it is possible to detect clear and robust patterns of absence within the property space of organizational design features, such patterns may offer insights by making explicit the otherwise implicit and widely shared assumptions about what design elements should or should not go together.

Moving beyond empirically observable instances of organizational configurations is also important because it allows shifting the focus from the descriptive realm to the question of how to design better configurations. Here, insights from studying limited diversity of configurations may be helpful in at least two ways. First, such insights may allow building robustness and redundancy into organizational designs. If it is possible to identify more than one sufficient combination of design features that lead to high performance, then knowledge about different paths to an outcome can be used to construct a superior configuration that may be more robust to changes in the environment. Thus, set-theoretic methods may allow the design of configurations that offer robustness of essential systems while minimizing the use of resources. Second, once we know what design elements are necessary or sufficient to attain the outcome in question, studying limited diversity allows the researcher to identify additional design combinations that may extend or improve existing configurations. One might conceive of existing combinations as being close to peaks in a rugged performance landscape (Gavetti & Levinthal, 2000), but not necessarily at the apex of such peaks. A localized

search for additional configurations may then capitalize on knowledge about existing, workable configurations and non-existing, but perhaps promising design extensions of such configurations, particularly since the highest peaks in a rugged landscape tend to be located rather close to one another (Kauffman, 1993; Levinthal & Warglien, 1999). Studying limited diversity thus offers new insights to a configurational approach because it provides a novel strategy for learning about property spaces and the relationships between different design elements.

Set-theoretic Methods and Theory Building

While the assumptions of configurational theory require methods that can better assess complex, non-linear, and synergistic effects, such methods can in turn also provide new insights to configurational theory in particular and the theory of organizations more generally. I have already pointed out how knowledge about design configurations may help to identify promising organizational designs. However, set-theoretic methods may also affect theory on a deeper level by not only offering a way to analyze causal relationships, but also providing a language for expressing such relationships. The methods I have described here use a language that is "half-verbal-conceptual and half-mathematical-analytical" (Ragin, 2000: 4). This language is particularly suitable for combining the verbal expression of abstract concepts with the analytical rigor of logical relationships, something that is often amiss in current theory-building (Sutton & Staw, 1995). Much of our language for describing relationships tends to be correlational. However, statements about correlations relationships are different from statements about causal relationships. Statements about correlations are symmetrical, but statements about

causal relations are asymmetrical. For example, consider the following statement: "diversification will be negatively related to firm risk." As a correlational claim, it follows that firm risk is also negatively correlated with diversification. However, the *causal* relationship is directional and one-way: diversification decreases firm risk, not the other way around.

Furthermore, correlational statements cannot account for necessity and sufficiency, two crucial concepts for understanding causality. For example, consider the central tenet of structural contingency theory that organizational effectiveness depends on the fit between the organization and its environment. As Galunic and Eisenhardt put it, "the better the fit between structural components and contingent factors, the greater the viability and performance of the organization" (1994: 216). This is a concise and intuitively appealing statement. As a correlational claim, it is usually understood that this statement will apply while holding other relevant factors constant. The prediction is that if fit between structural components and e.g. the environment is relatively low, performance will tend to be low, while if the fit is relatively high, performance will also be high.

However, in terms of causal relationships, we may assume that more than just fit is necessary for high performance. We may find a number of firms that structurally show good fit with the environment but do not exhibit higher performance, perhaps due to a lack of resources or incompetent management. If that was the case, we may conclude that fit is a necessary, but not sufficient condition for higher performance, since without it high performance cannot be achieved, but fit by itself is not enough to guarantee high performance.

On the other hand, we may find a number of firms that score high on the performance measure but not high on the fit measure. This may be the case if some firms can compensate for their bad fit by some other means, such as lucrative patents or a particularly committed workforce. If we find a considerable number of such firms, we may conclude that fit is sufficient, but not necessary for higher performance, since there seem to be other ways of achieving such performance.

Both kinds of cases I have described here are inconsistent with a correlational relationship, and we thus account for them by controlling for other characteristics. In some situations where there are a large number of inconsistent cases, we may "correct" for such heteroskedasticity by using statistical procedures. However, instead of treating such cases as a methodological nuisance, we may also consider how such cases can help us learn about the causal relationship between the characteristics in question. In fact, both kinds of cases I have described are perfectly consistent with a set-theoretic point of view. Thinking of firms as cases that have membership in different causal conditions thus forces us to consider whether these conditions are necessary, sufficient, or perhaps neither. Since necessity and sufficiency are two of the basic building blocks of causal relationships, incorporating them better into theory-building presents a step towards the building of theories that can account for complex causal relationships.

Implications for Other Fields of Management Research

While I have focused here mainly on contributing to research on organizational configurations, the implications of set-theoretic methods clearly extend well beyond this domain. For example, economists and strategy researchers such as Milgrom and Roberts

(1990, 1995), Porter (1996) and Siggelkow (2001, 2002) suggest that complementarities

between a firm's strategy and structure are essential for achieving high performance.

Milgrom and Roberts define activities as complements if "doing (more of) any one of

them increases the returns of doing (more of) the others" (1995: 181). They argue that

the clustering of characteristics found in technologically advanced manufacturing firms,

which often encompasses marketing, production, engineering, and organization, is the

result of a coherent business strategy that exploits complementarities, and that this is due

to identifiable changes in technology and demand. Furthermore, complementarities make

it profitable for a firm that adopts some characteristics to adopt more. For example,

greater flexibility of the production equipment makes increasing the breadth of the

product line more attractive, and vice versa (Jaikumar 1986, 1989).

Empirical studies have observed complementarities for flexible automation and

organizational variables in the manufacturing industry (Parthasarthy & Sethi 1993),

organizational innovations (Whittington et al. 1999), and entire organizational systems

(Porter 1996; Siggelkow 2001). However, complementarities theory has had its greatest

impact in the field of human resource management (e.g. Delaney & Huselid 1996;

Huselid 1995; Ichniowski, Shaw, & Prennushi, 1997; MacDuffie, 1995) and the search

for the best configurations of HRM practices that lead to high performance has arguably

become the dominant research issue of that field (Guest, 1997: 263).[5]

In surveying the empirical literature on complementarities, Porter and Siggelkow

(2004) suggest that prior research has proceeded mainly by comparing performance

implications of adopting a single activity versus sets of activities. However, many

empirical questions remain, and the econometric issues involved with assessing

complementarities are considerable (Athey & Stern, 1998). To identify complementary practices, prior studies have employed similar methods as research on organizational configurations, including cluster analysis (e.g. Arthur, 1992, 1994; MacDuffie, 1995), factor analysis (e.g. Huselid, 1995; MacDuffie, 1995; Wood & de Menezes, 1998), or examining the degree of correlations between various practices (Whittington et al., 1999). Most studies then use regression analysis to test the relationship between sets of practices and performance, although some researchers have proposed simultaneous equation models (Athey & Stern, 1998) or testing whether interaction effects are constant over entire samples by splitting them into groups (Porter & Siggelkow, 2004). It would therefore seem that problems of empirical testing in the literature on complementarities are quite similar to those in the study of organizational configurations, and set-theoretic methods may likewise offer an attractive way for empirically studying complementarities and substitution effects. Applying these methods would allow researchers to directly address questions such as which activities may be successfully removed without harming performance while also taking into account issues of limited diversity that have so far plagued empirical research on practice adoption (Athey & Stern 1998). A first step in this direction is offered by Kogut, MacDuffie and Ragin (forthcoming), suggesting that this is indeed a fruitful avenue for future research.

A set-theoretic approach may also contribute to the emergent literature on organizational complexity (e.g. Anderson, 1999; Levinthal, 1997; Levinthal & Warglien, 1999; Rivkin, 2000). For example, studies employing complexity theory tend to see organizations as dynamic, nonlinear systems, with an explicit focus on connections and interacting of variables in creating outcomes (Anderson, 1999). The agent-based

simulations often used in this literature examine the effects of multiple interactions to identify interdependencies and non-linear effects. Such concerns resonate well with a set-theoretic approach, and some researchers have already begun to apply a fuzzy set approach to complex systems (e.g. Morel & Ramanujam, 1999). Similarly, the search for robust designs that has informed complexity theory (e.g. Levinthal & Warglien, 1999) is very compatible with the concept of limited diversity. In addition, the use of set-theoretic methods may offer complexity research a different way of examining interactions. While computer simulations have the advantage of allowing the manipulation of multiple interdependencies, they are often more difficult to assess than traditional models, and the use of multiple parameters that are subtly interrelated can make meaningful interpretation quite difficult (Axtell, Axelrod, Epstein, & Cohen, 1996; Cohen, 1999; Morel & Ramanujam, 1999). As Porter and Siggelkow (2004) suggest, agent-based models furthermore focus on different degrees of connectedness rather than different types of connections, and interactions are determined stochastically via random values, making the examination of specific interactions problematic. In such situations, set-theoretic methods may provide an intermediate approach between simulation and conventional linear models and may allow researchers to examine complex, non-linear relations while using empirical data.

Set-theoretic methods may also add to research in the tradition of the resource-based view (RBV) (e.g. Barney, 1991, 1996; Conner, 1991, Dierickx & Cool, 1989; Peteraf, 1993; Wernerfelt, 1984). As pointed out by Black and Boal (1994), most prior work within the RBV has evaluated resources from a stand alone viewpoint, with little attention paid to how the value of resources depends on the presence of other resources.

Yet, resources typically do not stand alone, but are "nested in and configured with one another and the nature of relationships between them" (Black & Boal, 1994: 132). While the idea of "resource bundles" has been recognized by RBV theorists (Barney & Zajac, 1994; Dierickx & Cool, 1989; Galunic & Rodan, 1998), it has been largely ignored in empirical studies. However, competitive advantage may frequently depend on interactions between resources. As an example of such a situation, consider the automation study of Parthasarthy and Sethi (1993), which showed that only the combination of speed and scope flexibility led to higher performance; by themselves, neither speed nor scope had a significant effect. Such conditions, where two or more resource factors are necessary but not sufficient, are more likely the rule than the exception in firms, thus calling for an approach that can effectively address causal combinations. Furthermore, resource bundles may themselves combine with other resource bundles to form configurations at higher levels, perhaps allowing for substitution of one combination for another. Within the RBV, conceptual attempts to capture such complex interactions have so far relied on network theory (Black & Boal, 1994) or a modular view of the firm that examines the likelihood of different resource combinations (Galunic & Rodan, 1998). A set-theoretic approach may contribute to the RBV by offering both a conceptual framework and an empirical methodology for analyzing how resources combine to form bundles and how these bundles affect firm performance.

Configurational approaches also need not be restricted to the organization level. While Meyer, Tsui, and Hinings (1993) suggest a number of applications for configurational approaches at the individual and group levels, configurations and

complementarities are also of importance at the industry and national level. For example, the idea of coherence between different societal institutions such as labor relations, education and training systems, and corporate governance practices has informed a number of works on national economic systems (Hall & Gingerich, 2004; Hall & Soskice, 2001; Streeck, 1992). This literature has argued that complementarities between elements of national economic systems contribute to comparative institutional advantage. For example, in the Japanese *keiretsu* system, complementarities between life-time employment, corporate organization, and inter-firm relations lead to higher capacities for rapid cross-sector technology transfer (Aoki, 1994; Hall & Soskice, 2001).

Empirical research on institutional complementarities has tended to rely on case studies or smaller samples of countries (e.g. Albert, 1993; Hollingsworth & Boyer, 1997; Whitley, 1999), and the empirical testing of larger samples is only beginning to emerge (e.g. Amable, 2000; Hall & Gingerich, 2004). Still, this stream of research faces very similar methodological issues in examining configurations of institutions, and early work by Guillén (1994) as well as more recent work by Kogut and Ragin (2002) suggests that set-theoretic methods may be successfully used to study complementarities at this macro-economic level.

An Example of Applying Set-theoretic Methods

To demonstrate the potential payoffs of set-theoretic methods, I now further consider some of the practical issues involved with applying them to the study of organizational configurations. In a first step, the researcher would identify an appropriate area to examine configurations. For example, the field of human resource management

provides an attractive empirical context here. It is by now widely recognized that an organization's human resource systems are of critical strategic importance (e.g. Baron & Kreps 1999; Hambrick & Snow, 1989; Hamel & Prahalad, 1985; Pfeffer 1994; Wright & McMahan 1992), and configurational approaches have figured prominently in assessing how HRM practices affect organizational performance (e.g. Arthur, 1994; Delery & Doty 1996; Doty et al. 1993; Ichniowski et al., 1997; MacDuffie, 1995). HRM practices are furthermore attractive because they allow for a multi-level examination of configurations. As pointed out by Wood (1999), configurations can be examined in terms of how HRM practices relate to each other, how systems of HRM practices relate to other organizational systems, and how HRM and other systems relate to the environment. This permits a rich analysis of configurations and their effects on substantively important outcomes such as performance.

A set-theoretic analysis will often proceed as follows.[6] After developing the theoretical framework for the study and deciding which variables may best measure the theoretical constructs, these variables will be recoded into sets. For many variables, binary sets will be appropriate. For example, for some HRM practices such as job rotation or profit sharing, it may be sufficient to code the practices as present or absent (e.g. Ichniowski et al., 1997). Other variables will be more complex and a binary coding may be too limiting. For example, membership in the set of high-performing organizations could be measured in a number of different ways requiring a more continuous coding, including productivity, quality, labor turnover, customer satisfaction, as well as various measures of financial performance and profitability. For these

variables, fuzzy sets should be used, with different levels of set membership connected to meaningful thresholds based on substantive knowledge.

As pointed out by Ragin (2000), it is important to remember in this context that variables cannot be mechanistically translated into fuzzy sets because they usually do not refer to sets. For instance, productivity variables such as production-line uptime (Ichniowski et al., 1997) or hours required to build a vehicle (MacDuffie, 1995) may be used to create sets, but they are not yet sets. In each instance, the coding of set membership levels should be tied to substantive meaning of high performance, rather than using an uncalibrated measure. Typically this will lead the researcher to define variation above or below a certain threshold value as irrelevant. For example, regarding the set of organizations with high return on equity, all organizations that score below a certain value may be assigned a membership score of zero since all of these organizations are fully out of the set. Conversely, all organizations that show returns above a certain threshold may be assigned scores of one, signaling full membership in the set. For a continuous variable such as return on equity, decisions about full membership and non-membership will involve an assessment of what levels of return on equity are generally considered high and not high, and these assessments may differ by country or industry. Furthermore, intermediate values that indicate partial membership scores can likewise be tied to substantive knowledge, perhaps using ratios of what is considered high performance, or—where such knowledge is not available or applicable—more sample dependent values such as mean or median performance.

Once the data has been coded into sets, it can be analyzed using software packages such as fs/QCA.[7] In a first step, the researcher will examine the data for

combinations of attributes are necessary to obtain the outcome in question. For example, the researcher might discover that a high level of automation, a low product age, and the absence of diseconomies of scale are all necessary conditions for achieving high productivity, as found by Kogut et al.(forthcoming) in their re-analysis of MacDuffie's (1995) data on car assembly plants. Determining such necessary conditions is an interactive process that will usually involves robustness checks to determine how calibration of the measures may affect the findings.

In a second step, the data can then be analyzed as to which combinations of attributes are sufficient to obtain the outcome. In this regard, Kogut et al. found that there was no one single configuration of production characteristics that was sufficient for high performance, but that there were three different constellations of the HRM system, the shop-floor organization, and the management of buffers between work activities that resulted in high levels of performance. In comparing the performance means of productivity and quality for these configurations, Kogut et al. (forthcoming) were also able to show that, while there was overall equifinality, these configurations exhibited different strengths in regard to productivity and quality. In sum, the use of set-theoretic methods allowed these researchers to conduct a detailed assessment of how causes combined to produce high-performance in work systems, resulting in findings that were consistent with MacDuffie's (1995) findings but furthermore allowed a more refined understanding of interactions between factors that would not have been achieved with the use of conventional interaction effects.

Instead of conducting a full analysis of necessary and sufficient conditions using the probabilistic criteria described above, the researcher may also decide to combine set-

theoretic methods with other conventional statistical procedures, as done by Roscigno and Hodson (2004). For example, the researcher may use set-theoretic analysis to identify configurations and then test the relationship between these configurations and performance using t-tests or OLS. This approach is structurally similar to previous research on configurations combining cluster analysis with ANOVA or regression analysis, but is superior by offering a more robust approach to identifying and testing causal combinations and their effect on the outcome in question.

CONCLUSION

While the study of organizational configurations holds considerable promise for organization theory and strategy, it is currently impeded by a discrepancy between its theory and methods. To overcome this discrepancy, I have proposed the use of set-theoretic methods to examine how different organizational elements combine rather than compete to produce an outcome. While I have only been able to provide a very brief sketch of these methods, it appears evident that a set-theoretical approach is much more closely aligned with the theoretical thrust of configurational theory, which stresses the existence of effects that are not simply linear, additive, and unifinal. Set-theoretic methods offer a rigorous and nuanced way of assessing the complex ways in which causes combine to create outcomes, and these methods also show promise for a variety of research fields beyond the theory of organizational configurations.

Regarding the field of strategy in particular, a set-theoretic approach is furthermore important because it brings us closer to understanding the realities of strategizing. While causal complexity may in fact be the most common form of causality

facing a firm's decision makers, it is still not sufficiently addressed in empirical strategy research. There is a clear need to move beyond simple contingency approaches, since most firms face multiple contingencies such as strategy, structure, leadership, and technology, with significant interdependencies between these contingencies (Burton & Obel, 2004; Galunic & Eisenhardt, 1994). Furthermore, these multiple contingencies may present the firm with contradictory requirements on strategy and structure (Miller, 1992). The resulting questions about trade-offs between multiple and differing demands are arguably at the core of strategy research and have led researchers to call for a new methodology that takes into account configurational patterns, equifinality, and multiple contingencies (Drazin & Van de Ven, 1985; Galunic & Eisenhardt, 1994; Greckhamer, Misangyi, Elms, & Lacey, 2004). Set-theoretic methods not only fit this demand, but have the added benefit of also allowing the analysis of small-N situations, that is, situations where the number of cases is too large for traditional qualitative analysis and too small for many conventional statistical analyses (e.g., between 10 and 50 cases). Due to its comparative approach, the analysis of such small-N situations presents one of the strengths of a set-theoretic approach (e.g. Lacey, 2001; Ragin, 1994; 2000).

Set-theoretic methods may furthermore contribute to management research by focusing explicitly on localizing causal complexity. This aspect is especially significant for the domain of business policy. Set-theoretic approaches are particularly adept at identifying localized effects. Rather than estimating the relative importance of different strategies across all cases, set-theoretic methods allow us to better examine which strategies make sense for which kinds of firm. By contextualizing effects, it becomes easier to go beyond global and typically vague statements about effects, and the

identification of different paths rather than a single path offers more opportunities for

policy intervention (Ragin & Fiss, 2004). Again, a set-theoretic approach can guide both

theory and empirical investigation in this regard, thus offering an improved

understanding of the nature and effect of complex configurations.

[1] For the moment, I will not consider the empirical truth of these examples but merely use them to illustrate set-theoretic relationships.

[2] In small-N situations where N is less than 30, a binomial probability test can be used instead of a z test. For a more extensive treatment of benchmarks and significance tests, see e.g. Ragin (2000), Ragin and Fiss (2004), or Braumoeller and Goertz (2000).

[3] A more detailed discussion of counterfactual reasoning in comparative analysis can be found in Ragin and Sonnet (forthcoming).

[4] Some of the combinations that do not occur may involve configurations that are somehow unfeasible, logically impossible, or simply fail to show empirical instances. One needs to keep in mind that that the number of possible configurations grows exponentially with the number of attributes examined and that a lack of empirical instances may simply be due an overabundance of cells within the property space. For a more extensive discussion of limited diversity, see Ragin (1987; 2000) and Ragin and Sonnet (forthcoming).

[5] For overviews of this literature, see Guest (1997) or Wood (1999).

[6] When employing a new methodology, it is often appropriate to contrast its results with those obtained using conventional methods. After identifying an appropriate dataset of HRM practices, the researcher may therefore decide to conduct a re-analysis of the original data to replicate previous findings. This has the advantage of establishing a benchmark against which set-theoretic methods can be measured while also familiarizing the researcher with the specific issues and limitations of the data in question.

[7] The QCA and fs/QCA software packages and manuals can be downloaded at http://www.fsqca.com.

REFERENCES

Albert, M. 1993. *Capitalism against capitalism*. London: Whurr.

Amable, B. 2000. Institutional complementarity and diversity of social systems of innovation and production. *Review of International Political Economy*, 7: 645–687.

Amburgey, T. L., & Dacin, T. M. 1994. As the left foot follows the right? The dynamics of strategic and structural change. *Academy of Management Journal*, 37: 1427-1452.

Anderson, P. 1999. Complexity theory and organization science. *Organization Science*, 10: 216-232.

Aoki, M. 1994. The Japanese firm as a system of attributes. In Aoki, M., & Dore, R. (Eds.), *The Japanese firm: Sources of competitive strength*, 11-40. Oxford: Oxford University Press.

Arthur, J. B. 1994. The link between business strategy and industrial relations systems in American steel minimills. *Industrial and Labor Relations Review*, 45:488-506.

Arthur, J. B. 1994. Effects of human resource systems on manufacturing performance and turnover. *Academy of Management Journal*, 37:670-687.

Athey, S., & Stern, S. 1998. *An empirical framework for testing theories about complementarity in organizational design*. National Bureau of Economic Research Working Paper 6600, available from http://www.nber.org/papers/w6600

Axtell, R., Axelrod, R., Epstein, J., & Cohen, M. 1996. Aligning simulation models: A case study and results. *Computational & Mathematical Organization Theory*, 1: 123-141.

Baker, D. D., & Cullen, J. B. 1993. Administrative reorganization and configurational context: The contingent effects of age, size, and change in size. *Academy of Management Journal,* 36: 1251-1277.

Barney, J. B. 1991. Firm resources and sustained competitive advantage. *Journal of Management*, 17: 99-120.

Barney, J. B. 1996. The resource-based theory of the firm. *Organizational Science*, 7: 469-502.

Barney, J. E., & Hoskisson, R. E. 1990. Strategic groups: Untested assertions and research proposals. *Managerial and Decision Economics,* 11: 187-198.

Barney, J. B., & E. J. Zajac. 1994. Competitive organizational behavior: Toward an organizationally-based theory of competitive advantage. *Strategic Management Journal*, winter special issue, 15: 5-9.

Baron, J. N., & Kreps, D. M. 1999. *Strategic human resources: Frameworks for General Managers*. New York: Wiley & Sons.

Bensaou, M., & Venkatraman, N. 1995. Configurations of interorganizational relationships: A comparison between U.S. and Japanese automakers. *Management Science,* 41: 1471-1492.

Black, J. A., & Boal, K. 1994. Strategic resources: Traits, configurations and paths to sustainable competitive advantage. *Strategic Management Journal,* 15: 131-148.

Boswell, T., & C. Brown. 1999. The scope of general theory: Methods for liking inductive and deductive comparative history. *Sociological Methods and Research* 28: 154-185.

Braumoeller, B. F., & G. Goertz. 2000. The methodology of necessary conditions. *American Journal of Political Science*, 44:844-858.

Burton, R. M., & Obel, B. 2004. *Strategic organizational diagnosis and design: The dynamics of fit.* Third edition. Dordrecht: Kluwer.

Cohen, M. 1999. Commentary on the Organization Science special issue on complexity. *Organization Science*, 10:373-376.

Conner, K. R. 1991. A historical comparison of resource-based theory and five schools of thought within industrial organization economics: Do we have a new theory of the firm? *Journal of Management*, 17: 121-154.

Cool, K., & Schendel, D. E. 1987. Strategic group formation and performance: The case of the US pharmaceutical industry, 1963-1982. *Management Science,* 33: 1102-1124.

Delaney, J. T., & Huselid, M. A. 1996. The impact of human resource management practices on perceptions of organizational performance. *Academy of Management Journal*, 39: 949-969.

Delery, J. E., & Doty, D. H. 1996. Modes of theorizing in strategic human resource management: Tests of universalistic, contingency, and configurational performance predictions. *Academy of Management Journal,* 39: 802-835.

Dess, G. G., & Davis, P. S. 1984. Porter's (1980) generic strategies as determinants of strategic group membership and organizational performance. *Academy of Management Journal,* 27: 467-488.

Dess, G. G., Lumpkin, G. T., & Covin, J. G. 1997. Entrepreneurial strategy making and firm performance: Tests of contingency and configurational models. *Strategic Management Journal,* 18(9): 677-695.

Dierickx, I., & Cool, K. 1989. Asset stock accumulation and sustainability of competitive advantage. *Management Science*, 35: 1504-1511.

Dion, D. 1998. Evidence and inference in the comparative case study. *Comparative Politics*, 31(3):127-145.

Doty, D. H., & Glick, W. H. 1994. Typologies as a unique form of theory building: Toward improved understanding and modeling. *Academy of Management Review,* 19: 230-251.

Doty, D. H., Glick, W. H. & Huber, G. P. 1993. Fit, equifinality, and organizational effectiveness: A test of two configurational theories. *Academy of Management Journal,* 36: 1196-1250.

Downs, G. W. 1989. The rational deterrence debate. *World Politics*, 41:225-237.

Drass, K., & Ragin, C. C. 1992. *QCA: Qualitative comparative analysis*. Evanston: Institute for Policy Research, Northwestern University.

Drass, K., & Ragin, C. C. 1999. *fs/QCA: Fuzzy set/qualitative comparative analysis*. Evanston: Institute for Policy Research, Northwestern University.

Drazin, R., & Van de Ven, A. H. 1985. Alternative forms of fit in contingency theory. *Administrative Science Quarterly,* 30: 514-539.

Dyas, G. P., & Thanheiser, H. T. 1976. *The emerging European enterprise: Strategy and structure in French and German industry*. Boulder, CO: Westview.

Eisenhardt, K. D. 1988. Agency- and institutional-theory explanations: The case of retail sales compensation. *Academy of Management Journal,* 31: 488-511.

Ferguson, T.D., & Ketchen, D.J. 1999. Organizational configurations and performance: The role of statistical power in extant research. *Strategic Management Journal,* 20: 385-395.

Fiegenbaum, A., & Thomas, H. 1990. Strategic groups and performance: The U.S. insurance industry, 1970-84. *Strategic Management Journal,* 11: 197-215.

Galunic, D. C., & Eisenhardt, K. M. 1994. Reviewing the strategy-structure-performance paradigm. *Research in Organizational Behavior,* 16: 215-255.

Galunic, D. C., & Rodan, S. 1998. Resource combinations in the firm: Knowledge structures and the potential for Schumpeterian innovation. *Strategic Management Journal*, 19: 1193-1201.

Ganzach, Y. 1998. Nonlinearity, multicollinearity and the probability of Type II error in detecting interaction. *Journal of Management,* 24: 615-622.

Gavetti, G., & Levinthal, D. 2000. Looking forward and looking backward: Cognitive and experiential search. *Administrative Science Quarterly,* 45: 113-137.

Geddes, B. 1990. How the cases you choose affect the answer you get: Selection bias in comparative politics. *Political Analysis*, 2:131-150.

Goldstone, J. A. 1997. Methodological issues in comparative macrosociology. *Comparative Social Research*, 16:121-132.

Greckhamer, T., & Misangyi, V. F., Elms, H., & Lacey, R. 2004. *An alternative view on firm performance: Complexity, heterogeneity, and conjunctive causality*. Working paper, University of Florida, Gainsville, Florida.

Gresov, C., & Drazin, R. 1997. Equifinality: Functional equivalence in organization design. *Academy of Management Review,* 22: 403-428.

Guest, D. E. 1997. Human resource management and performance: A review and research agenda." *International Journal of Human Resource Management*, 8: 263-276.

Guillén, M. F. 1994. *Models of management: Work, authority, and organization in a comparative perspective*. Chicago: University of Chicago Press.

Gupta, A. K., & Govindarajan, V. 1993. Methodological issues in testing contingency theories: An assessment of alternative approaches. In Yuji Ijiri (Ed.), *Creative and innovative approaches to the science of management:* 453-471. Westport, CT: Quorum Books.

Hall, P. A., & Gingerich, D. 2004. *Varieties of capitalism and institutional complementarities in the macroeconomy: An empirical analysis*. Max-Planck-Institut für Gesellschaftsforschung Discussion Paper 04/5, available at http://www.mpi-fg-koeln.mpg.de/pu/mpifg_dp/dp04-5.pdf

Hall, P. A., & Soskice, D. (Eds.). 2001. *Varieties of capitalism: The institutional foundations of competitive advantage*. Oxford: Oxford University Press.

Hambrick, D. C. 1983. An empirical typology of mature industrial-product environments. *Academy of Management Journal,* 26: 213-230.

Hambrick, D. C. 1984. Taxonomic approaches to studying strategy: Some conceptual and methodological issues. *Journal of Management,* 10: 27-41.

Hambrick, D.C. & Snow, C.C. 1989. Strategic reward systems. In C.C. Snow (Ed.), *Strategy, organization design and human resource management*, 84-97. Greenwich, CT: JAI.

Hamel, G. & Prahalad, C. K. 1985. Do you really have a global strategy? *Harvard Business Review*, 63:139-148.

Hollingsworth, J. R., & Boyer, R. (Eds.). 1997. *Contemporary capitalism: The embeddedness of institutions*. Cambridge: Cambridge University Press.

Huselid, M. A. 1995. The impact of human resource management practices on turnover, productivity, and corporate financial performance. *Academy of Management Journal*, 38:635-672.

Ichniowski, C., Shaw, L, & Prennushi, G. 1997. The effects of human resource management practices on productivity. *American Economic Review*, 87: 291-313.

Inkpen, A., & Chowdhury, N. 1995. The seeking of strategy where it is not: Towards a theory of strategy absence. *Strategic Management Journal,* 16: 313-323.

Jaikumar, R. 1986. Post-industrial manufacturing. *Harvard Business Review*, 37: 69-76.

Jaikumar, R. 1989. Japanese flexible manufacturing systems: Impact on the United States. *Japan and the World Economy*, 1: 113-143.

Kaufman, S. 1993. *The origins of order*. Oxford: Oxford University Press.

Katz, D., & Kahn, R. L. 1978. *The social psychology of organizations.* Second edition. New York: Wiley.

Ketchen, D. J., Combs, J. G., Russel, C. J., Shook, C., Dean, M. A., Runge, J., Lohrke, F., Naumann, S., Haptonstahl, D. E., Baker, R., Beckstein, B. A., Handlers, C., Honig, H. & Lamoureux, S. 1997. Organizational configurations and performance: A meta-analysis. *Academy of Management Journal,* 40: 223-240.

Ketchen, D. J., Thomas, J. B., & Snow, C. C. 1993. Organizational configurations and performance: A comparison of theoretical approaches. *Academy of Management Journal* 36: 1278-1313.

Ketchen, D. J., & Shook, C. L. 1996. The application of cluster analysis in strategic management research: An analysis and critique. *Strategic Management Journal,* 17: 441-485.

King, G., Koehane, R. O., & Verba, S. 1994. *Designing social inquiry: Statistic inference in qualitative research*. Princeton: Princeton University Press.

Kogut, B., MacDuffie, J. P., & Ragin, C. C. Forthcoming. Prototypes and strategy: Assigning causal credit using fuzzy sets. *European Management Review*.

Kogut, B., & Ragin, C. C. 2002. *Nations as institutional arenas: testing theories of complex causality*. Paper presented at the workshop on "Do Facts Matter in Elaborating Theories?" CRG-Ecole Polytechnique, Paris, France.

Lacey, R. 2001. *Creating generalized knowledge from case studies: A new methodological approach*. Paper presented at the Strategic Management Society 21st Annual International Conference, San Francisco.

Levinthal, D. A. 1997. Adaptation on rugged landscapes. *Management Science*, 43: 934-950.

Levinthal, D. A., & Warglien, M. 1999. Landscape design: Designing for local action in complex worlds. *Organization Science*, 10:342-357.

Lieberson, S. 1994. More on the uneasy case for using Mill-type methods in small-N comparative studies. *Social Forces*, 72:1225-1237.

MacDuffie, J. P. 1995. Human resource bundles and manufacturing performance: Organizational logic and flexible production systems in the world auto industry. *Industrial and Labor Relations Review*, 48: 197-221.

Meyer, A. D., Tsui, A. S., & Hinings, C. R. 1993. "Configurational approaches to organizational analysis. *Academy of Management Journal,* 36: 1175-1195.

Miles, R. E. & Snow, C. C. 1978. *Organization strategy, structure, and process.* New York: McGraw-Hill.

Milgrom, P., & J. Roberts. 1990. The Economics of modern manufacturing: Technology, strategy, and organization. *American Economic Review*, 80(3): 511-528.

Milgrom, P., & J. Roberts. 1995. Complementarities and fit: Strategy, structure, and organizational change in manufacturing. *Journal of Accounting and Economics*, 19: 179-208.

Miller, D. 1986. "Configurations of Strategy and Structure: A Synthesis." *Strategic Management Journal* 7: 233-249.

Miller, D. 1988. Relating Porter's business strategies to environment and structure: Analysis and performance implications. *Academy of Management Journal,* 31: 280-308.

Miller, D. 1992. Environmental fit versus internal fit. *Organization Science,* 3: 159-178.

Miller, D. 1996. Configurations revisited. *Strategic Management Journal,* 17: 505-512.

Miller, D., & Friesen, P. H. 1984. *Organizations: A quantum view.* Englewood Cliffs, NJ: Prentice-Hall.

Mintzberg, H. 1979. *The structuring of organizations: A synthesis of research.* Englewood Cliffs, NJ: Prentice-Hall.

Mintzberg, H. 1980. Structures in 5's: A synthesis of the research on organization design. *Management Science,* 26: 322-341.

Mintzberg, H. 1983. *Structures in 5's: Designing effective organizations*. Englewood Cliffs, NJ: Prentice-Hall.

Morel, B., & Ramanujam, R. 1999. Through the looking glass of complexity: The dynamics of organizations as adaptive and evolving systems. *Organization Science*, 10:278-293.

Most, B., & H. Starr. 1989. *Inquiry, Logic, and International Politics*. Columbia: University of South Carolina Press.

Parthasarthy, R., & Sethi, S. P. 1993. Relating strategy and structure to flexible automation: A test of fit and performance implications. *Strategic Management Journal*, 14:529-549.

Pennings, J. 1992. Structural contingency theory: A reappraisal. *Research in Organizational Behavior,* 14: 267-309.

Peteraf, M. 1993. The cornerstones of competitive advantage: A resource-based view. *Strategic Management Journal*, 14: 179-191.

Pfeffer, J. 1994. *Competitive advantage through people: Unleashing the power of the work force*. Boston : Harvard Business School Press.

Porter, M. 1980. *Competitive strategy.* New York: Free Press.

Porter, M. 1996. What is strategy? *Harvard Business Review*, 74(6):61-78.

Porter, M., & Siggelkow, N. 2004. *Contextual interactions within activity systems and sustainable competitive advantage*. Working paper available from http://www-management.wharton.upenn.edu/siggelkow/pdfs/contex17.pdf

Ragin, C. C. 1987. *The comparative method: Moving beyond qualitative and quantitative strategies.* Berkeley, CA: University of California Press.

Ragin, C. C. 1994. *Constructing social research: The unity and diversity of method*. Thousand Oaks: Pine Forge Press.

Ragin, C. C. 2000. *Fuzzy set social science.* Chicago: University of Chicago Press.

Ragin, C. C. 2003. *Recent advances in fuzzy-set methods and their application to policy questions*. Working paper available at http://www.compasss.org/Ragin2003.PDF

Ragin, C. C. 2004. *From fuzzy sets to crisp truth tables*. Working paper available at http://smalln.spri.ucl.ac.be/RaginFSForthcoming.PDF

Ragin, C. C., & Fiss, P.C. 2004. *Fuzzy Set Policy Analysis*. Unpublished book manuscript. University of Arizona, Tucson, Arizona.

Ragin, C. C., & Sonnet, J. Forthcoming. Between complexity and parsimony: Limited diversity, counterfactual cases, and comparative analysis. In Kropp, S., & Minkenberg, M. (Eds.), *Vergleichen in der Politikwissenschaft*. Wiesbaden: VS Verlag für Sozialwissenschaften.

Rivkin, J. W. 2000. Imitation of complex strategies. *Management Science*, 46:824-844.

Roscigno, V. J., & Hodson, R. 2004. The organizational and social foundations of worker resistance. *American Sociological Review*, 69:14-39.

Shadish, W. R., Cook, T. D., & Campbell, D. T. 2002. *Experimental and quasi-experimental designs for generalized causal inference*. Boston: Houghton Mifflin.

Siggelkow, N. 2001. Change in the presence of fit: The rise, the fall, and the renaissance of Liz Claiborne. *Academy of Management Journal*, 49:838-857.

Siggelkow, N. 2002. Misperceiving interactions among complements and substitutes: Organizational consequences. *Management Science*, 48:900-916.

Streeck, W. 1992. *Social institutions and economic performance: Studies on industrial relations in advanced European capitalist countries* London: Sage.

Sutton, R. I., & Staw, B. M. 1995. What theory is not. *Administrative Science Quarterly,* 40: 371-384.

Thomas H, & Venkatraman, N. 1988. Research on strategic groups: Progress and prognosis. *Journal of Management Studies,* 25: 537-555.

Van de Ven, A., & Drazin, R. 1985. The concept of fit in contingency theory. *Research in Organizational Behavior,* 7: 333-365.

Wernerfeldt, B. 1984. A resource-based view of the firm. *Strategic Management Journal*, 5: 171-180.

Whitley, R. 1999. *Divergent capitalisms: The social structuring of business systems*. Oxford: Oxford University Press.

Whittington, R., Pettigrew, A., Peck, S., Fenton, E., & Conyon, M. 1999. Change and complementarities in the new competitive landscape: A European panel study, 1992-1996. *Organization Science,* 10: 583-600.

Wiggins, R. R., & Ruefli, T. W. 1995. Necessary conditions for the predictive validity of strategic groups: Analysis without reliance on clustering techniques. *Academy of Management Journal,* 38: 1635-1656.

Wood, S. 1999. Human resource management and performance. *International Journal of Management*, 1:376-413.

Wood, S., & de Menezes, L. 1998. High commitment management in the U.K.: Evidence from the Workplace Industrial Relations Survey, and Employers' Manpower and Skills Practices Survey. *Human Relations*, 51:485-515.

Wright, P. M., & McMahan, G. C. 1992. Theoretical perspectives for strategic human resource management. *Journal of Management*, 18: 295-320.

TABLE 1

Truth Table for Hypothetical Combinations of Organizational Characteristics

| Configuration Number | Organizational Characteristics | | | | Outcome |
| | A | B | C | D | Z |
	Efficient Production System	High Rate of Product Innovation	Heterogeneous Environment	Hierarchical Control Structure	High Performance
1	Yes	Yes	Yes	Yes	Yes
2	Yes	Yes	Yes	No	No
3	Yes	Yes	No	Yes	Yes
4	Yes	Yes	No	No	Yes
5	Yes	No	Yes	Yes	No
6	Yes	No	Yes	No	No
7	Yes	No	No	Yes	Yes
8	Yes	No	No	No	Yes
9	No	Yes	Yes	Yes	Yes
10	No	Yes	Yes	No	No
11	No	Yes	No	Yes	Yes
12	No	Yes	No	No	No
13	No	No	Yes	Yes	?
14	No	No	Yes	No	No
15	No	No	No	Yes	?
16	No	No	No	No	?