The purpose of this article is to eliminate further conceptual obstacles to the development of a workable theory of innovation and to move toward a better theoretic statement. The approach to overcoming the conceptual problems centers primarily around four ideas: (1) building a theory around the "innovation decision" as the unit of analysis, rather than either innovations or adopters; (2) lifting the level of generality of independent variables so that a great deal of statistical interaction is avoided; (3) splitting the act of innovation into two stages, diffusion and adoption, to eliminate the confounding effects of time of awareness in studies of innovation; (4) introducing the idea of a "fair-trial point" into the conceptualization of innovation, solving several additional problems at once.

TOWARD A THEORY OF INNOVATION

GEORGE W. DOWNS, Jr.
University of California, Davis

LAWRENCE B. MOHR
University of Michigan

Theory-building in many social science subfields has apparently reached an impasse. The ability to make the kinds of generalizations and predictions that are typically associated with science and models is consistently being undermined by the phenomenon of complexity (cf. Campbell, 1973). The essence of complexity is interaction, or nonlinearity, many varieties of which make it impossible to specify the effect of a

AUTHORS' NOTE: *Prepared for delivery at the 1977 Annual Meeting of the American Political Science Association, the Washington Hilton Hotel, Washington, D.C., September 1-4, 1977. We gratefully acknowledge the collaboration of David Rocke. This research was supported by NSF Grant No. 014874, Division of Research and Policy Analysis. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of the National Science Foundation.*

variable without so qualifying the statement with contingent conditions that simple, comprehensible generalizations are not possible. This article is about one particularly troubled area of investigation—innovation research.

Little space will be used here in trying to convince the reader that interaction effects are important in social science as a whole or in innovation research in particular. Powerful evidence that interaction is effectively blocking progress in a variety of fields has been presented elsewhere (Cronbach, 1975; Rabkin and Struening, 1976; Medawar, 1977), and the hallmark of its existence (coefficient instability) is omnipresent in innovation research. Instead, the focus will be on those characteristics of the current paradigm that exacerbate the difficulties posed by interactive relationships.

In the final section we present a provisional, largely heuristic model which we believe represents the sort of strategy that must be pursued if any "general" theory of innovation is to be developed. However, it is not our purpose to sell a particular model of innovation. For this to be done convincingly will require a large amount of data and extensive refinement of concepts and indices. Rather, it is our aim to describe the necessary conditions for formulating a theory of innovation and to develop a model that satisfies these conditions. Naturally, the validity of the model is important, but the general message is more significant than particular variables or parameters. Should the basic issues be ignored, it is unlikely that a general theory of innovation will ever emerge.

To date, research into the determinants of innovation in complex organizations has yielded voluminous findings but the development of no real theory that permits us to predict confidently the extent to which—or the time at which—a given organization will adopt a given innovation. The evolution of such a theory has been hindered because research findings have been characterized by a disconcerting level of *instability*. That is, virtually every determinant employed has proved to be a highly and inexplicably erratic predictor of innovativeness with an impact that varies dramatically across studies. The list of examples is formidable and includes all of those variables thought to be key determinants: wealth, size, decentralization, professionalism, and the like (Rogers and Shoemaker, 1971: 350-376). A number of studies find that a given variable is strongly related to innovation, while a substantial number of others discover that it is a weak predictor or entirely unrelated. It is not even uncommon for a variable to be positively related to innovation in one study and negatively related in another.[1]

This state of affairs not only has had the effect of making forecasting a hazardous business, but has also hindered the development of an empirically grounded theoretical structure. Paradoxically, instead of clarifying our understanding of the determinants of innovation through each new piece of research, generalizations have only become harder to make. As appears to be frequently the case in social science, the belief that theory will gradually emerge from the accumulation of more and more data appears to be naive.

If progress in this area is to take place, it is clear that we must both understand the sources of instability and devise a means capable of overcoming it. The sources of instability, together with their theoretical and methodological consequences, have been discussed at length elsewhere (Downs and Mohr, 1976). However, no strategy has yet been devised to deal with its two most troublesome sources: interaction among independent variables and the conceptualization of the dependent variable. This article outlines a theory of innovation and proposes a new research approach designed to minimize instability and provide a framework in which successive research efforts can have an authentically cumulative impact upon further theoretical development.

INTERACTION

Undoubtedly the most straightforward explanation for why different studies have reached varying if not contradictory conclusions about the impact of a variety of potential determinants is that many determinants possess no single, unique impact, but one which varies as the elements of the decision-making context change. This is equivalent to saying that the impact of determinants is *contingent* upon other variables, or that *interaction* is taking place among them. For example, the effect that decentralization has on innovation is likely to depend on the amount of heterogeneity in values and information that exists among organizational members. If members share the same perspective and are equally well-informed, there would be little reason to believe that the innovative behavior of subunits would differ in a decentralized as opposed to a centralized system (cf. Kaufman, 1960). Similarly, organizational wealth or slack will play a much larger role in a firm's calculations surrounding the potential adoption of a costly innovation, such as a new computer, than in those concerning a relatively costless innovation, such as the installation of new office procedures. Thus, there are grounds for hypothesizing interaction between decentralization and value heterogeneity, and between organizational wealth and the cost of an innovation.

It is important to recognize that we are speaking of elements in a *decision-making context* or *choice situation* rather than *organizational* variables as conventionally defined. It is upon the former rather than the latter that any theory of innovation must be based. This is true for two reasons. First, the impact of most so-called organizational characteristics on adoptive behavior varies depending on what innovation is being considered. This has already been illustrated in the wealth-cost example above and dozens of others quickly come to mind (e.g., the impact of organizational expertise will depend on how great are the technical requirements of the innovation). Second, not only does the impact of an organizational characteristic vary, but the organizational characteristic itself may vary from innovation to innovation. An organization's degree of centralization, for example, is not always the same but depends, rather, on what is being decided; in almost no organization is the hierarchical level of decision authority invariable.

The same argument holds for complexity, formalization, specialization, professionalization, and almost any other organizational property that is a potential determinant of innovation. In short, the properties of organizations cannot in general be measured nor can their impact be assessed without reference to the properties of the innovation considered. For exactly the same reasons, the properties of innovations (compatibility, relative advantage, and so on) cannot be measured nor their impact assessed without reference to the organization considering them.

Therefore, any model that attempts to predict the extent and time of adoption must include both characteristics of the organization and the innovation in the context surrounding a particular decision. This means that the proper unit of analysis for investigating the determinants of innovation is what might be called the *innovation decision*: an organization in *relation* to an innovation (see Downs and Mohr, 1976). If we are studying the adoption of 10 innovations by 100 organizations, our sample size would be 1,000. In this way we acknowledge both that an organization is not a reified object with immutable properties and that an innovation is rarely the same thing for two organizations (Winter, 1968).

The innovation-decision design combats the confounding effects of interaction by bringing interacting variables together in the same equation. When the properties of organization and innovation that depend upon one another are juxtaposed, the interactive effects may be made explicit instead of remaining unrecognized and mysterious. This does not solve all of the problems of interaction; in fact, it makes the total magnitude of the problem more evident. Emphasizing one source of interaction, that between properties of the organization and the innovation, draws attention to others. It quickly becomes apparent that the impact of a variable such as organizational complexity is likely to depend on 9, 10, or even more factors. These include the degree of centralization, the ideological diversity of the groups involved, the communicability of the innovation in question, its benefit-cost ratio for the groups involved, and so on.

Fortunately, it is possible that a portion of this excessively complex interaction is a function of the particular variables included in the analysis rather than of some fundamental and intrinsic quality of the behavior called innovation. Variables differ in the extent to which arguments linking them with innovation contain implicit assumptions of a conditional nature. Accordingly, the approach reported below depends upon identifying (1) dimensions of the choice situation that are more stable in their impact than those variables currently in use, but not so global as to contribute little to predictive theory, and (2) a theoretical and mathematical framework that links these dimensions (Downs, 1976: 130).

Neither is an easy task, but the first is especially difficult. Arriving at "summary" dimensions through a clustering technique such as factor analysis is not the answer since such algorithms are based upon bivariate correlations and are therefore intrinsically insensitive to any interaction that may exist. While there is no clear-cut formula for discovering the kinds of dimensions that are needed, their identification can be fostered by carefully considering the probable justification for including variables presently found in studies of innovativeness. Asking precisely *why* a particular variable is expected to be related to innovativeness can help to reveal implicit dimensions at a higher level of generality and abstraction. Instability will clearly be reduced when predictors are framed so as to be broadly applicable, rather than applicable only to certain kinds of innovation situations. Below we report the results of our attempt to do this. However, before proceeding it is necessary to take a closer look at another source of instability, the operationalization of the dependent variable.

THE CONCEPTUALIZATION OF INNOVATION

Introductory definitions are required to ground the ensuing discussion. Innovation is conceptualized here as a quantified dimension of behavior. When considering the agent that might undertake the behavior, the referent is organizations, although the theoretical approach to be offered should also be applicable to individuals as a subset. We define innovation as *the earliness or extent of use by a given organization of a given new idea,* where "new" means only new to the adopting agent, and not necessarily to the world in general (cf. Rogers and Shoemaker, 1971: 19; Mohr, 1969: 114). Basic to the validity of the innovation-decision design and the theoretical approach to be undertaken here is the fact that the behavior in question may be viewed both from the perspective of the adopting agent and the idea adopted. As a property of the adopting organization, the behavior indicates "innovativeness"; as a property of the diffusing idea, the same behavior indicates "adoptability." Thus, if an organization adopts a certain new idea relatively quickly and extensively, the action provides some evidence both that the organization is quite innovative and that the idea is quite adoptable.

One major source of instability in statistics relating innovation to its determinants is interaction among the determinants. Another, however, is the conceptualization of the dependent variable itself. Social scientists have allowed "innovation" to take on too many different meanings and have allowed its meaning to be ambiguous in too many significant respects. It is healthy, in general, to permit the operationalization of a focal concept to vary slightly from one research application to another, but one can hardly expect consistent, stable results when the meaning of the concept itself, explicit or implied, is quite different in a variety of studies. Such differences have occurred for several reasons.

One major source of confusion lies in defining innovation sometimes as *extent* of use and sometimes as *earliness* of use.

We propose that both of these dimensions of innovation can be understood within the same theoretical framework, to be outlined in this article. However, there is no reason to expect that the *parameters* of the model will be the same in both cases. Once the latter expectation is abandoned, the differences in research results attained from the two dependent variables will not appear as instability, but rather as a further source of insight into the process of innovation.

Where time of adoption is the dependent variable, a second source of instability and confusion lies in the failure to recognize that innovation is a process that occurs in two stages (Rogers and Shoemaker, 1971: 100-101; Zaltman et al., 1973: 58-70). The first is the *diffusion* stage, which terminates when a prospective adopter may be said to have heard about the innovation in question, i.e., to have become aware that the new idea exists and might be of benefit to the organization. The second stage is the *adoption* stage, which begins at the point of awareness and continues until an adoption decision has been reached by that particular organization. We recommend this theoretical separation of the two stages and, in the present article, confine our interest to a theory of the second, or adoption stage of innovation.

Distinguishing between the diffusion and adoption stages eliminates a bidimensionality in the conceptualization of time of adoption. Hearing about something and adopting it are two different behaviors that should not be commingled in the same dependent variable. The consequence of doing so is instability. The magnitude of coefficients of impact will depend on the kind of innovation studied. When adoption tends to follow quite regularly after awareness but time of awareness varies widely, those variables that determine when one becomes aware assume dominant status; when the time of awareness varies little (e.g., the idea has long been known to all, or becomes known to all at about the same time), decision-making kinds of variables evoked after awareness become dominant. In some cases, both types may be important. In sum, if time of awareness is not uniformly cancelled out, and it has not been in previous research, then all of its correlates, including centrality in a social network, opinion leadership, wealth, prestige motivation, and the like, will tend to appear more important in some studies of time of adoption than in others.

Futhermore, restricting attention to the adoption stage makes it possible to investigate both time of adoption and extent of use within the same theoretical framework. The key to this possibility is the disentanglement of diffusion from adoption. Since the diffusion process until time of awareness is inherently different, an entirely different sort of explanatory model would be required. Earliness of adoption after the point of awareness, however, is a matter of organizational decision just as with the question of extent of use. The same kinds of considerations, as outlined in the sections to follow, may be seen as determining both of these outcomes.

Several additional problems have plagued attempts to extract or construct a general theory of innovation and will continue to do so until they are addressed specifically. These must also be expected to result in instability. Consider, for example, the following troublesome questions: when does greater extent of *use* (e.g., more and more acres of hybrid corn, more and more patients given a new drug) finally cease to be greater extent of *innovation?* how can the extent of adoption of one innovation (e.g., 300 acres) be compared with the extent of adoption of another (e.g., 25 patients)? if an innovation can be adopted on a large scale or a small one, how much innovation do we refer to when we ask about *its* cost or *its* relative advantage? and finally, if the extent of adoption by an organization is so small as to be insignificant and inconsequential, shall we consider it to be innovation or not?

All of these problems are specifically addressed by the introduction of a "fair-trial point" into the conceptualization of innovation. A spinoff of this device that also assumes substantial importance is the "token-adoption point."

The fair-trial point is the extent of use at which the adopter has enough experience with the innovation to assess its costs and benefits accurately. In a word, the adopter had given the innovation a fair trial. This point is rendered in different terms for different innovations, as appropriate; for example, a number of patients for whom a drug has been prescribed, an amount of time that a new organizational arrangement has been in effect, or a proportion of acreage on which a new seed or fertilizer has been applied. Giving a new idea such a fair trial is at the heart of what is meant by the term "innovation" and will serve as the basis for the operationalization of that concept. Extent of innovation in any instance may then be measured as a proportion, i.e., the ratio of actual extent of use (patients, time, acreage, and so on) to the amount specified by the fair-trial point, with a ceiling of 1.0. One important implication of this is that extent of use beyond the fair-trial point will no longer count as innovation. Once the costs and benefits are known, more extensive application of a given new idea—planting more acres of corn, for example—is no longer considered to be innovative behavior.

It is noteworthy that, by this same reasoning, we are also led to exclude as innovation all instances in which zero experience is the fair-trial point (in which case the extent ratio would have a zero denominator). A fair-trial point of zero is what Rogers would call "100% psychological trialability" (Rogers and Shoemaker, 1971: 155); i.e., instances in which the potential adopter need not acquire experience in order to decide whether or not to adopt, but may achieve certainty on the question simply by trying out the innovation in his mind. In actuality, this exclusion is a most welcome constraint. It leads us to accept the principle that *not every adoption of a new idea is innovation.* Moreover, whether or not 100% psychological trialability occurs in practice, the principle leads us to make an important connection. It allows us conceptually, in a specific way, to tie the idea of uncertainty to the idea of innovation. Since adoption under conditions of 100% psychological trialability and use beyond the point of accurate assessment of costs and benefits are excluded, everything included in the definition of innovation is "risky." Innovation then becomes defined as use of a new idea, technique, and so on, when there is uncertainty attached to the enterprise.

Finally, we are also led by this line of reasoning to establish a "token-adoption point." Sometimes organizations, especially large ones, adopt a new idea on such a small scale that no risk whatever is involved and no useful information about costs and benefits is derived from the experience. This is frequently done in order to reap the prestige conferred by adoption without incurring the risks inherent in innovation (Mohr, 1969). Token adoption, then, is not innovation; the latter begins only when extent of use passes the no-risk, or token-adoption point.

It remains to specify how the fair-trial point is to be operationalized in research. In the last analysis, the determination is arbitrary, and the acceptance of conclusions will depend on assessments of the quality of this operationalization, as well as others. We suggest, however, that it will be most helpful to think in terms of an "advocate" for each new idea studied, a source who has the important conceptual role of specifying the special benefits and costs for organizations connected with that idea (e.g., faster cures, higher yields per acre) and the point at which adopting organizations can assess these benefits and costs accurately. In practice, these specifications would be made by the investigator together with professionals or experts in the field of the new idea, or the marketer who is trying to sell it, or the change agents who advocate its use.

The concept of fair-trial point is advantageous in several key respects.

(1) It brings conceptual precision to the idea of innovation as a quantitative dimension. It pins the concept down by stipulating that use under conditions of certainty is not innovation.
(2) It provides a theoretically based reference point from which to measure, as a proportion, the extent of innovation that has taken place.
(3) The use of proportion in this way permits the extent of adoption of all innovations to be expressed in the same metric

terms.

(4) The fair-trial point is a meaningful level that is relevant to all innovation. It can serve well as a common referent for questions about the attributes of an innovation decision when the answer depends on the quantity of innovation contemplated. Taking cost as an example, instead of trying to document the cost of innovation at a vague and unspecified level of use, we can document its cost at the level of use specified by the fair-trial point.

(5) The use of a token-adoption point enables us to score no-risk, small-scale adoption as noninnovation. This is especially important when time of adoption alone is the dependent variable. The "what" of innovation then necessarily becomes a dichotomy—you have either adopted or not. In such cases, token adoption would count as "not," i.e., as noninnovation.

DEVELOPING A THEORY OF INNOVATION

The point has been made that the generality and abstraction of variables commonly used in innovation research must be raised to a higher level in order to avoid the damaging effects of instability. Our mechanism for finding new variables at a higher level of abstraction has been to begin with the old ones and ask *why* one might expect them to be important. For example, why would the complexity of an organization be considered to be a determinant of innovativeness? Answer: because it increases the costs of making a decision and implementing a change. Why would "reversibility" help determine how adoptable a new idea might be? Answer: because a nonreversible innovation would have involved an organization in excessive costs if the organization were to change its mind shortly after adopting. In brief, this procedure leads over and over again to the statement of new variables in terms of costs and benefits—especially costs.

Past research results also suggest a benefit-cost approach in that resources have repeatedly been found to be important in studies of innovation, often extremely important. Why is this so? The answer must be because most innovation is not free. Resources are necessary to offset costs. Thus, resources of various kinds would logically become even better, more stable predictors of innovation when the associated costs are also considered. Wealth, for example, will be a good predictor when cost is high, but not when cost is low. If the costs of the innovation are not specified, the varying impact of specific resources will frustrate efforts to build cumulative theory. Costs, then, should be included in the list of descriptors of the innovation decision. This same logic leads one to include the idea of benefits, as well, since the costs clearly are more or less important depending on what the potential benefits are.

A good theory should enable accurate prediction and control over events and should satisfy the esthetic criteria of parsimony and of providing a satisfying explanation for the behavior in question. It is particularly in this last category that many former hypotheses have been deficient. The combined effects of size, centralization, and similar variables may at times have yielded a high multiple correlation, but the particular sets of variables that have been used have rarely told a clear story. They do not appear to provide a readily intelligible explanation of how and why innovation takes place. To use a corporate analogy, they are conglomerates more than integrated concerns. A benefit-cost theory has the advantage of constituting a well-integrated explanation.

Another requirement for a new theory of innovation, or for any theory, is completeness. If we seek an explanation, we seek a whole one. Much former research on innovativeness has conspicuously and unfortunately omitted any attention to the *motivation* to innovate. The benefit side of the cost-benefit approach is evoked by the need to fill this gap. Noting the benefits to be obtained helps us to understand *why* an innovation was or was not adopted. Completeness is especially important when an explanation is known to contain a good deal of interaction. Unless important variables such as benefits are included, the coefficients on the variables that interact with them and that are included cannot possibly be stable. These coefficients will bounce up and down mysteriously from one research project to another, depending on the levels of the omitted variables—the benefits—that happened to obtain in each case.

Developing descriptive innovation theory on the basis of costs and benefits might appear both naive and unenlightening since any behavior can obviously be reduced to pleasure and pain or equivalent terms. The choice of the model here, however, is a strategic one. Despite its universal applicability, benefit-cost theory would not recommend itself as the best model for the explanation of all behavior. For the normal, more routine kinds of organizational decision-making, a configuration of concepts including sequential attention to goals, quasi-resolution of conflict, reaction to feedback, and problemistic search (Cyert and March, 1963) no doubt comprise a more productive descriptive model than costs and benefits. For adaptive behavior, a configuration including stimulus, reinforcement, response, and learning comprise a better set, and so on for many other behavioral phenomena. A benefit-cost model is a good descriptive model for innovation because innovation is instrumental—it is supposed to achieve a better state. The consequences of change, positive and negative, absorb decision-making attention and trigger a comparative rational process, an evaluation of states in terms of the goods and the bads, even though the calculations may not be precise nor the information complete or correct.

In one sense, to say that benefits divided by costs equals innovation is to make a trivial statement. Of course, a rational organization innovates when the benefits outweigh the costs. Ultimately, the statement is even a tautology; the fact that change has taken place by choice may be said to demonstrate in itself that the perceived benefits somehow outweighed the costs (cf. Simon, 1959). However, to specify the breakdown of these two terms into productive components is far from trivial. The kinds of benefits and costs that best explain voting behavior, for example, are not at all the same as those that best explain innovation. Having said the words "benefits" and "costs," it then becomes necessary to specify the particular benefits and costs that are important. That specification is the core of the theoretical effort. What we will call "programmatic" benefits, for example, have been neglected in lists of independent variables, but they are indispensable. Most innovation is programmatically instrumental; new techniques are usually appraised for their probable contribution to the performance of societal roles. We propose that a substantial proportion of the variation in adoption can often be explained simply by how useful an innovation is perceived to be in carrying out a job. As obvious as this hypothesis is, it has been used surprisingly little in research on organizational innovation. Prestige or social-approval benefits must also be included. Social approval is a ubiquitous and salient concern, and it appears that successful innovation, even in traditional or conservative groups, almost always conveys prestige. We must expect, therefore—and prior research supports the expectation—that innovation will quite frequently be appealing as a vehicle for achieving social approval.

In the following section, we continue in this vein to specify a particular set of costs, benefits, resources, and associated variables that comprise a theory of innovation. We have attempted to guide the effort self-consciously by the constraints of parsimony, integration, completeness, accuracy of prediction, and amenability to manipulation or control. Above all, we emphasize that the applicability of the theory is not meant to be confined to a certain kind of innovation or a certain set of conditions. Within the definitions of terms and allowing for modification through research, its objective is to explain fully all instances of the adoption and nonadoption of proposed new ideas, regardless of the time, place, or circumstances under which the adoption is contemplated. Such an objective can never be fully realized; nonetheless, it is an appropriate goal to adopt. It is time, in innovation theory and in other areas of social research, to essay an attack upon the problems of instability and the apparently hopeless noncumulativeness of results through efforts of this kind. By this means, if a truly general empirical theory of innovation is not possible, we will have a better idea of why it is not and genuine guidance toward alternative solutions.

DIMENSIONS

While reading what follows it is important to recall that the aspirations of this model are behavioral, not normative. Dimensions were not chosen on the basis of what *should* be taken into consideration in evaluating an innovation, but rather on the basis of what factors *are* taken into consideration.

BENEFITS

It has long been known that there is no single motivation behind innovation at either the individual or organizational level. Yet while it would be possible to enumerate a dozen or more specific kinds of benefits that have been found to be related to the adoption of innovations, these invariably seem to fall into one of three categories.

(1) Programmatic benefits: benefits of increased effectiveness and efficiency in accomplishing externally related goals. These benefits are often summarized by "profit" in the private sector.
(2) Prestige benefits: benefits of recognition and approval that accrue to the organization and its members by virtue of their being earlier rather than later adopters of new programs and technologies.
(3) Structural benefits: purely internal benefits such as greater worker satisfaction and better internal relationships.

These varieties of benefits may be interrelated with respect to a given innovation but in many instances they will not be. Every student of bureaucratic behavior is familiar with innovations (e.g., reorganizations) that produce some structural and prestige benefits but virtually no programmatic ones. Moreover, it is often the case that the rapid but superficial adoption of an innovation by a given organization will yield substantial prestige benefits but few programmatic ones. Other organizations may adopt the same innovation to a greater extent somewhat later and receive considerably more programmatic benefits but little prestige.

The impact of different types of benefits and the interaction between benefits and other variables are topics that remain largely unexplored. This has created a serious deficiency in research with respect to "completeness" since most explanations of innovation have implicitly assumed an equal level of positive motivation throughout the population of possible adopters. Accepted uncritically, such explanations would lead us to expect innovation to take place whenever disincentives (e.g., prohibitive cost) were absent. Obviously this is an unhappy state of affairs since, carried to an absurd but logical extreme, it compels us to predict that General Motors will adopt the newest innovation in chemotherapy or dress design because the costs are low enough and the resources high enough.

In studying the determinants of organizational innovativeness, only economists have consistently attempted to measure the effect of perceived benefits and they have concentrated almost exclusively on the additive impact of "expected profits," showing no interest in other sorts of benefits or in the interaction between benefits and other variables. This approach suffers from incompleteness and is subject to all of the well-known problems of model misspecification. In particular, inferences about the effects of certain variables that are employed in such designs will be incorrect because of the unspecified interaction between these variables and omitted benefits. A few moments' reflection, as well as empirical evidence (Mohr, 1969), attest to the fact that the impact of a number of variables depends on the level of various kinds of benefits. Characteristically, sociologists and political scientists treat benefit-related variables, such as "returns to investment" and "relative advantage," as intrinsic attributes of the innovation that make "it" more or less adoptable, rather than as independent variables to be used in predicting the extent or time at which a given organization will adopt a given innovation. The difficulty with this approach is that benefits are not intrinsic attributes of innovations but variable attributes of the choice situation. Few innovations yield the same benefits to all organizations. A recent advance in cancer chemotherapy is likely to produce greater benefits for a chronic disease hospital than for a general hospital (let alone for General Motors!). Knowing about the amount of perceived benefits in each case will increase markedly our ability to predict how each organization will react.

Several points need to be made regarding the measurement of benefits. To begin with, because the extent of benefits varies enormously depending on the extent to which an innovation is adopted, some uniform reference point must be used in calculation. The most logical such point is the fair-trial point, if it is relative to that bench mark that we measure the extent of adoption.[2] Second, it should be reemphasized that the data sought involve perceived rather than objectively determined benefits and cannot be calculated in the manner of an investigator performing a traditional benefit-cost study. Finally, the levels of benefits included in the model represent relative, not absolute benefits. That is, they represent the increase in benefits to be derived by adopting the innovation at a level equal to the fair-trial point over the benefits resulting from continuing to employ resources as they are currently invested. The attractiveness of an innovation clearly depends on the current status quo. Ceteris paribus, adopting an innovation with a profit margin of 6% will be more desirable than continuing to follow present practices in an organization where resources equal to the cost of the innovation are yielding 4%. However, the same innovation would not be attractive to an organization whose resources were currently invested in projects yielding 8% or more. The predictive and heuristic advantages of integrating this information into any model are substantial.

COSTS

Costs are partitioned into two general categories.

(1) Decision costs: the costs of arriving at a decision on whether to implement an innovation or not and, if so, to what extent and at what rate. When operationalized this category should be broken down into the costs of technical and managerial skill time, the costs of gathering new information, and internal social costs (i.e., costs associated with disrupting the organization's internal status quo).
(2) Implementation costs: the costs associated with the actual implementation of the innovation to the fair-trial point. Subcategories are: equipment costs, manpower costs, and internal and external social costs (the latter being costs associated with disrupting the status quo in the organization's environment; i.e., adopting an innovation that is somehow frowned upon in the relevant environment).

Costs, like benefits, are properly thought of as properties of the choice situation that can vary widely as different organizations come in contact with a given innovation. The money costs, manpower costs, and so on of a typical innovation are not the same for all organizations. Organization A may have an organizational structure or location that makes implementation less costly for it than organization B. As in the case of benefits, the advantages of integrating this knowledge into a model that attempts to predict the extent to which A and B will adopt the innovation in question are clear.

The distinction between decision and implementation costs reflects a common division of the process of innovating into a decision or initiation stage and an implementation stage (Zaltman et al., 1973: 58). Although these two categories are composed of some of the same cost elements, they are kept separate since it is likely that various costs have greater consequences during one stage than another. For example, decision makers might be much more reluctant to expand manpower resources during the decision stage than during the implementation stage. This being true, an innovation that costs a large amount of manpower resources during the decision stage is likely to be less adoptable than another innovation requiring the same amount of resources during the implementation stage.

As in the case of benefits, the cost figures in which one is ultimately interested are increases in costs necessary to go from the status quo to the fair-trial point. This would include savings that might stem from the planned discontinuance of present programs or procedures that the innovation would replace.

RESOURCES

The centrality of resources in any model of the determinants of innovation has long been acknowledged. Wealth particularly has figured in hundreds of studies on both the organizational and individual levels. Nevertheless, much remains to be learned about the relative importance of different kinds of resources. Five types of resources whose impacts appear to warrant inclusion are: wealth, manpower—expertise and time, equipment, information, and staff tolerance for change.

In order to maximize a model's predictive power, resources, like benefits and costs, must be treated as characteristics of the choice situation. This means that they must not automatically be assumed to be intrinsic characteristics of the organization, such as cash on hand or capital holdings. From the point of view of the decision maker, the amount of available resources an organization possesses depends in a very real way on what change is being considered. For example, contrary to what might be inferred from the pertinent discussion by Cyert and March (1963: 36-38), it is no easy matter to assign an organization a unique value to represent its level of slack fiscal resources. The amount of slack resources considered to be available for an innovation depends upon the return rate associated with those resources. Should decision makers be confronted with an innovation believed to produce a benefit-cost ratio of 1/3, it is unlikely that they would consider *any* of the organization's holdings or unused credit to be slack—not even cash reserves lying idle in the bank. This is true because the rates of return which its resources are currently yielding are almost certainly greater than that of this innovation. On the other hand, if the decision makers judged the innovation to have a benefit-cost ratio of 30/1, it is probable that they would consider virtually everything that they could beg, borrow, or steal to be investable "slack." Resources already committed elsewhere would, within legal and practical bounds, quickly be diverted to the new project.

DISCOUNTING FACTORS

Equivalence in the basic benefit and cost calculations made by two organizations is no guarantee that they will respond to the innovation in an identical fashion. This is true because the values that they attach to benefits and costs are likely to vary somewhat. Four factors that play a significant role in determining the utility functions of organizational decision makers with respect to benefits, costs, and resources are:

(1) risk: degree of concern over possible "catastrophe";
(2) average cost of discontinuance: the average cost associated with cancelling the innovation between 0% adoption and the fair-trial point;
(3) uncertainty: the lack of confidence that the organization has in its benefit-cost calculations;
(4) instability in the future stream of benefits: fear that the benefit-cost ratio will unexpectedly decrease at some date beyond the fair-trial point due to depreciation, obsolescence, and the like.

The precise impact of the first, third, and fourth factors will depend on the risk-taking propensity of decision makers (Slovic and Lichtenstein, 1968; MacCrimmon and Taylor, 1976). Thus we need to introduce another variable under the general heading of discount factors:

(5) venturesomeness: the tendency for organization decision makers to ignore risk and uncertainty.

Perhaps the most interesting of these variables are "risk" and "uncertainty" because while their importance has been demonstrated in case studies and research on the adoptability of innovations, they have generally not been included as predictor variables in studies of organizational innovativeness. Despite the fact that it is obvious that the risk or uncertainty of implementing a particular innovation will vary from organization to organization and may have a substantial impact on the calculations of decision makers, these variables have been omitted, once again, because they are not, strictly speaking, properties of an organization. No one would think of asking decision makers how much risk or uncertainty they feel "in general." Yet, it is possible to ask how much risk and uncertainty they believe are associated with a specific innovation. Employing the innovation-decision design and focusing on the choice situation instead of simply the organization enable us to gain the predictive advantage that knowledge of risk and uncertainty affords and to explore the precise roles that they play in the decision to innovate.

It could be argued that risk, the average cost of discontinuance, and so forth, are already integrated into the decision makers' assessment of benefits and costs and that to include them separately is redundant. However, the well-known tendency of decision makers to avoid complex calculations. to segment problems, and to employ simplified decision rules (cf. Cyert and March, 1963; MacCrimmon and Taylor, 1976) suggests that these elements are calculated independently and are not included in estimates of benefits and costs. It would not be wise to ask decision makers to specify the probability distribution on each benefit and cost estimate. The measurement of these factors, like that of the model's other dimensions, must reflect the reality of how decision makers assess an innovation, not how they should assess it. We assume that decision makers do not directly integrate such factors into their benefit-cost calculations; they do not tediously calculate the risk of an innovation by carefully attaching probabilities to every unfavorable outcome and then calculating the expected value of failure. Instead, it is likely that they ask themselves only, "What is the worst thing that could happen and what is the chance of its occurring?" Similarly, they generally have neither the time, ability, nor inclination to estimate precisely how long the benefit-cost ratio they perceive is likely to remain stable or what its trend over time will be. However, it is likely that they do pause to speculate on how probable it is that the innovation will become obsolete in the near future and, if so, what that would cost them.

THE FORM OF THE THEORY

Innovation is hypothesized to be a function of the dimensions described in the previous section. Clearly, the exact form of the most useful statistical model cannot be decided upon without considerable data; however, theoretical considerations do suggest an exploratory model. The previous discussion has emphasized that extensive interaction makes the ordinary linear additive model inapplicable. For those familiar with standard statistical practice, what immediately suggests itself is simply to expand the inadequate linear model by the addition of numerous multiplicative terms, each expressing the interaction among specific variables. This functional form still has at least two undesirable features in the present context. First, if costs, benefits, and resources were all increased in proportion, the amount of innovation ought not also to increase proportionately, as it would under the additive model. Such a formulation would essentially propose that when one organization is a thousand or a hundred thousand times bigger than another, which is common, its innovativeness in terms of time and extent will be a thousand or a hundred thousand times greater, which is hardly possible. An alternative view would propose that innovation would remain constant across such situations. It is also reasonable to presume positive but decreasing marginal effects upon innovation of greater size or resources alone (i.e., benefits and costs constant). Innovation should not increase without bounds in response to increases in resources. The second difficulty with the linear additive functional form is that it fails to depict benefits and resources as necessary conditions for innovation. If a critical resource were in inadequate supply (neither currently on hand nor available through grants or loans), the additive equation would still predict innovation greater than zero, as long as the benefits outweighed the costs. Such a prediction is clearly illogical.

Therefore, we propose to use a model that is basically multiplicative and that incorporates ratios of the variables in such a way as to avoid these problems. Specifically, the functional form is suggested by the motivation-resources model (Mohr, 1969) and consists of

$$I = \frac{B}{C} \cdot R \cdot D \qquad [1]$$

where I is innovation, B/C are the benefits divided by the costs,[3] R is resources, and D represents the discounting factors. The quantity (B/C)D represents the motivation to innovate.

The detail underlying the terms B, C, and D is straightforward. We propose to use

$$B = \Sigma\beta_j B_j \qquad [2]$$

$$C = \Sigma\gamma_i C_i \qquad [3]$$

$$D = \Sigma\delta_k D_k \qquad [4]$$

where the β_j, γ_i, and δ_k indicate the relative impacts of the various types of benefits, costs, and discounting factors, respectively.

R is a factor that measures the effect of the availability of resources of specific types to match costs of the same type. Let R_i represent a resource and C_i its associated cost. Define

$$P(X) = \begin{cases} 0 & X < 0 \\ X & X \geqslant 0 \end{cases}.$$

Then we propose to use

$$R = \Pi P^{\alpha_i}\left(\frac{R_i - C_i}{R_i}\right). \qquad [5]$$

This formulation has three desirable properties. (a) It provides for a prediction of zero innovation when the numerator of any fraction in equation 5 is negative; i.e., when a resource is inadequate, given the magnitude of its associated cost. (b) It provides for a constant response to scale, since both B/C and equation 5 remain unchanged under proportional increases in benefits, costs, and resources, and it provides for a declining marginal effect of resources, since the fraction in equation 5 becomes asymptotic to 1.0 as a resource increasingly dominates its associated cost. (c) It provides for a magnifying effect of costs on resources; e.g., wealth will be a more important determinant of innovation as the money cost of the innovation increases. This results from greater variation among organizations in

$$\left(\frac{R_i - C_i}{R_i}\right)$$

when C_i is large than when it is small. In the latter case, the fraction would be nearly constant with respect to all organizations.

Clearly, some features of this model may have to be altered in the face of data, but we believe that a model of this sort can be used successfully to explore the relationships of the variables we have developed.

CONCLUSION

Empirical research within any theoretical structure inevitably involves certain difficulties and challenges. The three that seem worthy of note in connection with the benefit-cost approach to innovation are: (1) dealing with variation in the perception of benefits and costs within the organization; (2) determining the fair-trial point; and (3) identifying the factors that determine perceived benefit and cost levels. Since these problems, while important, are incidental to the main thrust of the article, a brief discussion of each can be found in the Appendix.

We would not argue that many variables traditionally used should no longer be studied, only that progress in understanding the determinants of innovation must take place within an organizing theoretical framework that permits research to have a cumulative impact. This requires that we employ dimensions that are sensibly limited in number and that either possess a stable impact or interact with each other in a relatively simple fashion. To achieve the latter in an area as fraught with complex contingencies as an organization's decision to innovate, the dimensions which make up any general theory must be able to summarize much of the interaction that we know is taking place among observables. Benefits, costs, resources, and the five discounting factors seem to possess this property.

These dimensions, being at a more abstract and general level, also seem more likely to possess the property of *durability*—constancy of importance under transformations in time and place—than do those variables that are traditionally used to predict innovation. A variable whose impact is relatively stable across the enormous variety of decision contexts that presently exists is likely to be relatively stable across those contexts that will evolve over time, or that are represented by different cultures. The justification for this belief is simple. Durability is an extension of stability. Change in the impact of a variable over time and place is most frequently brought about by changes in other variables with which it interacts. For example, the impact of fiscal resources and professionalism on innovativeness may well change over time as a consequence of changes in the cost and technological complexity of innovations. If the impact of a variable is not stable across existing contexts, its impact is not likely to be durable; conversely, cross-sectional stability at least offers the hope of durability. Theories are modified over time and eventually replaced, but one is at a loss to know how to modify if the theory is not durable, if it is applicable only to an ill-understood and vaguely defined subset of conditions. Generality in the variables is needed to make interaction manageable. Generality and controlled interaction together permit stability and durability. Stability and durability permit cumulative research.

NOTES

1. Readers who think that we may be exaggerating the amount of instability that exists should consult the Rogers and Shoemaker citation. In their systematic review of past research findings they find consistent support for only 4 of 38 propositions relating different variables to innovation. Not surprisingly, the 4 propositions with a consistent record have been treated in only a very few studies.

2. Even if the measurement is tied to the fair-trial point, perceptions of what the benefits and costs would be at that point can vary over time. Thus, measurement must strive to identify the perceived benefit and cost configuration surrounding the decisions that were responsible for the current level of adoption.

3. We intend this as shorthand for what will probably become a more complicated form. One can incorporate the relativity of benefit/cost ratios to current return by using $B/C - B_0/C_0$ where B_0 and C_0 reflect the status quo. One could also divide this difference by B_0/C_0 to obtain the relative difference. Some experience with actual data will be needed to determine the correct choice.

REFERENCES

CAMPBELL, D. (1973) "The social scientist as methodological servant of the experimenting society." Policy Studies J. 2: 72-75.

COHEN, M. and J. MARCH (1974) Leadership and Ambiguity. New York: McGraw-Hill.

CRONBACH, L. (1975) "Beyond the two disciplines of scientific psychology." Amer. Psychologist 30 (February): 116-127.

CYERT, R. and J. MARCH (1963) A Behavioral Theory of the Firm. Englewood Cliffs, NJ: Prentice-Hall.

DOWNS, A. (1967) Inside Bureaucracy. Boston: Little, Brown.

DOWNS, G. (1976) Bureaucracy, Innovation, and Public Policy. Lexington, MA: D. C. Heath.

——— and L. MOHR (1976) "Conceptual issues in the study of innovation." Admin. Sci. Q. 21: 700-714.

KAUFMAN, H. (1960) The Forest Ranger: A Study in Administrative Behavior. Baltimore: Johns Hopkins Univ. Press.

KNIGHT, K. (1967) "A descriptive model of the intra-firm innovation process." J. of Business 40: 478-496.

MacCRIMMON, K. and R. TAYLOR (1976) "Decision making and problem solving," in M. Dunnette (ed.) Handbook of Industrial and Organizational Psychology. New York: Rand McNally.

MARCH, J. and H. SIMON (1958) Organizations. New York: John Wiley.

MEDAWAR, P. (1977) "Unnatural science." New York Review of Books (February 3): 13ff.

MOHR, L. (1969) "Determinants of Innovations in Organizations." Amer. Pol. Sci. Rev. 63: 111-126.

NISKANEN, W. A. (1971) Bureaucracy and Representative Government. Chicago: Aldine-Atherton.

NORMANN, R. (1971) "Organizational innovativeness: product variation and reorientation." Admin. Sci. Q. 16: 203-215.

RABKIN, J. and E. STRUENING (1976) "Life events, stress, and illness." Sci. 198: 1013-1020.

ROGERS, E. and F. SHOEMAKER (1971) Communication of Innovations. New York: Free Press.

SIMON, H. (1959) "Theories of decision-making in economics and behavioral science." Amer. Economic Rev. 49: 253-283.

SLOVIC, P. and S. LICHTENSTEIN (1968) "The relative importance of probabilities and pay offs in risk taking." J. of Experimental Psychology Monograph Supplement 78, 3: part 2.

WILSON, J. (1966) "Innovation in organizations: notes toward a theory," in J. Thompson (ed.) Approaches to Organizational Design. Pittsburgh: Univ. of Pittsburgh Press.

WINTER, S., Jr. (1968) Toward a Neo-Schumpeterian Theory of the Firm. Publication No. P-3802. Santa Monica: Rand Corporation.

ZALTMAN, G., R. DUNCAN, and J. HOLBEK (1973) Innovations and Organizations. New York: John Wiley.

APPENDIX

(1) *Dealing with variation in the perception of benefits and costs within the organization.* One would not attempt to aggregate benefits and costs across the whole organization. Rather, one would seek to identify the benefits and costs that were important to the making of the decision by discovering who were the key decision makers and utilizing them as informants. Obviously, situations exist where it will be problematic to accurately identify the locus of decision. It must be borne in mind, however, that it is not necessary to construct an exhaustive and properly weighted list of decision makers, but rather a panel that is sufficient to yield accurate information about the factors that influenced the decision.

(2) *Determining the fair-trial point.* There are undoubtedly instances where there would be considerable disagreement as to where the fair-trial point should be set. On the other hand, there is a broad range of cases in which consensus can quite readily be reached. The majority of technological innovations (e.g., new drugs, agricultural techniques, computer applications) fall into this category, as well as many bureaucratically inspired policy innovations (e.g., certain public health and correctional programs). The ease or difficulty of establishing the appropriate fair-trial point depends largely on the availability of the kind of technical information that would permit the accurate assessment of impacts (e.g., yields per acre) and the level of experience and knowledge that is available about the adoption of innovations in that particular field. Operationalization of the fair-trial point represents one of two major constraints on the selection of innovation decisions for study. In order to investigate properly the model of innovation proposed, it is essential to obtain sufficient variation on the independent variables. This is a sine qua non for accurate estimation of parameters. While challenging, this constraint also permits a fair amount of latitude. In addition, one must accept the constraint of selecting insofar as possible from among innovations in which the operationalization of the fair-trial point may be expected to be reliable, while avoiding those for which little basis exists for a sound decision.

(3) *Identifying the factors that determine perceived benefit and cost levels.* The model proposed here does not specify these factors but it does not preclude the eventual integration of variables that are responsible for variation in benefits, costs, or risk across decision situations (no more than traditional models preclude incorporating the determinants of an organization's level of complexity or professionalism). On the contrary, it is our hope that research will eventually identify both the variables and the pattern of interaction among them that determine the values decision makers assign to a particular innovation on the model's various dimensions. For one example, we would like to know what variables are responsible for the level of risk that an organization attaches to an innovation. Such an elaboration of the proposed model is something of a precondition for intelligent intervention into matters of organizational design; i.e., how to modify an organization so that it will be more innovative. Exploring the determinants of programmatic and prestige benefits, especially in the public sector, is also particularly important since so little is known about what motivates decision makers to innovate. While there have been some provocative speculations by various theorists (e.g., Niskanen, 1971; Cohen and March, 1974; Downs, 1967) about the kinds of incentives to which public sector decision makers respond, there is virtually no empirical research into what determines the benefit levels they attach to an innovation. Before engaging in such research, however, it is desirable to know the nature—both the magnitude and the functional form—of the impact that the various categories of benefits presently included in the model have on the decision to innovate. This is necessary in order to estimate the likely utility of probing more deeply into their individual determinants and to know how to interpret research findings.

George W. Downs is Assistant Professor of Political Science at the University of California, Davis, and Lawrence B. Mohr is Professor of Political Science and Public Policy at the University of Michigan. Both authors have written on a number of topics in the areas of organization theory and innovation and have collaborated previously.