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Organizational Complexity and Innovation: Developing and Testing Multiple Contingency Models

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Current research in organizational innovation is extensive, yet, because of limitations in scope, most studies are not adequately encompassing. These studies typically relate organizational variables to innovation and control at most for the effect of one contingency factor. Because innovation depends upon a complex host of factors, such theories have limited predictive application. This study intends to develop and test theories that explain the variation in the organizational complexity-innovation relationship in greater detail. The study considers two major indicators of organizational complexity—structural complexity and organizational size. Hypotheses are proposed on the effects of 14 contingency factors on the relationships between structural complexity and innovation and organizational size and innovation. The contingency factors include environmental uncertainty, organizational size, industrial sectors, types of innovation, and stages of innovation adoption. Using a meta-analytic procedure for multivariate analysis, the hypotheses are then tested with data from published studies in organizational innovation during the last three decades. The effects of four methods variables—operational definitions of innovation, structural complexity and size, and similarity of data sources—are controlled for in testing the hypotheses. This process results in two powerful and encompassing models: (1) the association between structural complexity and innovation depends upon operational definition of complexity, environmental uncertainty, use of manufacturing organizations, use of service organizations, focus on technical innovations, focus on product innovations, and focus on implementation of innovation; and (2) the association between organizational size and innovation depends upon operational definition of size, environmental uncertainty, use of service organizations, use of for-profit organizations, focus on technical innovations, and focus on product innovations. These models suggest avenues for further theory development and research, which we discuss.

(*Organizational Innovation; Structural Complexity; Organizational Size; Contingency Model; Meta-analysis*)

Introduction

Despite continued scholarly effort in the past three decades to understand both the innovation process and the conditions under which innovation is facilitated, current empirically developed theories of organizational innovation are not adequately encompassing. These theories either relate one predictor variable to innovation—for example, complexity is positively associated with innovation—or consider the moderating effect of a third variable on the predictor variable-innovation relationship—for example, complexity is more positively related to innovation in turbulent than in stable environments. Innovation is a complex construct, however, and innovation theories including only two or three variables have limited predictive ability. This study intends to develop a more encompassing theory of organizational complexity and innovation. It

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employs an approach to theory-building that has proven effective for developing more complete theories of relationships between organizational variables when the relationships are influenced by multiple contingency factors (Huber et al. 1990, Miller et al. 1991).

The study focuses on two aspects of organizational complexity—structural complexity and organizational size. They are important facets of organizational growth and complexity (Whetten 1987) and are among the most important predictors of organizational innovation (Ettlie et al. 1984, Kimberly and Evanisko 1981). Despite a considerable number of empirical studies, however, no highly explanatory theory of structural complexity-innovation and size-innovation yet exists. Past studies have explored variation in innovation alone; in contrast, this study examines variations in two relationships: (1) variation in the relationship between structural complexity and innovation; and (2) variation in the relationship between organizational size and innovation. The dependent variables, therefore, are the association between structural complexity and innovation and the association between organizational size and innovation, each of which is regressed on three groups of contingency factors. Structural complexity and organizational size are themselves associated, but because they are used here as two separate indicators of organizational complexity that association is not a focus of this study.

Fourteen contingency factors are included in this study and are categorized in three groups: (1) commonly cited contingency factors (environmental uncertainty, organizational size); (2) industrial sectors (manufacturing, service, for-profit, and not-for-profit); and (3) dimensions of innovation, including types of innovation (administrative, technical, product, process, radical, and incremental) and stages of innovation adoption (initiation and implementation). These represent extra-organizational factors and innovation attributes that are commonly believed to influence structure-innovation relationships (Damanpour 1991, Tornatzky and Klein 1982).[1] Hypotheses about the effects of the contingency factors on the structural complexity-innovation and organizational size-innovation relationships are developed; these hypotheses are then tested by simultaneously considering the effects of each group of contingency factors using Hedges and Olkin's (1985) meta-analysis method for testing multivariate theories. This process results in a seven-variable theory of the structural complexity-innovation relationship and a six-variable theory of the organizational size-innovation relationship.

[1] While the contingency factors were selected primarily based on their importance in organization studies, and especially in studies of organizational innovation, because meta-analysis methods are used for model testing, availability of past empirical results also affected the inclusion of contingency factors.

Innovation, Structural Complexity, and Size

Definition of Innovation

Innovation has been studied at the level of the industry, the firm, or the individual. This study focuses on innovation at the organizational level, where it is defined as the adoption of an idea or behavior new to the adopting organization (Daft 1978, Damanpour and Evan 1984). In this definition, the adoption of innovation is conceived as a process that includes the generation, development, and implementation of new ideas or behaviors. Further, innovation is conceived as a means of changing an organization, either as a response to changes in the external environment or as a preemptive action to influence the environment. Hence innovation is here broadly defined to encompass a range of types, including new products or services, new process technologies, new organizational structures or administrative systems, or new plans or programs pertaining to organizational members.

Structural Complexity-innovation Relationship

Structural complexity has been defined and measured in different ways, for instance, as the number of locations at which work is performed, as the number of jobs or services performed, or as the number of hierarchical ranks performing different tasks (Mileti et al. 1977, p. 210). Four dimensions of differentiation in organizations—spatial, occupational, hierarchical, and functional—are considered by Blau to constitute the core of the formal structure of organizations (1970, p. 201). The degree of structural complexity is often indicated by the extent of differentiation along these four dimensions (Hall 1977, Miller and Contay 1980). This study focuses

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on two dimensions: (1) *departmentation or functional differentiation*, the extent to which an organization is divided into structural components or units (Aiken et al. 1980, Kimberly and Evanisko 1981); and (2) *role specialization or occupational differentiation*, the variety of specialists that work in an organization (Hage and Aiken 1967, Damanpour 1987). Both dimensions represent the extent of horizontal complexity of an organization and are generally considered as better predictors of innovation than vertical and spatial dimensions.

Research results demonstrate that structural complexity is positively associated with innovation (Ettlie et al. 1984, Zmud 1984). In complex organizations, coalitions of specialists in differentiated subunits increase the depth of the knowledge base which, in turn, increases the development of new ideas (Aiken and Hage 1971). Also, a greater variety of specialists provides a more diversified knowledge base and increases cross-fertilization of ideas, both of which result in more innovation (Aiken and Hage 1971, Kimberly and Evanisko 1981). The results of empirical research are fairly consistent on the direction of the complexity-innovation relationship; however, the variance of research results is high (Damanpour 1991). The conditions under which this positive relationship is particularly strong (or weak) have not been clearly identified; this study is designed to articulate those conditions more clearly.

Size-innovation Relationship

Size is one of the most important factors affecting the structure and processes of an organization (Blau 1970, Kimberly 1976). Both advantages and disadvantages are associated with large size. While large organizations have more slack resources for new projects and diversification, greater challenges and more opportunities for promotion and growth among their employees, and more control over the external environment, they also are more bureaucratic and less flexible, are unable to change and adapt quickly, and tend to have impersonal work environments (Hitt et al. 1990, Whetten 1987).

The functional and dysfunctional consequences of large size have, in turn, influenced arguments about the effect of size on innovation. Some researchers have argued that size would affect innovation positively because large organizations have more financial slack, marketing skills, research capabilities, and product development experience (Kimberly and Evanisko 1981, Nord and Tucker 1987, Young et al. 1981). Large organizations are thus better able to tolerate potential losses caused by unsuccessful innovations. Also, large organizations employ more professional and skilled human resources, and have high technical knowledge and technical potential and, thus, are in the forefront of technological development (Dewar and Dutton 1986, Ettlie et al. 1984).

However, large size has also been said to inhibit innovation (Aldrich and Auster 1986, Hage 1980) because large organizations are typically more formalized, managerial behavior is more standardized, inertia is higher, and managerial commitment to innovation is lower (Hitt et al. 1990). Small organizations, on the other hand, are said to be more innovative because they are more flexible, have greater ability to adapt and improve, and demonstrate less difficulty accepting and implementing change. Innovation requires the coupling of different parts of an organization (Mintzberg 1979), which can be achieved more easily in small than in large organizations (Nord and Tucker 1987).

Clearly, researchers' views on the size-innovation relationship are incongruent. Each group of researchers can refer to ample empirical findings in support of its argument (see Ettlie and Rubenstein 1987, p. 90–91). In a previous study, to resolve this issue, the author conducted a meta-analytical review and found a positive relationship between size and innovation (Damanpour 1992). However, the variance among research results was high, even after accounting for the independent effects of several moderators. Because this earlier study used a meta-analysis procedure (Hunter et al. 1982) that is limited to testing individual hypotheses with *t*-tests of difference between subsample, it could only report the effect of one moderator variable at a time on the size-innovation relationship. The present study uses a different form of meta-analysis (Hedges and Olkin 1985) which allows for accounting the simultaneous effects of multiple moderating factors; it also employs a larger number of contingency factors. The present analysis thus provides a more general and reliable theory of organizational size and innovation than the previous one.

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Models of Complexity-innovation and Size-innovation

The above review suggests two possible models of organizational complexity and innovation: (1) structural complexity is positively associated with innovation; and (2) organizational size is positively associated with innovation. In this section, a series of contingency hypotheses is developed for each of the two models using the three groups of contingency factors.

Commonly Cited Contingency Factors

Environmental Uncertainty. Environmental uncertainty is determined by both *environmental complexity*—the extent and variety of environmental components—and *environmental variability*—the frequency and predictability of changes in environmental components (Daft 1992, Duncan 1972). The more complex and changing the environment, the higher is the level of environmental uncertainty. From an information perspective, organizations need to process more information for decision-making when environmental uncertainty is high (Galbraith 1973).

Past research shows that environmental uncertainty would positively affect all types of organizational change and innovation, including those that are externally focused (e.g., changes in strategy or customer relations), those that are internally focused (e.g., changes in production process or culture), or those that change organizational form (Huber et al. 1993). Under conditions of low environmental uncertainty, organizations would be neither structurally complex nor innovative; thus, both organizational complexity and innovation would exhibit restriction of range, and their associations would be weak (less positive). However, as environmental uncertainty increases, more variety in both innovation and complexity would result, leading to a stronger (more positive) relationship between the latter two variables.[2]

[2] When environmental uncertainty becomes very high, both complexity and innovation could exhibit restriction of range again (i.e., they would be high for most firms). Thus, this study excludes the conditions of extremely high uncertainty and compares the conditions of low uncertainty with conditions of moderately high uncertainty. The author is thankful to an anonymous reviewer for pointing out this assumption.

For example, under conditions of high uncertainty, some organizations may create specialized staff positions and units to secure and evaluate relevant information (Child 1977). These organizations try to develop the expertise to deal with a variety of environmental components and to launch coordinated responses to emerging environmental conditions. Differentiating the structure by creating specialized positions and units, and introducing integrating devices to coordinate them, would then increase the size of the organization. Other organizations in response to environmental uncertainty may adopt a flexible structure and reduce their size by decentralizing decision making to the lowest levels; they create smaller, fully independent units that focus on a certain segment of the environment. These units could purchase support or services from sources outside of the organization, reducing the size of the corporate staff and support groups within the organization. Therefore, while under conditions of low uncertainty, most organizations would exhibit low levels of organizational complexity, at higher levels of uncertainty, more variety in both structural complexity and size would exist.

HYPOTHESIS 1a. *Structural complexity would be more positively related to innovation in organizations operating under high than those operating under low environmental uncertainty.*

HYPOTHESIS 1b. *Organizational size would be more positively related to innovation in organizations operating under high than those operating under low environmental uncertainty.*

Organizational Size. The effect of size as a contingency factor is applied to the structural complexity-innovation relationship only. The structure of most small organizations is simple, but, as organizations expand, their structures become more differentiated and specialized. Growth in size, especially growth from diversification, might also make the structure more hierarchical and formalized, to enable top managers to achieve control over diversified activities (Child 1973, Mintzberg 1979). Because bureaucratic control influences innovations negatively (Pierce and Delbecq 1977), some large organizations may adopt structures that are flexible and simple. Therefore, a greater variety of struc-

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tural forms would exist for large than for small organizations; structural complexity exhibits a limited range of values in small organizations.

Innovation would also exhibit a more limited range in small organizations, as a greater variety of innovations of different types could be associated with large organizations. For example, when organizations become larger, they face more difficult problems of administrative control and coordination, in response to which they would adopt administrative innovations (Kimberly and Evanisko 1981). Or, in the early stages of their growth, when firms are small, they emphasize product performance and would primarily introduce product innovations; but, as they grow larger, they would also introduce process innovations to improve productivity in the production process (Utterback and Abernathy 1975). Thus,

HYPOTHESIS 2. *Structural complexity would be more positively related to innovation in large organizations than in small organizations.*

Industrial Sectors

Manufacturing and Service. Because of differences in service and manufacturing technologies, everything else being equal, service organizations require more specific structures than manufacturing organizations. Service technologies are more intangible and variable than manufacturing technologies (Kotler 1986). While in a typical manufacturing organization, outputs can be produced and stored for later usage, in a typical service organization, production and consumption of outputs are more simultaneous (Daft 1992). That is, while in the manufacturing organization the technical core can be buffered from the customer to reduce disruptions, in the service organization, the producer and the customer should interact for the delivery of the output to be complete (Mills and Margulies 1980). Employees in service organizations thus would need to have more decision-making authority and more flexibility in dealing with their clients than those in manufacturing organizations (Huber et al. 1990), especially when the degrees of interaction with clients and customization of services are high (Miller et al. 1991). Hence, these organizations' structures need to be more horizontally differentiated and their roles more specialized. For example, private banking divisions of many banks group and train lending officers to serve specific clients, such as doctors, lawyers, corporate executives, small business executives, artists, and entertainers. Such specialization would restrict the range of values for structural complexity in service more than in manufacturing organizations, suggesting a weaker relationship between structural complexity and innovation in service organizations.

The size-innovation relationship also would be weaker in service than in manufacturing organizations because large size would create less advantageous condition for service organizations. An increase in size generally results in more formalization, and it might inhibit the service provider's flexibility to deal with customer unpredictability. When manufacturing firms grow in size, more outputs can be produced with more regularity because a higher level of standardization can be introduced into the buffered technical core. In a service firm, the introduction of higher standardization might constrain the service provider-client relation. Moreover, while a manufacturing firm can aggregate operations in a single location for economies of scale, the greatest economies for a service firm are achieved through disaggregation into small units that can be located close to the customer and serve his/her specific needs (Daft 1992). Thus size would exhibit a more limited range of values in service compared to manufacturing firms. Therefore,

HYPOTHESIS 3a. *Structural complexity would be more positively related to innovation in manufacturing organizations than in service organizations.*

HYPOTHESIS 3b. *Organizational size would be more positively related to innovation in manufacturing organizations than in service organizations.*

For-profit and Not-for-profit. On average, the range of values for innovation is more restricted in not-for-profit than for-profit organizations. Not-for-profit organizations are subject to greater influence by external political and regulatory institutions, are more constrained by external rules, and are exposed to more external scrutiny and accountability than for-profit organizations (Perry and Rainy 1988). Decision-making flexibility is constrained by external control (Dean et al. 1991); thus, not-for-profit organizations take fewer risks in their strategic decisions, which would negatively

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influence innovation because innovation, as departure from existing norms and practices, requires risk taking. Moreover, research has suggested that the high degree of external control characteristic of not-for-profit organizations has a negative influence on their executives' desire to delegate authority, thus creating higher levels of centralization, formalization, and standardization of personnel procedures than are typical in for-profit organizations (Perry and Rainy 1988). High bureaucratic control also inhibits innovation (Pierce and Delbecq 1977). In summary, external forces that promote well-specified outcomes and accountability in performance generate complex internal and external standard operating procedures (Tushman and Romanelli 1985), which would limit the extent of innovation in not-for-profit organizations. Thus,

HYPOTHESIS 4a. *Structural complexity would be more positively related to innovation in for-profit than not-for-profit organizations.*

HYPOTHESIS 4b. *Organizational size would be more positively related to innovation in for-profit than not-for-profit organizations.*

Dimensions of Innovation

Administrative and Technical. The distinction between administrative and technical innovations is commonly considered to be important in studies of structure-innovation because: (1) it relates to a more general distinction between the social and the technical systems of an organization (Damanpour and Evan 1984); and (2) administrative and technical innovations are initiated in different parts of the organization and follow different processes of adoption (Daft 1978). *Administrative innovations* pertain to organizational structure, administrative processes, and human resources (Damanpour and Evan 1984); they are indirectly related to the basic work activity of an organization and directly related to its management (Kimberly and Evanisko 1981). *Technical innovations* pertain to products, services, and the technology used to produce products or render services (Damanpour and Evan 1984); they are directly related to the basic work activity of an organization (Kimberly and Evanisko 1981).

Administrative innovations are primarily adopted in organizations that are large and structurally more complex. As stated earlier, these organizations face more difficult problems of control and coordination of differentiated units; thus, they would adopt administrative innovations to solve such problems. In addition, these organizations may adopt administrative innovations because of the larger size of their administrative components, through which most administrative innovations are introduced (Daft 1978). Technical innovations would be adopted in organizations with a greater variety of structures as they are perceived to be relatively more advantages than administrative innovations (Damanpour and Evan 1984). Hence, the range of values for both structural complexity and organizational size might vary less with respect to the adoption of administrative innovations than to the adoption of technical innovations, suggesting a more positive relationship between technical innovations and both structural complexity and size. Empirical findings from the studies that have distinguished between administrative and technical innovations support this assertion (Damanpour 1987, Kimberly and Evanisko 1981, Zmud 1984). Therefore,

HYPOTHESIS 5a. *Structural complexity would be more positively related to technical than to administrative innovations.*

HYPOTHESIS 5b. *Organizational size would be more positively related to technical than to administrative innovations.*

Product and Process. *Product innovations* refer to the introduction of new products or services to meet an external market or user need. *Process innovations* refer to the introduction into the organization's production process or service operations of new elements (e.g., input materials, task specifications, work and information flow, and equipment) that are used to produce a product or render a service (Ettlie and Reza 1992, Utterback and Abernathy 1975).

On average, firms adopt more product than process innovations (Myers and Marquis 1969). Process innovations are: (1) less observable and perceived to be relatively less advantageous, as they are merely related to the delivery of outcomes, rather than being the outcome themselves;[3] and (2) more difficult to implement, as

[3] This point is primarily based on past studies conducted in North America. Since the success of Japanese manufacturing firms in im-

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their successful implementation depends upon more widespread changes in organizational structure and administrative systems (Ettlie and Reza 1992). A survey of executives indicated that, on average, firms introduce more product than process innovations in every stage of their life cycle (Strebel 1987). However, research suggests that the emphasis firms place on each type varies in different stages (Utterback and Abernathy 1975). As discussed earlier, in the early stages, when the firm is small and its structure simple, it primarily introduces product innovations, but as the firm grows and becomes more complex, it also introduces process innovations (Utterback and Abernathy 1975). Thus, conditions of high complexity and large size are more advantageous for process than for product innovations, resulting in a more positive relationship between both complexity and size with process than with product innovations.

HYPOTHESIS 6a. *Structural complexity would be more positively related to process than to product innovations.*

HYPOTHESIS 6b. *Organizational size would be more positively related to process than to product innovations.*

Radical and Incremental. The adoption of innovation changes both the structure and the processes of an organization; however, the extent of change is not equal for all innovations. Thus, innovations can be classified according to the degree of change they cause in an organization. Systematically different patterns of structure and process exist between innovations of different degrees of radicalness or "novelty" (Pelz and Munson 1982, Van de Ven and Chu 1989). Different classifications of innovation radicalness can be collapsed into the following two definitions: *radical innovations* are those that produce fundamental changes in the activities of the organization and represent a large departure from existing practices; and *incremental innovations* are those that result in a lesser degree of departure from existing practices (Dewar and Dutton 1986, Ettlie et al. 1984).

Radical innovations, on average, are less frequently adopted than incremental innovations. They present a more severe challenge to the existing structure of political influence, causing more resistance during their implementation (Frost and Egri 1991). They are more original, appear more complex to organizational members, and generate greater uncertainty about the structural requisites to develop and implement them (Gopalakrishnan and Damanpour 1994, Pelz 1983). Research findings suggest that large organizations are more successful than small ones in introducing radical innovations because radical innovations typically require technical knowledge and slack resources that are available to large and complex organizations (Ettlie and Rubenstein 1987). Large organizations have the resources to overcome obstacles against radical innovations; for instance, human and technical resources to initiate and develop these innovations and financial resources to absorb the higher cost of failure of such innovations. Therefore, the advantages of complexity and size are more important for radical than for incremental innovations, suggesting a more positive relationship between both of them and radical innovations.

HYPOTHESIS 7a. *Structural complexity would be more positively related to radical than to incremental innovations.*

HYPOTHESIS 7b. *Organizational size would be more positively related to radical than to incremental innovations.*

Initiation and Implementation. There are quite a few stage models of the innovation process (Schroeder et al. 1989, Wolfe 1994), but there is little research, other than case studies, to ascertain these models' empirical validity. In the present study, a two-stage conceptualization, advocated by Rogers (1983) and Zaltman et al. (1973), is adopted: *initiation of innovation* is defined as consisting of all activities pertaining to problem perception, information gathering, attitude formation and evaluation, and resource attainment leading to a decision to adopt; and *implementation of innovation* is defined as consisting of all the events and actions pertaining to modification of both the innovation and the organization, the initial utilization, and the continued use of the innovation until it becomes a routine feature of the organization.

The "ambidextrous" model of organizational innovation proposes that high organizational complexity facilitates the initiation of innovations, while low complexity facilitates their implementation (Duncan 1976).

proving product quality by primarily process innovations, management researchers have recently emphasized the importance of process innovations in organizations (Davenport 1993).

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That is, greater complexity leads to a greater variety and diversity of available information and more new proposals for innovation. But greater complexity also leads to a variety of opinions and potential conflicts, and more difficulty in reaching consensus, which could cause more difficulty in implementing innovations (Duncan 1976, Zaltman et al. 1973). Despite the soundness of the "ambidextrous" model, research results on the effect of organizational complexity on initiation and implementation of innovation are mixed (Marino 1982, Zmud 1982).

Similarly, there is discrepancy between theory and research findings on size's effect on the initiation and the implementation of innovations. Theory suggests that large size facilitates the initiation of innovations because large firms possess greater knowledge resources, greater professionalism, and more differentiated structure, while small size facilitates the implementation of innovations because small firms "require less communication, less coordination, and less influence to gather support" (Nord and Tucker 1987, p. 18). A recent review of empirical research, however, has suggested that size is more strongly related to the implementation than to the initiation of innovations (Damanpour 1992).

The discrepancy between theoretical arguments and empirical findings might be explained by the fact that the arguments apply only to a certain group of organizations. For example, large "machine bureaucracies" (Mintzberg 1979) are structurally complex, have a dual-structure for operation and innovation, and are more likely than small organizations to initiate more and implement fewer innovations. This initiation-implementation distinction may not be applicable to organizations such as "adhocracies" (Mintzberg 1979), however. These organizations also are structurally complex, but they rely less on bureaucratic control and more on horizontal coordination to facilitate the implementation of innovations.

Moreover, large organizations can facilitate the implementation of innovations by adopting more flexible structures and organizing themselves into smaller units. For example, a longitudinal survey of innovations and innovative firms in the United Kingdom found that large, divisionalized organizations had, over time, reduced the size of their divisions and increased their share of innovations (Pavitt et al. 1989). Additionally, large organizations may not initiate and develop all innovations internally; instead, they may purchase the innovation from outside, or generate it through partnerships, joint ventures, or licensing agreements with other firms. Contrary to previous theories, therefore, this study expects that there would be no significant difference in the effect of organizational complexity on initiation and implementation of innovations.

HYPOTHESIS 8a. *Structural complexity's influence on the initiation of innovation would not be significantly different from its influence on the implementation of innovation.*

HYPOTHESIS 8b. *Organizational size's influence on the initiation of innovation would not be significantly different from its influence on the implementation of innovation.*

Methods

The above hypotheses represent two models: one pertaining to the relationship between structural complexity and innovation, and the other pertaining to the relationship between organizational size and innovation. Each model contains three groups of hypothesized determinants: commonly cited contingency factors, industrial sectors, and innovation dimensions. A theory-testing meta-analysis (Hedges and Olkin 1985) was employed to test the three groups of hypotheses; a more widely applied meta-analysis procedure (Hunter et al. 1982) was rejected because it is limited to testing individual hypotheses (i.e., the effect of one contingency factor at a time). Hedges and Olkin's (1985) procedure was more suitable because it allows for dealing with multiple contingency factors. It involves using multiple regression analysis to test several sets of contingency hypotheses while controlling for methods variables simultaneously (Miller et al. 1991). The method has been employed recently in two organizational studies that have clearly demonstrated its usefulness in explaining variations in a relationship (Huber et al. 1990, Miller et al. 1991). This study follows the same procedure as did the two previous studies.

Sample

Empirical studies published in the last three decades in English language publications that related structural complexity or size to organizational innovation constituted the sample for this study. These studies were iden-

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tified through Damanpour's (1991) review, which searched *Sociological, Psychological, and Economic Abstracts*. Twenty-one relevant studies were found that included 27 correlations (a pool of 1867 observations) that related structural complexity to innovation and 36 correlations (a pool of 3050 observations) that related organizational size to innovation. (The list of studies, as well as all variables' codings, is available from the author.)

The domain of innovation research is very broad, and not all empirical studies of innovation could be included in this paper. Studies were selected based on the following criteria: (1) the main dependent variable was organizational innovation;[4] (2) the analysis addressed the organizational, rather than the individual or organizational population, level of innovation; (3) at least two innovations were studied; and (4) the study was published in a scholarly book or journal. When several publications were based on one data set (e.g., Kimberly and Evanisko 1981 and Moch 1976 used the same data collected from a sample of hospitals), only one publication was included. When studies used multiple independent samples (e.g., Kaluzny et al. 1974 and Dewar and Dutton 1986 reported correlation coefficients for more than one type of innovation), or were repeated over time (Aiken and Hage 1971 and Hage and Aiken 1967), multiple correlations from a study were considered only if each correlation represented a unique combination of the structural complexity-innovation or size-innovation relationship. For example, the size-innovation correlation for implementation of innovations from Zmud (1982) was not included because the same correlation was included from Zmud (1984), which apparently used the same data set. (A list of studies excluded because they did not satisfy these criteria is also available from the author.)

Data for most variables were coded by the author and a Ph.D. student who was trained for this coding. The coding for each study was done separately, then compared when sets of studies were completed; the two coders reexamined the studies for which inconsistencies were discovered until complete agreement was reached. After six months, to reassess coding stability, the author reviewed all the studies originally collected and reexamined the coding once more. The reexamination resulted in adding one article that had not been included earlier; except for eight from a total of 370 coding assignments, the agreement between the two codings was complete. Data for environmental uncertainty, organizational size as a contingency factor, and similarity of data sources (defined below) were coded at a later date by the author. For reliability assessment, these three variables were also recoded after four months. Except for average organizational size in two studies, complete agreements existed between the two codings of the three variables.

Measures

Structural Complexity-innovation Correlations. Two indicators of structural complexity are often employed in studies of complexity and innovation: (1) functional differentiation, typically measured by the total number of units below the chief executive level (Blau and McKinley 1979, Young et al. 1982); and (2) occupational differentiation or role specialization, normally measured by the number of occupational specialties or job titles (Aiken et al. 1980; Hage and Aiken 1967). Complexity-innovation correlations, from studies that had employed one or both indicators of complexity, were coded. If a study had reported correlations between both indicators and innovation, an average correlation was computed.

Organizational Size-innovation Correlations. Correlations between size and innovation, from studies that had employed either a personnel or a nonpersonnel indicator of size, were coded. The personnel indicator was operationalized by the number of employees (Corwin 1975, Kim 1980); the nonpersonnel indicator was measured by physical capacity (number of beds in a hospital, Kimberly and Evanisko 1981), input or output volume (number of students in a school, Baldridge and

[4] In identifying the population of studies for a meta-analytic review, researchers should ensure that all relevant studies in that population are included; the accuracy of a meta-analytic review depends on the representativeness of the studies included (Guzzo et al. 1987). Although no search can be exhaustive, the use of only studies in which innovation was the main dependent variable ensured that all relevant studies were included in our analysis. On the other hand, the identification of all studies in which a structure-innovation relationship is reported, but in which innovation is not the main dependent variable, is nearly impossible and, hence, would most likely violate the inclusion rule.

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Burnham 1975), or financial resources (annual budget, Damanpour 1987). To prevent inappropriate conclusions, operational definitions of structural complexity, organizational size, and innovation were controlled for in the analyses (see Control Variables below).

Environmental Uncertainty. Environmental uncertainty was coded as high (=1) when the samples were characterized by firms in industries that experienced high environmental turbulence and competition, such as computer software or consumer electronic firms (Kim 1980, Zmud 1984). Environmental uncertainty was coded as low (=0) when samples were characterized by firms that operated under low environmental variability and competition, such as federal or local government agencies (Aiken et al. 1980, Damanpour 1987). The mean of binary code was used when the samples were characterized by firms in different industries (Miller and Friesen 1982) or firms operating under diverse environmental conditions (Kimberly and Evanisko 1981).

Average Organizational Size. Organizational size was coded as a contingency factor for the structural complexity-innovation relationship only. Using the number of employees, average size was coded as small (=0) if the firms in the sample averaged less than 500 employees, and large (=1) if the firms averaged 500 or more employees (Acs and Audretsch 1990, Huber et al. 1990). The average size was either directly reported in the original study (26 out of 38 independent samples) or, following Huber and colleagues (1990), it was coded as large or small by applying the 500-employee threshold to descriptions of the organizations in the original study. For example, Kimberly and Evanisko's (1981) data were derived from a study of approximately 1000 U.S. hospitals, apparently conducted in the late 1960s or early 1970s (Moch 1976). The average organizational size for this study was coded small because U.S. hospitals, on average, employed fewer than 500 employees at the time of the study.[5]

Industrial Sectors. The grouping of manufacturing and service and for-profit and not-for-profit organizations was based entirely on the original investigators' distinctions. The majority of original studies used firms from only one sector; only four studies either mixed manufacturing and service firms or did not specify the sector class, while five either mixed or did not clearly distinguish between for-profit and not-for-profit classes. Four dummy variables were created to reflect whether an organization belonged to a particular sector. For example, for manufacturing organizations, the dummy variable was coded as 1 if all the sample firms were reported by the original investigator as manufacturing organizations, and 0 if they were not. The three other sectors were coded similarly. This coding implies that the variables will not be fully independent and might be negatively correlated (Miller et al. 1991); however, it isolates firms in a specific sector from all other firms.

Dimensions of Innovation. Six dummy variables were created to code six innovation types. For each innovation type, a dummy variable was coded as 1 if all innovations studied were specified as that type in the original article, and 0 if they were not. Similarly, two dummy variables were created to code initiation and implementation of innovations. For initiation of innovations, for example, a code of 1 identifies a study in which only the initiation of innovations is investigated, and a code of 0 identifies a study that has not focused on initiation. Innovations were considered initiated when they were proposed but were not actually in use (Aiken et al. 1980); they were considered implemented when they were in use by organizational members or clients (Kim 1980).

Control Variables

The empirical findings of a study are affected by the research methods used in it. One advantage of the approach used in this study is that it can account for the influences of different methodologies in original studies (Miller et al. 1991). This accounting reduces the possibility that certain research methods will inflate or deflate the effects of contingency variables on the

[5] In 1969, the average number of employees in the general hospitals in the United States was 304 (Statistical Abstracts of the U.S., 1972: Table 106, p. 72); in 1972, it increased to 378, still below the 500 mark (Statistical Abstracts of the U.S., 1991: Table 167, p. 106). It should be noted, however, that the average size reached the 500 level in 1980, and has remained at more than 500 ever since (Statistical Abstracts of the U.S., 1991: Table 167, p. 106).

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complexity-innovation or size-innovation relationships. Four methods variables were included in the analysis to control for differences beyond those already hypothesized in the findings of the original studies.

Measure of Complexity. Past studies have measured structural complexity by different indicators. The strength of the complexity-innovation relationship is not the same for different indicators of complexity (Damanpour 1991). Thus, the differential influence of single versus multiple indicators is controlled for in this analysis. Accordingly, measure of complexity was coded as 0 when it was based on one of the two indicators of complexity adopted in this study and as 1 when it was based on both.

Measures of Size. Kimberly (1976) argued that the relationship between size and other organizational characteristics is influenced by the measure of size. The measure of size can relate to different aspects of size, such as number of employees, capacity, input or output volume, or financial resources (Kimberly 1976). The present study uses the distinction between personnel and nonpersonnel measures of size. Size was coded as 0 when the number of employees constituted the measure in the original study and as 1 when a nonpersonnel measure—such as sales, budget, or the number of beds in a hospital—was used.

Measure of Innovation. Organizational innovation typically is measured by the rate of adoption of innovations, which is often operationalized by the number of innovations adopted within a given period of time (Daft and Becker 1978, Kimberly and Evanisko 1981). Some studies, however, use a surrogate measure, such as the number of awards or the number of patents (Blau and McKinley 1979, Hull and Hage 1982). Different methods of operationalization of innovation can be a source of variance among studies (Bigoness and Perreault 1981); hence, studies that measured innovation by the number of adopted innovations were distinguished from those that used a surrogate measure. The measure of innovation was coded as 1 when it was based on the number of innovations initiated or implemented, and 0 when it was based on other measures of organizational innovation.

Similarity of Data Sources. Variation among the results of empirical studies also derives from whether the data on the dependent and independent variables are collected from the same or different sources. Wagner and Gooding (1987) reported significant differences between mean correlations of participation and several outcome variables when they grouped the sample into single-source (percept-percept) and multi-source (nonpercept-percept) data pools. Furthermore, Huber and colleagues (1990) found that centralization-effectiveness correlations are stronger (i.e., more negatively correlated) when centralization and effectiveness data are collected from similar rather than dissimilar sources. Therefore, similarity of data sources, for both complexity and innovation and size and innovation, was coded as low (=0) when the dependent and independent variables were collected from different sources (e.g., one by an objective and the other by a perceptual measure) and high (=1) when both variables were collected from the same source (Miller et al. 1991).

Analysis

The analysis involved three steps. First, using Hedges and Olkin's (1985) procedure, mean correlations between both structural complexity and innovation and organizational size and innovation, weighted on sample size, were calculated. Second, variances among correlations were calculated and corrected for variance due to sampling error. (If sampling error accounts for most of the variance among correlations, additional variables need not be introduced (Hedges and Olkin 1985, Hunter and Schmidt 1990).) Third, when unexplained variance, after correcting for sampling error, was still high, the complexity-innovation and size-innovation correlations were regressed on the three sets of contingency factors. The regression analyses are weighted analyses; each observation was weighted by sample size (Hedges and Olkin 1985). To determine the relative effects of each group of contingency factors and to prevent spurious conclusions, a conservative approach was adopted in regression analyses (Huber et al. 1990, Miller et al. 1991): (1) control variables were entered first, and remained in all regression models; (2) environmental uncertainty and average organizational size, the most commonly cited contingency factors, were entered next, and also remained in all subsequent regression models;

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Table 1 Correlation Matrix[a,b,c,d]

	1	2	3a	3b	4a	4b	4c	5
1. Complexity-Innovation Correlation								
2. Size-Innovation Correlation								
3 Similarity of Data Sources								
a Complexity	0 07							
b Size		0.01						
4 Measure of								
a Innovation	0 46***	−0 09	0 33	0 57***				
b. Complexity	0.13		0 37		−0.18			
c. Size		0 54***		0.31	0 21			
5. Environmental Uncertainty	0 28**	0.51***	−0.16	−0 11	0.10	−0 47*	0 00	
6. Organizational Size	−0.26**		0 04		0.02	−0 52**		0.37*
7. Industrial Sectors								
a. Manufacturing	0 34***	0.24***	−0 59**	−0.25	0 06	−0.46*	−0 25	0 36*
b. Service	0.11	−0.01	0 43*	0 35*	−0.10	0.77***	0.42*	−0.65***
c. For-Profit	−0.14	0.32***	−0 10	0.01	−0 03	−0.74***	−0.19	0 52***
d Not-for Profit	−0 33***	−0.53***	−0.06	0.13	−0 01	0 46*	−0.10	−0.82***
8 Innovation Types								
a. Administrative	−0.45***	−0.12	0.12	−0 02	0 06	0 06	0 05	0 23
b. Technical	0 45***	−0 15*	−0 46*	−0 21	−0 11	−0.17	−0 42*	−0 25
c. Product	0.08	0.27***	−0.21	−0.42*	−0.40*	−0.32	0.06	−0.05
d Process	0.28**	0.28***	−0 27	−0 15	0 20	−0 12	0.03	0.48**
e. Radical	0.21*	0 21***	−0.35	−0.05	0.11	−0.27	−0.01	0.22
f Incremental	0.16	0 10	−0.35	−0 05	0 11	−0.27	−0 01	0.22
9. Adoption Stages								
a Initiation	−0 49***	−0 19**	−0.49**	−0.52**	−0.36*	0.27	−0.25	0.06
b Implementation	0.50***	0 01	0.32	0.45**	0 52***	−0.18	0.25	−0 23
Weighted mean	0.38	0 35	0.70	0.74	0 82	0.58	0 40	0 29

[a] Significance levels in columns 1 and 2 were found using simple regression (Hedges and Olkin 1995, p. 241), for other correlations they were found in the customary way
[b] Number of complexity-innovation correlations are 27 representing 1867 observations
[c] Number of size-innovation correlations are 36 representing 3050 observations
[d] $N = 27$ for columns 1 and 3a, $N = 36$ for columns 2 and 3b, and $N = 38$ for the other columns
* $p \leq 0.05$, ** $p \leq 0.01$, *** $p \leq 0\,001$.

and (3) industrial sector and innovation dimension variables were entered last, first separately to determine each group's explanatory power alone, then together to determine the overall effects of all contingency factors.

Results

The mean correlations, weighted by sample size, between complexity and innovation and size and innovation were 0.382 ($p < 0.001$) and 0.346 ($p < 0.001$), respectively (Table 1). The simplest theory that arises from these values is that both structural complexity and organizational size are positively related to organizational innovation and explain, respectively, about 15 and 12 percent of variation in it. This conclusion, however, is not entirely accurate because of the variance in the correlations reported in the sample studies. The ranges of correlations for structural complexity-innovation and size-innovations were −0.09 to 0.71 and −0.04 to 0.76, respectively. Moreover, for both relationships the variance explained by the sampling error was less than seven percent, ruling out sampling error as a cause of variation in either complexity-innovation or size-innovation correlations. Sufficient data were not available to correct for other artifacts in each individual study, except for examining range restriction in the size-innovation correlations. Based on a procedure suggested by Hunter and Schmidt (1990, p. 159–187), the distribution of correlations of the total sample for size-innovation was examined for range restriction by using

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Table 1 *Continued*

6	7a	7b	7c	7d	8a	8b	8c	8d	8e	8f	9a	9b
0.22												
−0.51***	−0.59***											
0.49**	0.57***	−0.62***										
−0.40*	−0.31	0.52***	−0.54***									
0 20	−0.16	−0.25	0.06	−0 26								
−0.22	0.25	0.00	−0.18	0.26	−0.63***							
0.04	0.16	−0.15	0.15	0 03	−0.14	0.22						
0.02	0.45**	−0.37*	0.16	−0.43**	0.25	−0.04	−0.12					
0.32*	0.43**	−0.22	0 21	−0.22	−0.11	0.00	−0 06	0 28				
0.32*	0.43*	−0.22	0 21	−0.22	−0.11	0.00	−0.06	0 28	−0.05			
−0.12	−0.09	−0.11	−0.16	0.09	0.22	−0 07	−0.08	0 02	−0 07	−0.07		
0.04	0.12	0.12	−0 05	0.02	−0.12	0.09	−0.05	0 04	0.09	0.09	−0.79***	
0 14	0.08	0 79	0.22	0.50	0.20	0.61	0.07	0 16	0.05	0.05	0.08	0.87

the data on the independent variable available in eight studies (Damanpour 1992). The variance due to variation in range on the independent variable was 0.0160, reducing the corrected variance from 0.0446 to 0.0286 and raising the explained variance to 40 percent. This percentage is still well below the "75 percent rule" suggested by Hunter and Schmidt (1990) as an appropriate cut-off point for determining that analysis of the moderating effects is unnecessary. Therefore, there is need for more encompassing theories for both structural complexity-innovation and size-innovation to identify contingency factors that further explain the variations among correlations.

Control Variables

The complexity-innovation and size-innovation correlations were first regressed on the three control variables (Table 2). The similarity of data sources significantly affected the complexity-innovation relationship only. Measure of innovation affected both correlations significantly, but in opposite directions: the complexity-innovation correlation was positively affected when "number of innovations" was used as a measure, while the size-innovation correlation was negatively affected for this measure. Also, measures of complexity and size were significant determinants of the complexity-innovation and size-innovation correlations, respectively. Overall, the control variables significantly influenced the complexity-innovation and size-innovation relationships and explained, respectively, 20 and 27 percent of variance in them (Table 2).

Environmental Uncertainty and Organizational Size

Environmental uncertainty and average organizational size were then entered into the model to test Hypotheses 1a, 1b, and 2 after accounting for the effects of control variables (Table 3). Both Hypotheses 1a and 1b were supported, as environmental uncertainty had a positive effect on the complexity-innovation and size-innovation relationships. Hypothesis 2, however, was not

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Table 2 **Complexity-Innovation and Size-Innovation Correlations Regressed on Control Variables[a]**

	Complexity-innovation[b]	Size-innovation[c]
Similarity of Data Sources	−0.145*	−0.057
	(0.062)	(0.052)
Measure of Innovation	0.435***	−0.126*
	(0.071)	(0.059)
Measure of Complexity	0.177**	
	(0.055)	
Measure of Size		0.357***
		(0.039)
Intercept	0.039	0.364
Adjusted *R* Square	0.201***	0.275***

[a] Table entries are unstandardized regression coefficients (standard errors, adjusted following Hedges and Olkin's procedure (1985, p. 174), are in parentheses).

[b] $N = 27$, representing a total of 1867 observations.

[c] $N = 36$, representing a total of 3050 observations.

* $p \leq 0.05$; ** $p \leq 0.01$; *** $p \leq 0.001$.

supported; this finding suggests that structural complexity influences innovation more positively in small organizations. The combined effects of the two contingency and control variables explained approximately 32 and 58 percent of the variance in the complexity-innovation and size-innovation correlations, respectively (Table 3). Thus, not only were uncertainty and size significant predictors of the relevant correlations, they also considerably increased the predictability of the models over the methods variables.

Industrial Sectors

Manufacturing and service, and for-profit and not-for-profit, organizations were entered into the model separately for two reasons. First, the separation allowed for analysis of the independent effects of each sector class on the complexity-innovation and size-innovation relationships. Second, it deflated the potential for confounded results for the two sector classes, which could have occurred because of considerable overlap between manufacturing and for-profit, and service and not-for-profit, organizations in the sample, as evidenced by high correlations between each pair (Table 1).

Hypotheses 3a and 3b stated that both structural complexity and size are more positively related to innovation in manufacturing than in service organizations. Results indicate that the regression coefficients for manufacturing organizations are greater than those for service organizations in the direction of the hypotheses (Models 1 and 3, Table 4); however, the differences between regression coefficients are not statistically significant. Results for Hypotheses 4a and 4b, which stated that both complexity and size are more positively related to innovation in for-profit than in not-for-profit organizations, were mixed: the data supported this expectation only for the size-innovation relationship (Models 2 and 4, Table 4). A comparison of adjusted *R* squares, in Tables 3 and 4, demonstrates that the inclusion of for-profit and not-for-profit organizations does not increase the predictability of the models beyond control variables and commonly cited contingency factors, while the inclusion of manufacturing and service organizations does. Further, despite arguments in support of differences between characteristics of for-profit and not-for-profit organizations (Perry and Rainy 1988, Roessner 1977), findings of this study suggest that, at least with respect to the effect of structural complexity

Table 3 **Complexity-Innovation and Size-Innovation Correlations Regressed on Control Variables, Uncertainty and Size[a]**

	Complexity-innovation[b]	Size-innovation[c]
Similarity of Data Sources	−0.097	0.044
	(0.066)	(0.054)
Measure of Innovation	0.385***	−0.244***
	(0.073)	(0.061)
Measure of Complexity	0.205**	
	(0.072)	
Measure of Size		0.349***
		(0.039)
Environmental Uncertainty	0.359***	0.469***
	(0.083)	(0.054)
Organizational Size	−0.162*	
	(0.081)	
Intercept	−0.085	0.256
Adjusted *R* Square	0.319***	0.578***

[a] Table entries are unstandardized regression coefficients (standard errors, adjusted following Hedges and Olkin's procedure (1985, p. 174), are in parentheses).

[b] $N = 27$, representing a total of 1867 observations.

[c] $N = 36$, representing a total of 3050 observations.

* $p \leq 0.05$; ** $p \leq 0.01$; *** $p \leq 0.001$.

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Table 4 **Complexity-Innovation and Size-Innovation Correlations Regressed on Control Variables, Uncertainty and Size, and Industrial Sectors[a]**

	Complexity-Innovation[b]		Size-Innovation[c]	
	Model 1	Model 2	Model 3	Model 4
Similarity of Data Sources	0.021 (0.093)	−0.148* (0.073)	0.013 (0.062)	0.015 (0.055)
Measure of Innovation	0.302*** (0.085)	0.372*** (0.080)	−0.189** (0.071)	−0.223*** (0.061)
Measure of Complexity	0.131 (0.078)	0.238* (0.095)		
Measure of Size			0.313*** (0.047)	0.376*** (0.042)
Environmental Uncertainty	0.372*** (0.087)	0.114 (0.154)	0.546*** (0.078)	0.337*** (0.097)
Organizational Size	−0.030 (0.111)	−0.154 (0.083)		
Manufacturing Organizations	0.471*** (0.108)		0.408*** (0.082)	
Service Organizations	0.314* (0.125)		0.278** (0.094)	
For-Profit Organizations		−0.001 (0.090)		0.155** (0.057)
Not-for-Profit Organizations		−0.205 (0.112)		−0.024 (0.069)
Intercept	−0.364	0.110	−0.032	0.266
Adjusted R Square	0.464***	0.284***	0.670***	0.591***

[a] Table entries are unstandardized regression coefficients (standard errors, adjusted following Hedges and Olkin's procedure (1985, p. 174), are in parentheses).

[b] $N = 27$, representing a total of 1867 observations.

[c] $N = 36$, representing a total of 3050 observations.

* $p \leq 0.05$; ** $p \leq 0.01$; *** $p \leq 0.001$.

on innovation, there is no considerable difference between for-profit and not-for-profit organizations.

Innovation Dimensions

Three types of innovation and stages of adoption were entered into the model pairwise to explore the effects of each category beyond those of control variables and commonly cited contingency factors (Table 5).

For administrative and technical innovations, results supported Hypotheses 5a and 5b, which stated that both complexity and size are more positively related to technical than to administrative innovations. Models 1 and 5 (Table 5) demonstrate that the addition of this innovation type increased the explained variation over the models in Table 3 (adjusted R square for complexity-innovation increased from 0.32 to 0.61 and for size-innovation from 0.58 to 0.65). Hypotheses 6a and 6b, which stated both structural complexity and size are more positively related to process than to product innovations, were not supported by the data (Models 2 and 6, Table 5). On the contrary, product innovation was found to be a significant determinant of both complexity-innovation and size-innovation associations. A comparison of adjusted R squares of Models 2 and 6 in Table 5 with those in Table 3 demonstrates that the addition of this innovation type improved the predictability of both models (R squares changed from 0.32 to 0.46, and from 0.58 to 0.63, for complexity-innovation and size-innovation, respectively). Hypotheses 7a and 7b, which stated that both structural complexity and size are more positively related to radical than to incremental innovations, were supported (Models 3 and 7, Table 5). The addition of this innovation type, however, did not increase the explained variation in either complexity-innovation or size-innovation models over those in Table 3.

Hypotheses 8a and 8b stated that both structural complexity's and size's influence on the initiation of innovations would not be significantly different from their influence on the implementation of innovations. Results suggest, on the contrary, that both complexity and size influence the initiation of innovations less positively than they influence the implementation of innovations (Models 4 and 8, Table 5). The addition of stages of adoption to the models helped explain more variation in the complexity-innovation relationship but not variation in the size-innovation relationship (see Models 4 and 8 in Table 5 and corresponding models in Table 3).

Table 6 summarizes the effects of control variables and contingency factors on complexity-innovation and size-innovation associations reported in Tables 2–5.

Developing Parsimonious Models

Results did not support all the hypotheses put forth in this study. Moreover, a total of 18 independent variables (14 contingency and 4 methods) was employed in the analysis. Thus, a theory-trimming procedure was used to develop two distinct but

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Table 5 **Complexity-Innovation and Size-Innovation Correlations Regressed on Control Variables, Uncertainty and Size, and Innovation Dimensions[a]**

	Complexity-innovation[b]				Size-innovation[c]			
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Similarity of Data Sources	0.001	−0.129	0.024	−0.268**	0.064	0.152*	0.057	−0.030
	(0.077)	(0.073)	(0.080)	(0.084)	(0.055)	(0.060)	(0.054)	(0.059)
Measure of Innovation	0.381***	0.520***	0.304***	−0.097	−0.259***	−0.248***	−0.264***	−0.243***
	(0.075)	(0.085)	(0.079)	(0.152)	(0.062)	(0.063)	(0.062)	(0.069)
Measure of Complexity	0.240**	0.348***	0.187***	0.318***				
	(0.076)	(0.081)	(0.072)	(0.077)				
Measure of Size					0.395***	0.307***	0.349***	0.338***
					(0.044)	(0.040)	(0.039)	(0.040)
Environmental Uncertainty	0.345***	0.433***	0.323***	0.257**	0.548***	0.451***	0.441***	0.455***
	(0.083)	(0.093)	(0.084)	(0.098)	(0.058)	(0.061)	(0.057)	(0.060)
Organizational Size	−0.082	−0.131	−0.221**	−0.095				
	(0.090)	(0.082)	(0.084)	(0.083)				
Administrative Innovations	−0.161*				−0.131*			
	(0.071)				(0.062)			
Technical Innovations	0.194**				0.103			
	(0.072)				(0.058)			
Product Innovations		0.502***				0.360***		
		(0.109)				(0.092)		
Process Innovations		−0.016				0.107		
		(0.070)				(0.061)		
Radical Innovations			0.314*				0.185*	
			(0.130)				(0.088)	
Incremental Innovations			0.249				0.050	
			(0.130)				(0.088)	
Initiation of Innovation				−0.479**				−0.329*
				(0.171)				(0.139)
Implementation of Innovation				0.362*				−0.100
				(0.160)				(0.126)
Intercept	−0.207	−0.323	−0.097	0.142	0.177	0.163	0.258	0.435
Adjusted *R* Square	0.606***	0.464***	0.320***	0.439***	0.655***	0.630***	0.571***	0.597***

[a] Table entries are unstandardized regression coefficients (standard errors, adjusted following Hedges and Olkin's procedure (1985, p. 174), are in parentheses).

[b] $N = 27$, representing a total of 1867 observations.

[c] $N = 36$, representing a total of 3050 observations.

* $p \leq 0.05$; ** $p \leq 0.01$; *** $p \leq 0.001$.

parsimonious models for the complexity-innovation and size-innovation relationships. In a stepwise regression analysis, all contingency and control variables were added and replaced until the value of the chi square indicating the incremental predictiveness of a model was not significant at the 0.05 level (Hedges and Olkin 1985, Miller et al. 1991). A seven-variable structural complexity-innovation model, and a six-variable organizational size-innovation model, resulted from this analysis (Table 7).

Model 1 in Table 7 indicates that the observed association between structural complexity and innovation is a function of (1) the operational definition of structural complexity, (2) the level of environmental uncertainty, (3) the use of manufacturing organizations, (4) the use of service organizations, (5) focus on technical innova-

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Table 6 Summary of the Results of the Effects of Control Variables and Contingency Factors on Structural Complexity-Innovation and Size-Innovation Associations

Independent Variables	Structural Complexity-innovation Association	Size-innovation Association	Source
Control Variables			
Similarity of Data Sources	Negative	Nonsignificant	Table 2
Measure of Innovation	Positive	Negative	Table 2
Measure of Complexity	Positive		Table 2
Measure of Size		Positive	Table 2
Commonly Cited Contingency Factors			
Environmental Uncertainty	Positive	Positive	Table 3
Organizational Size	Negative		Table 3
Industrial Sectors			
Manufacturing Organizations	Positive	Positive	Table 4
Service Organizations	Positive	Positive	Table 4
For-profit Organizations	Nonsignificant	Positive	Table 4
Not-for-profit Organizations	Nonsignificant	Nonsignificant	Table 4
Innovation Dimensions			
Administrative Innovations	Negative	Negative	Table 5
Technical Innovations	Positive	Nonsignificant	Table 5
Product Innovations	Positive	Positive	Table 5
Process Innovations	Nonsignificant	Nonsignificant	Table 5
Radical Innovations	Positive	Positive	Table 5
Incremental Innovations	Nonsignificant	Nonsignificant	Table 5
Initiation of Innovations	Negative	Negative	Table 5
Implementation of Innovations	Positive	Nonsignificant	Table 5

tions, (6) focus on product innovations, and (7) focus on implementation of innovations. Model 2 in Table 7 shows that the observed association between organizational size and innovation depends on (1) the operational definition of organizational size, (2) the level of environmental uncertainty, (3) the use of service organizations, (4) the use of for-profit organizations, (5) focus on technical innovations, and (6) focus on product innovations. In addition to operational definitions of complexity and size that were included in the respective models, the models share four contingency variables, and the direction of influence of all shared variables is the same. Both models include at least one variable from each set of contingency factors examined, and the variables included in the models are highly predictive of the focal associations. The adjusted R square for the complexity-innovation and size-innovation models are, respectively, 0.82 and 0.74, both significant at 0.001 (Table 7). These models are the most encompassing and powerful models of structural complexity-innovation and organizational size-innovation thus far developed. They are discussed in more detail below.

Discussion

The analyses reported in Tables 2–5 indicate that both methods variables, and each group of contingency factors, helped explain variations in the structural complexity-innovation and organizational size-innovation relationships. Therefore, a general suggestion for research is that, as a minimum requirement, these groups of variables should be considered as potential determinants in developing structure-innovation models.

Examining the effects of methods variables on the focal relationships is an advantage made possible by the methodology used in this study, as past innovation studies have rarely controlled for differences due to these variables. The methods variables had a significant impact, and together they explained a sizable percentage of variations in both complexity-innovation and

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Table 7 **Complexity-Innovation and Size-Innovation Correlations Regressed on Control Variables, Uncertainty and Size, Industrial Sectors, and Innovation Dimensions[a]**

Independent Variables[b]	Complexity-innovation[c] Model 1	Size-innovation[d] Model 2
Measure of Complexity	0.192*	
	(0.079)	
Measure of Size		0.304***
		(0.051)
Environmental Uncertainty	0.451***	0.604***
	(0.088)	(0.079)
Manufacturing Organizations	0.267**	
	(0.097)	
Service Organizations	0.341***	0.346***
	(0.093)	(0.078)
For-profit Organizations		0.265***
		(0.059)
Technical Innovations	0.218***	0.157***
	(0.056)	(0 046)
Product Innovations	0.252*	0.326***
	(0.108)	(0.086)
Implementation of Innovations	0.451***	
	(0.067)	
Intercept	−0.646	−0.381
Adjusted R Square	0.820***	0.739***
Lack-of-fit Chi Square	17.685	55.212**

[a] Table entries are unstandardized regression coefficients (standard errors, adjusted following Hedges and Olkin's procedure (1985, p. 174), are in parentheses).

[b] Among 18 independent variables, only those that entered into at least one of the stepwise regression models are listed.

[c] $N = 27$, representing a total of 1867 observations.

[d] $N = 36$, representing a total of 3050 observations.

* $p \leq 0.05$; ** $p \leq 0.01$; *** $p \leq 0.001$.

size-innovation correlations (Table 2). Measures of complexity and size were included in most of the intermediate models (Tables 3–5) and in the final models (Table 7). Because structural complexity is a multidimensional construct (Blau 1970, Hall 1977), more composite measures of complexity should more realistically represent the complexity-innovation relationship; accordingly, the results show that complexity is more positively associated with innovation in studies which used multiple indicators than those which used a single indicator (Model 1, Table 7). For the operational definition of organizational size, the results indicate that size is more positively associated with innovation when a nonpersonnel measure of size is used (Model 2, Table 7). Kimberly (1976) argued that different aspects of size are relevant to different kinds of organizational problems or activities. Thus, personnel measure of size, the most commonly used measure of size in organizational studies, might not always be the best measure in innovation studies. Future innovation studies may consider different measures of size in different contexts; for example, size can be quantified using a "personnel" measure (number of employees) in labor-intensive organizations, a "volume" measure (number of units produced or sold) in consumer goods companies, or a "financial" measure (sales or assets) in insurance firms or banks.

Operational definition of innovation and similarity of data sources did not enter the final models (Table 7). The data show that measure of innovation, whether it be the number of innovations or a surrogate measure, has no significant effect on complexity-innovation and size-innovation relationships. This finding suggests that, despite differences in operational definition of innovation used in different studies, the findings of innovation research can be compared and cumulated. Likewise, whether data on structural complexity and innovation or size and innovation were collected from the same or different sources had no effect. This result has a precedent, as Miller and colleagues (1991) also found that similarity of data sources does not significantly influence technology-structure relationships.

A strong finding of the study is the effect of environmental uncertainty on both structural complexity-innovation and size-innovation relationships. Not only did environmental uncertainty help explain more variance beyond control variables (Table 3), it also remained a significant coefficient in nearly all regression models (Tables 4, 5, and 7). Researchers agree that environmental conditions provide an impetus for organizational change and innovation (Burns and Stalker 1961, Hage 1980, Huber et al. 1993); however, while the role of environment is implicit in certain empirical studies of organizational innovation, the effects of environmental uncertainty on organizational innovation have seldom been probed directly (Kimberly and Evanisko 1981 and Meyer and Goes 1988 studies are exceptions). Environmental uncertainty influences both the magnitude and the nature of innovation adopted by organi-

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zations. For example, Tushman and colleagues have argued that, during their evolution, organizations go through periods of "convergence" and "reorientation," and that the degree of environmental uncertainty is different in these periods; thus, both the frequency and the type of innovation required for organizational effectiveness would differ (Romanelli and Tushman 1986, Tushman and Anderson 1986, Tushman and Romanelli 1985). Huber and colleagues (1993) have distinguished among turbulence (variability), complexity, and competitiveness as components of environment and have found that all components do not affect organizational change equally. Along with these findings, the results of the present study suggest that future research should attempt to develop environmentally sensitive theories of organizational innovation by explicitly controlling for the degree and the nature of environmental uncertainty.

An examination of industrial sectors showed that the direction of influence of both manufacturing and service organizations was the same. This suggests a need to introduce more control into future studies to understand the differences among industrial sectors. If the primary reason for the expected differences between manufacturing and service organizations is the difference between technologies they use (Daft 1992), controls for type of technology might help explain the finding. For example, firms with "long-linked" technologies require more stable and routine work environments and, consequently, they are expected to be less innovative, whereas firms using "intensive" technologies are potentially more innovative because they require more nonroutine problem solving (Chatman and Jehn 1991, Thompson 1967). Because both long-linked and intensive technologies can be used in both service and manufacturing organizations, it is recommended that researchers control for the type of technology in future comparative studies of organizations in all sectors.

Distinguishing between technology types is particularly important because of the rise of knowledge-based organizations. The application of advanced information technology renders the functioning of manufacturing and service organizations more similar. Manufacturing flexibility is now regarded as a competitive priority in many firms and should be viewed strategically (Gerwin 1993). For example, a manufacturing firm can increase product variety by employing computer-integrated manufacturing and, like a service firm, it can also use information technology to facilitate operations personnel's direct contact with the clients or customers. In fact, technological intensity might be an even more effective factor than industrial sector class in determining structure-innovation relations in organizations and, thus, it deserves more attention in further research.

The findings of this study also confirmed the importance of focusing on innovation attributes in studies of organizational innovation. In particular, administrative and technical and product and process innovations increased the explained variation on both focal relationships beyond methods and commonly cited contingency factors (Table 3 and 5). The inclusion of technical and product, but not administrative and process, innovations in the final models (Table 7) points out the differences in organizational commitment towards these types. Technical and product innovations are more observable and trialable, and are perceived to be relatively more advantageous, than administrative and process innovations (Damanpour and Evan 1984, Frost and Egri 1991). Administrative and process innovations, on the other hand, are less tangible and are perceived to be more difficult to implement than technical and product innovations (Ettlie and Reza 1992, Frost and Egri 1991). Moreover, technical and product innovations require more initial resources to be developed successfully. These attributes provide technical and product innovations with more managerial attention and commitment. They also increase the chances of institutional imitation (Daft 1992); organizations imitate other organizations in their institutional environment and adopt technical and product innovations that have been already adopted by an elite organization or an industry leader (Hage and Dewar 1973, Rogers 1983). Thus, technical and product innovations are more "industry-specific," while administrative and process innovations are more "organization-specific"; that is, the latter innovations cannot be imitated without considerable modifications to make them compatible with the structure, culture, and systems of the adopting organization.

The distinction between radical and incremental innovations did not add to the predictability of the complexity-innovation and size-innovation models (Table 5). This typology would require further scrutiny in future research, however. Organizational scholars agree

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on the importance of distinguishing between radical and incremental innovations because the two types of innovation have dissimilar dynamics, need to be managed differently, and are not affected similarly by different organizational variables (Frost and Egri 1991, Hage 1980, Tushman and Romanelli 1985). Several interesting hypotheses have been advanced which await empirical data for confirmation. For example, Tushman and Romanelli (1985) have related these innovation types to stages of organizational evolution; they suggest that radical innovations occur during periods of discontinuous change, and incremental innovations occur during periods of adaptation. Hage (1980) argued that radical innovations occur when executives set high standards of performance relative to output and are more committed to change. Ettlie and Rubenstein (1987) stated that medium-sized firms introduce both radical and incremental innovations successfully, large firms are more effective at radical product innovations, and very large firms introduce more radical process innovations. To examine these and other assertions, systematic identification of innovations according to their degree of radicalness should become a part of theory-building and future empirical research.

The results of this study also indicate that organizational complexity influences the implementation of innovations more positively than it influences the initiation of innovations (Table 5), and that the implementation of innovation is one of the significant predictors of the structural complexity-innovation relationship (Model 1, Table 7). The direction of the effect of structural complexity on initiation and implementation of innovation (Model 4, Table 5), however, is the opposite of that proposed by the ambidextrous model. Zmud (1982) found that the propositions of the ambidextrous model are correct for technical innovations, but not for administrative innovations. Nicholson et al. (1990) argued that, although the distinction between initiation and implementation is useful, it is unwise to associate organizational forms exclusively with either stage. Instead, they suggested that it is probably more useful to examine how certain management and decision-making processes relate to the innovation process in each stage. These findings and assertions suggest that, in order to develop fine-grained theories of structure and stages of innovation, future investigators should: (1) control for innovation types, (2) study more elaborate stage models, and/or (3) pay more attention to the process of innovation within each stage (Nicholson et al. 1990, Van de Ven 1986, Wolfe 1994).

From the above discussion, it is evident that combinations of the eight attributes of innovation would have some effects on the structure-innovation relationship. Past attempts to combine the attributes addressed only two pairs at a time (Damanpour 1988, Zmud 1982). While combination of more than two pairs has been recommended for future research (Wolfe 1994), the variety of possible combinations would make a thorough empirical examination very difficult. The author therefore recommends an alternative approach which distinguishes among different organizational types, each type exemplifying a certain combination of innovation attributes and other contingency factors. For example, organizations can be grouped according to their strategic types. Using Miles and Snow's (1978) typology, "prospectors" probably would emphasize product innovations because they grow through product and market development, while "defenders" would emphasize process innovations because they continually improve their technology to maintain efficiency.[6] Moreover, defenders probably would emphasize incremental over radical innovations because they operate in a certain (simple/stable) environment, while prospectors would emphasize radical over incremental innovations because they operate in an uncertain (complex/dynamic) environment (Nicholson et al. 1990). "Analyzers" probably would emphasize both product and process, and both radical and incremental, innovations because they try to operate in a hybrid domain that requires prospector and defender characteristics. Analyzers would also emphasize administrative innovations because they should operate and maintain a more complex administrative structure.

Finer distinctions among organizational types (e.g., among organizations pursuing the same strategy) would also be useful for a better understanding of innovation behavior. For example, while an entrepreneurial firm and an adhocracy both pursue an innovation strategy, they innovate in entirely different ways (Mintzberg 1979). The entrepreneurial firm innovates simply: the entrepreneur is

[6] The author would like to thank the anonymous associate editor for suggesting that he relate innovation types to Miles and Snow's typology.

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the sole person in control, he/she is the main source of both initiation and implementation of innovations, innovation is typically a product or a major process technology, and the firm is small and its structure simple. An adhocracy, on the other hand, simultaneously introduces different types of innovation. Innovation in an adhocracy is complex and cannot be developed by one person—team approach, cross-departmental communications, elaborate decision-making mechanisms, flat structure, and highly skilled and trained staff are needed. In summary, more elaborate and finer distinctions among types of organizations could help combine the effects of multiple attributes and contingencies, perhaps leading to the development of more useful and realistic theories of structure-innovation relationships.

Limitations

Because correlation coefficients between some of the independent variables were significant (Table 1), two tests for the effects of multicollinearity for regression models were conducted. First, condition indexes and variance decomposition proportions were calculated. According to Belsely et al. (1980, p. 153–154), multicollinearity can be considered a problem when more than 50 percent of variance of two or more regression coefficients is associated with a single high (greater than a threshold between 15–30) condition index. Condition indexes greater than 30 are considered strong, and those greater than 100 are considered to cause great potential harm to regression estimates (Belsely et al. 1980). The highest condition indexes for the regression models of this study were 18.53 and 20.75, for Models 4 and 8 (Table 5), respectively. For the final models (Models 1 and 2, Table 7), the highest condition indexes were 11.2 and 11.4, respectively; both were thus below the threshold, and each contributed more than 50 percent to the variance of one variable only. Second, variance inflation factors were calculated for all the regression models reported in Tables 2–5 and Table 7 and were found to be less than 10, a threshold value that could be considered an indication of sufficient influence of multicollinearity (Neter et al. 1985, p. 392). For the final models (Table 7), variance inflation factors were 1.1 and 1.2, for Models 1 and 2, respectively. From these two tests, therefore, it was concluded that the degree of multicollinearity was not high enough to cause serious concern over the estimates of the regression coefficients.

A chi-square lack-of-fit test (Hedges and Olkin 1985) for the final models (Table 7) showed that, while the structural complexity-innovation model fits the data very well (chi square 17.7), the organizational size-innovation model does not (chi square 55.2, $p < 0.01$). This suggests that additional variables beyond those gathered in this study are required to explain the variation in size-innovation correlations. Two groups of factors can be suggested for future investigations. One group can include variables representing more fine-grained distinctions among types of organizations, such as industry, age, technological intensity, and even size sector within an industry. The second group of potential predictors can be the intermediate variables that lie between size and innovation. For instance, in addition to its direct effect, size might also indirectly influence innovation through structural variables such as specialization, centralization, and functional differentiation (Moch 1976). While many studies of size and structure can be found in organizational sociology literature (Mileti et al. 1977, Miller and Contay 1980), empirical studies of size-structure-innovation are scarce. In a notable exception, Moch (1976) developed a path model of size-structure-innovation and found that, while both size and structure lead to adoption of technological innovations, the impact of size on innovation, while substantial, occurs primarily through its effect on structure (p. 661). Therefore, it would be likely that additional accounting for the effect of size on innovation through structure would lead to a better model of size-innovation than Model 2 in Table 7.[7]

Conclusions

Using cumulative data from three decades of research, this study has generated models of structural complexity-innovation and organizational size-innovation that are more encompassing and powerful than any such models developed previously. The effects of a group of methods

[7] It should be noted that the dependent variable in this study is a predictor variable-innovation relationship, for which data were collected from published studies. To apply the Hedges and Olkin's (1985) methodology to a three variable model—e.g., structure-size-innovation—requires a substantial number of studies (similar to Moch's study) that have empirically examined the three variable relationships. Such studies, however, are scarce and could not possibly be examined using the methodology employed in the present study.

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variables and three groups of contingency variables were analyzed, and each group was found to contribute in explaining variations in the complexity-innovation and size-innovation relationships. The final models (Table 7) include at least one variable from each of the four groups. While the concluding complexity-innovation model fits the data well, the size-innovation model could be improved by introducing additional contingency factors. Also, because structural complexity was represented here by only two dimensions of differentiation (functional and occupational), future studies could explore other dimensions of differentiation (spatial and vertical), as well as the dimensions of integration. Finally, the results of this study demonstrated the utility of a theory building and testing approach advanced by Huber and colleagues (1990). This approach allows researchers both to test previous theories using cumulative data and to build and test new theories that were impossible to test in individual past studies. Further application of this approach to studies of other organizational phenomena is highly recommended.[8]

[8] I would like to thank Chet Miller, Bill Glick, and Lisa Berlinger, the authors of SAS Program for Meta-Analysis, for allowing me to use the program, Naman Agarwal for his assistance in computer work, and Sharan Jagpal, the anonymous Associate Editor, and the two Referees of Management Science for their very helpful comments.

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