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Innovation Attributes, Policy Intervention, and the Diffusion of Computer Applications Among Local Governments*

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ABSTRACT

Several shortcomings of traditional diffusion research create major impediments to our understanding of the diffusion of innovations as well as to the development of effective strategies of policy intervention to facilitate diffusion. Among the criticisms of diffusion research are the selection bias of many diffusion studies and the futility of curve fitting as an adequate test of theoretical relevance. These shortcomings can be avoided by substantive and methodological changes in diffusion research. We argue that innovation attributes, together with policies associated with the diffusion of an innovation, account for significant differences in diffusion patterns. An empirical analysis of this thesis focuses on the diffusion of computer applications software in local government.

Diffusion research has "spread" in recent years from its traditional locus in sociology to the disciplines of economics and political science.[1] It has also begun to move from the investigation of a set of "reasonably narrow and well-defined situations"[2]

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[1] Kenneth E. Warner, "The Need for Some Innovative Concepts of Innovation: An Examination of Research on the Diffusion of Innovations," *Policy Sciences*, 5(4), 1974, 433–451.

[2] Ibid., p. 434.

toward the investigation of more complex and less well-defined settings[3]: the transfer of aerospace and defense technologies to local governments, the spread of public policy innovations among the states, and the diffusion of advanced technology among state and local mission-oriented agencies.[4] Such studies represent only a small fraction of the knowledge in a field of research about which Warner has commented: " . . . even if interdisciplinary research managed to incorporate the diverse findings and approaches into a unified whole, . . . social science's understanding of diffusion processes, processes of change, would remain unsatisfactory."[5]

This study takes Warner's criticism as its starting point. Other recent criticisms of diffusion research also are reviewed as a means of formulating the conceptual framework and study methodology. The empirical analysis focuses on the diffusion of computer applications software in local government. Local government computer applications are a set of multi-use, multi-dimensional technologies. The major empirical gap to which this study addresses itself is the relationship between innovation attributes and diffusion outcomes. The policy-related objective of the analysis is to identify the relationship of diffusion outcomes to two public policy considerations—the "design" of the innovation and the influence of policy interventions.

Critiques of Diffusion Research

Recent critiques by Warner, Downs and Mohr, and Rogers form the foundation for our analysis of some of the deficiencies of diffusion research.[6] Although many of the criticisms of diffusion research have considerable merit, a distinction is made in this study between whether these criticisms involve unexplored empirical issues or unresolved (and possibly unresolvable) conceptual and theoretical issues. For

[3] The definition of diffusion has remained relatively stable over the period the concept has garnered the attention of social scientists. Rogers and Shoemaker define the concept as "the process by which innovations spread to members of a social system." In a recent study of diffusion of innovations in municipal governments, Feller and Menzel employ a more detailed definition: "the rate and extent of acceptance and use of innovations among a class of adopters and the process(es) by which individual adopters interact with one another and with other change agents." See Everett M. Rogers and F. Floyd Shoemaker, *Communication of Innovations,* 2nd ed. (New York: The Free Press, 1971), p. 12; and Irwin Feller and Donald C. Menzel, *Diffusion of Innovations in Municipal Governments* (University Park, Pa: Institute for Research on Human Resources, 1976), p. 2.

[4] See W. Henry Lambright and Albert Teich, *Federal Laboratories and Technology Transfer: Institutions, Linkages, and Processes.* (Syracuse, NY: Syracuse University Research Corporation, 1974); Jack L. Walker, "The Diffusion of Innovations among the American States," *American Political Science Review,* **63**(3), 1969, 880–899; Virginia Gray, "Innovation in the States: A Diffusion Study," *American Political Science Review,* **67**(4), 1973, 1174–1185; Irwin Feller, Donald C. Menzel, and Alfred J. Engel, *Diffusion of Technology in State Mission-Oriented Agencies* (University Park, Pa: The Pennsylvania State University, Center for the Study of Science Policy, 1974); and Feller and Menzel, *Diffusion of Innovations in Municipal Governments.*

[5] Warner, "The Need for Some Innovative Concepts of Innovation: An Examination of Research on the Diffusion of Innovations," p. 434.

[6] Diffusion researchers have amassed a large body of literature with probably over 2500 sources to date. Review of such a massive body of literature is obviously beyond the scope of this study. We focus on the following three critiques: George W. Downs and Lawrence B. Mohr, "Conceptual Issues in the Study of Innovations," paper prepared for devlivery at the 1975 Annual Meeting of the American Political Science Association, San Francisco, Ca, September 2–5, 1975; Warner, "The Need for some Innovative Concepts of Innovation: An Examination of Research on the Diffusion of Innovation"; and Everett M. Rogers, "Innovation in Organizations: New Research Approaches," paper presented at the American Political Science Association, San Franciso, Ca, September 2–5, 1975.

instance, Warner's criticism that "there are no adequate general definitions which offer common ground for the operationalizing of concepts for research purposes" represents an issue that is not likely to be resolved soon given the variety of disciplines and multiplicity of types of innovations involved in diffusion research.[7] Our review identifies four issues worthy of attention because of the light they might shed upon the more intractable issues. These are (1) selection bias, (2) innovation attributes, (3) origin of the innovation, and (4) the value of curve fitting

Selection Bias

The most consistent area of recent criticism of diffusion research concerns the kinds of innovations selected for study. Downs and Mohr note in their analysis of current research approaches:

> We also believe that the ubiquitousness of S-shaped diffusion curves is partially an artifact of the kinds of innovations that are usually studied. For the most part, these have consisted of fairly unambiguous technological advances which eventually diffused to most of the population. Yet clearly there are innovations which are not ultimately successful in diffusing through the entire population, but just "fizzle out" after a flurry of early adoptions.[8]

Selection bias poses two major problems for unravelling the nature of diffusion processes. First, it ignores the possible contingent conditions that differentiate between the "take-off" and spread of a successful innovation and a similar, but non-diffusing, innovation. For policy-makers interested in intervening in technological change processes, these contingencies are frequently the most crucial information for successful policy development. Second, the selection bias of diffusion research also ignores "flops" that do diffuse. Warner comments: "Economists, would respond that flops do not in general diffuse very extensively. While this proposition may hold true for the competitive market cases, its validity in quasi- and non-market arenas is highly suspect; the phenomenon of 'fads' is tremendously important in many fields."[9]

Innovation Attributes

A second common criticism of diffusion research concerns the lack of attention given to the dimensions or characteristics of an innovation. Warner notes that diffusion research has for the most part been characterized by stable and unidimensional views of technology.[10] Some attention has been directed toward conceptualizing characteristics of innovations, but these concepts have seldom become the basis of empirical research.[11] Categorical distinctions are occasionally made between product and

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[7] Warner, "The Need for some Innovative Concepts of Innovation: Examination of Research on the Diffusion of Innovations," p. 441.

[8] Downs and Mohr, "Conceptual Issues in the Study of Innovation," p. 46.

[9] Warner, 'The Need for Some Innovative Concepts of Innovation: An Examination of Research on the Diffusion of Innovations," p. 442.

[10] Ibid.

[11] See, for example, Robert W. Backoff, "Operationalizing Administrative Reform for Improved Governmental Performance," *Administration and Society,* **6**(1), 1974, 73–106 and Dean Schooler, Jr., "Political Arenas, Life Styles, and the Impact of Technologies on Policymaking," *Policy Sciences,* **1**(2), 1970, 275–287.

process innovations or physical and behavioral innovations; these distinctions usually serve, however, as criteria for innovation selection and not as an explicit variable. A number of empirical studies have also considered the effects of the attributes of an innovation on its diffusion. Most of these studies, however, have been confined to rural sociology[12] and have utilized perceptual measures of innovation attributes.[13]

Origin of the Innovation

A third criticism of diffusion research, voiced by Warner, concerns the origins of an innovation. Warner writes:

> . . . no one has thoroughly examined how the nature of the innovation's sources—its invention, production, promotion—affects the speed and pattern of its adoption. Does a government-sponsored innovation receive the same selling job as a private sector innovation? Do different types of promoters (producers, etc.) have systematically different approaches to selling their product?[14]

The importance of this issue is demonstrated by the attention given it in recent studies on government innovation. Feller and Menzel have posited a number of interesting relationships between supplier activity and diffusion patterns among municipal governments.[15] Their interviews with sales and marketing personnel of firms seeking public sector markets for their products suggested relationships among city size, spatial location, and, to a lesser extent, a city's reputation for innovation. Bingham's analysis of innovation in public housing also suggests the need to consider the source of an innovation.[16]

The Value of Curve Fitting

A fourth criticism found in recent reviews of diffusion research concerns the *methodological* adequacy of diffusion curve analysis. The S-shaped curve found in traditional diffusion research has generally been attributed to the social interaction among adopters and non-adopters over time. Downs and Mohr observe:

> Diffusion curves may strongly suggest that communications-related variables are important for innovation, but they do not demonstrate the importance, nor do they quantify it, especially in relation to causes of other types. We emphasize this because we have observed

[12] With the exception of Mansfield's research on innovation by the firm, the studies cited by Rogers and Shoemaker in relation to propositions on innovation attributes are almost universally grounded in rural sociology. See Rogers and Shoemaker, *Communication of Innovations*, Chapter 4 and pp. 350–352.

[13] There is seeming disagreement in the literature about the amount of research on innovation attributes. Warner and Downs and Mohr note that few empirical studies have been conducted on innovation attributes. Rogers and Shoemaker, on the other hand, provide over fifty citations to studies of innovation attributes. This disagreement is partly attributable to differences in the definition of innovation attributes. Rogers and Shoemaker use "perceived attributes" as the operative definition. Downs and Mohr refer to "invariant characteristics" (therefore characteristics not subject to perceptual differences), suggesting a distinction between their definition and that of Rogers and Shoemaker.

[14] Warner, "The Need for Some Innovative Concepts of Innovation: An Examination of Research on the Diffusion of Innovations," p. 445.

[15] Feller and Menzel, *Diffusion of Innovations in Municipal Governments*.

[16] Richard D. Bingham, "Innovation in Local Government: The Case of Public Housing," paper presented at the 1975 Midwest Political Science Association Annual Meeting, Pick-Congress Hotel, Chicago, Il, May 1–3, 1975.

a recent tendency, especially among political scientists, to assume that because the diffusion of a particular innovation takes the shape of an 'S' curve when graphed, a knowledge of the communication network within the adopting population will "explain" the variations in innovativeness.[17]

Gray's study of the diffusion of public policies among the states is illustrative of some of the assumptions and problems associated with curve fitting.[18] Gray suggests that the social interaction explanation of innovation diffusion is the most appealing on substantive grounds because state government "decisionmakers emulate or take cues from legislation passed by other states."[19] Although Gray notes "the futility of curve fitting as a satisfactory test of theoretical relevance,"[20] she proceeds to apply a simple interaction model which employs a number of important assumptions. Among the assumptions are that "leaders from each adopter state come in contact with leaders from each nonadopting state"[21] (complete intermixture) and that there is no constant source from which the innovation is diffused.

The latter assumption is particularly suspect given Gray's discussion of some of the welfare policies scrutinized in the study and the reported frequency distributions for adoption of some of the policies. Diffusion from a constant source appeared to characterize a number of the innovations analyzed, including aid for dependent children and welfare merit system legislation. Gray's assumption that the population is completely intermixed is disputed by Walker:

> This diffusion process forms an essentially geographical pattern, and can be visualized as a succession of spreading ink-blots on a map created by the initial adoptions of new policies by states playing in a national "league" of cue taking and information exchange, followed by other states whose standards of comparison and measures of aspiration are more parochial and who typically adopt new policies only after others within their "league" have done so.[22]

Bingham also concludes that there are no national or state patterns of innovation diffusion among local governments.[23]

Conceptual Framework

These foregoing criticisms provide implied directions for research on the diffusion of innovation which are incorporated in our conceptual framework. The framework (Fig. 1) breaks with traditional diffusion research in several ways. The model focuses attention on the *structural* sources (innovation attributes) of variations in diffusion patterns. In the past, attention has been directed predominantly at *process* considerations (for example, professional communication) at the expense of developing an

[17] Downs and Mohr, "Conceptual Issues in the Study of Innovation," p. 46.

[18] Virginia Gray, "Innovation in the States: A Diffusion Study," *American Political Science Review*, 67(4), 1973, 1174–1185. Although Feller and Menzel employ curve fitting in *Diffusion of Innovations in Municipal Governments*, they also cite the noteworthy criticisms of L. Nabseth and G. F. Ray, *The Diffusion of New Industrial Processes* (London: Cambridge University Press, 1974). A more recent criticism together with suggestions for an alternative approach are provided by Robert Eyestone, "Confusion, Diffusion, and Innovation," *American Political Science Review*, 71(2), 1977, 441–447.

[19] Ibid., p. 1176. [20] Ibid. [21] Ibid.

[22] Walker, "The Diffusion of Innovations among the Amercian States," p. 1179.

[23] Richard Bingham, *Adoption of Innovations by Municipal Governments* (Milwaukee, Wi: Marquette University, 1975.

adequate theory of the a priori potential of innovation diffusion. The framework also opens the way for testing alternatives to interactive models of diffusion. It submits several of the assumptions of the interaction model of diffusion to an empirical test.

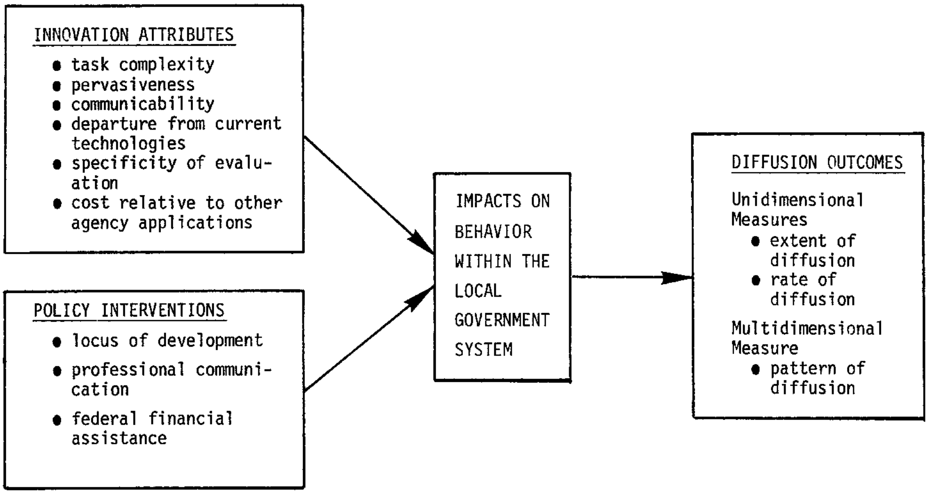

Fig. 1. Conceptual framework of the study.

Innovation attribute and policy intervention concepts are the explanatory variables used in the study (Fig. 1). Innovation attributes represent properties on which the innovation can be classified "without reference to a specified organization."[24] Several benefits are derived from studying the primary attributes of innovations. Innovation attributes reflect the multi-dimensional nature of innovations. Thus, they provide a means for characterizing the design of an innovation. Developing an understanding of the relationships of an innovation's "design" or attributes to its diffusion can enhance the explanatory import of diffusion research. It can assist in developing cumulative theory by increasing our ability to interpret the instability across current empirical studies.[25] It also can aid in evaluating strategies for diffusing innovations. If innovation attributes do indeed influence diffusion, then they should be considered when choosing incentive systems to encourage diffusion or when designing or redesigning an innovation for a particular system of potential users. In essence, innovation attributes represent a potentially manipulable, additional aspect of diffusion processes for consideration by policymakers.

The notion of manipulation is encompassed by the policy intervention concept. Policy interventions are activities or set of activities, public and private, associated with the diffusion of an innovation.[26] Policy interventions may be viewed as attempts

[24] Downs and Mohr, "Conceptual Issues in the Study of Innovation," p. 9.

[25] The problem of primary attribute variation and instability in diffusion research findings is discussed in Downs and Mohr, "Conceptual Issues in the Study of Innovation."

[26] Our use of the term policy coincides with its use in James F. Reynolds, "Policy Science: A Conceptual and Methodological Analysis," *Policy Sciences*, **6**(1), 1975, 1-18.

"to manage infrastructures (manipulate fields) and in so doing make it desirable for other organizations to behave in ways they would not have otherwise."[27] Attempts to manage infrastructures may be intentional or unintentional and may emanate from within the system of potential users or from external sources. Policy interventions therefore characterize the activities within the policy environment associated with the diffusion of an innovation.

The policy intervention concept takes explicit account of variables usually left unmeasured in traditional curve fitting studies as well as possible sources of constant source diffusion. Because it may vary and is subject to manipulation, the source of an innovation is viewed as only one dimension of policy intervention. Policy intervention as a concept also has normative implications. Since policy interventions are, like innovation attributes, multi-dimensional, their study can provide insight into diffusion tactics—including the choice of public or private sector channels.

Diffusion of Innovations

Two unidimensional measures of diffusion—extent of adoption and rate of adoption—have traditionally been employed in studies of innovation and are used as dependent variables in the present study. A third multidimensional measure—pattern of adoption—also is used.

Extent of adoption represents the cumulative percentage of adoptions for a particular innovation. Extent of adoption is measured by the number of adopters of a particular computer application divided by the number of usable responses to the survey.

Rate of adoption is defined by Rogers and Shoemaker as:

> . . . the relative speed with which an innovation is adopted by members of a social system. Thus, rate of adoption is usually measured by the length of time required for a certain percentage of the members of a system to adopt an innovation.[28]

While rate of adoption for the Rogers and Shoemakers measure is expressed in years, Fliegel and Kivlin employ a measure based on the number of adoptions per year.[29] Each is a valid measure of the relative speed at which an innovation is adopted, but each might actually measure different parts of a diffusion curve. If that is indeed the case, the results obtained from using these two measures of rate of adoption may vary considerably. Based upon the perspective that both are valid measures of rate of adoption, two specific measures for the rate of adoption of computer applications were developed for this study. The first measure is the number of years for a computer application to diffuse to three percent of the local government population. The

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[27] James D. Thompson, "Social Interdependence, the Polity, and Public Administration,"*Administration and Society,* **6**(1), 1974, 3-24 at 20.

[28] Rogers and Shoemaker, *Communications of Innovations,* p. 154.

[29] In a study of farm practices, Fleigel and Kivlin used the average percentage of adoptions per year for the eight consecutive years of most rapid adoption to measure rate of adoption. The differences in the "constants" associated with each measure (i.e., a specified percentage of the population for the Rogers and Shoemaker measure and a specified number of years of most rapid adoption for the Fliegel and Kivlin measure) suggest that the rate of diffusion for a given innovation might vary significantly between the measures. See: Frederick C. Fliegel and Joseph E. Kivlin, "Attributes of Innovations as Factors in Diffusion," *American Journal of Sociology,* **72**(3), 1966, 235-248.

second measure is the number of adoptions of computer applications per year over the ten consecutive years of most rapid adoption for that application.

Pattern of adoption represents the overall pattern of diffusion formed by the extent and rate of diffusion and the time of introduction of an innovation.[30] It is a multidimensional outcome variable for local government computer applications formed by cluster analysis of six variables that describe the diffusion pattern of each application. The six variables used in the cluster analysis were: mean year of adoption, standard deviation (in years) of the adoption distribution, peakedness (kurtosis) of the distribution, skewness, range (in years) of the adoption period, and the cumulative percentage of adoptions.

Ten patterns of adoption were identified for the population of applications from the cluster analysis. These patterns are presented in Table 1. Among the diffusion patterns are the standard S-curve cumulative frequency distribution (clusters 7, 9), several which suggest the likelihood of constant source diffusion (clusters 5, 6, 8), and several indicative of nondiffusing innovations (clusters 1, 2, 3). Cluster 10 in Table 1 includes all those applications (N = 95) which have only recently been introduced into the local government system.

Innovation Attributes

The literature suggests six attributes of innovations that might be expected to be related to diffusion. These are: task complexity, pervasiveness, communicability, specificity of evaluation, departure from current technologies, and cost. Each is explained next, and the operational definitions are presented in Appendix A.

Task complexity refers to the complexity of implementing different information processing tasks.[31] It distinguishes "the primary attribute of the information processing

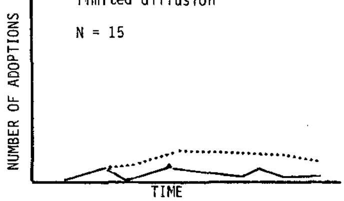
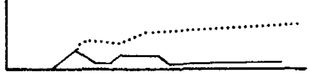
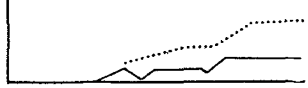
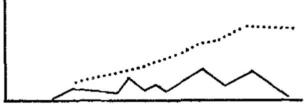
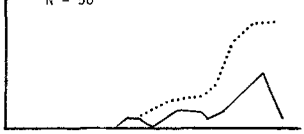
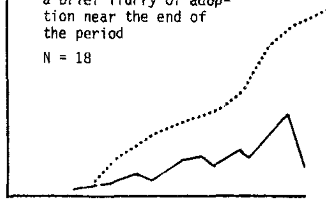
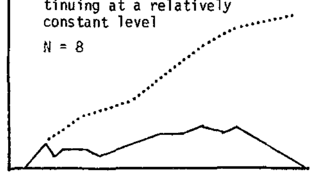
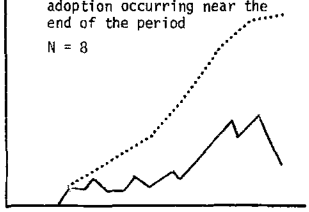
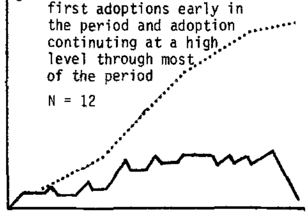
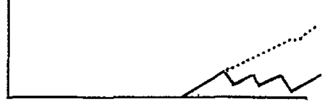
[30] Our earlier criticism of the assumptions of curve fitting as a methodology for analyzing innovation diffusion is the basis for the creation of the third dependent variable. We noted that curve fitting is not an adequate test of theoretical relevance and that it generally ignores constant source diffusion. Furthermore, since curve fitting requires an estimate of the maximum proportion of adopters, it also fails to explain why a particular innovation diffuses to only X percent of the population. Recognizing that the extent and rate of diffusion and the time of introduction of an innovation differ among innovations, it would be useful to employ a number of these dimensions simultaneously as an outcome variable. Such an approach requires fewer assumptions than curve fitting, accounts for more dimensions of variation in diffusion patterns, and does not rely on making inferences about diffusion processes directly from diffusion curves.

In a recent critique of research on the diffusion of policy innovations among the states, Eyestone suggests a methodology similar to that set forth here. He argues: "We do not yet know enough about policy content . . . to risk the confusions of lumping together large numbers of policies especially if in doing so we would be mixing representatives of several distinct diffusion models . . . Comparison of diffusion patterns may provide a way of generating policy clusters empirically according to their political similarity." Eyestone, "Confusion, Diffusion, and Innovation," pp. 14–15. Although Eyestone's suggestion points in the right direction, it requires considerable faith that the representations of distinct diffusion models will not be confused because of variance in diffusion factors unrelated to policy content. The approach we use here reflects the view that the effects of neither primary nor secondary attributes should be subject to a priori assumption.

[31] Rogers and Shoemaker define complexity as the "degree to which an innovation is perceived as relatively difficult to understand and use." Lin and Zaltman refine this definition by suggesting that "complexity may become manifest on two levels: (1) the innovation may contain a complex idea; (2) the implementation of the innovation may be complex." Our definition of task complexity refers to the latter of these two types of complexity. See: Rogers and Shoemaker, *Communication of Innovations,* p. 154; and Nan Lin and Gerald Zaltman, "Dimensions of Innovations," *Processes and Phenomena of Social Change,* ed. Gerald Zaltman (New York: John Wiley and Sons, 1973), pp. 93–116 at 103.

TABLE 1. COMPUTER APPLICATION DIFFUSION PATTERNS AMONG LOCAL GOVERNMENTS

________ Frequency
.... Cumulative Frequency

Cluster Number	Narrative Description	
1	Occasional adoption during the period, but extremely limited diffusion N = 15	
2	Minimal diffusion with most adoptions occurring early in the period N = 6	
3	Minimal diffusion with first adoptions about mid-way during the period N = 17	
4	Limited diffusion with first adoptions beginning early in the period N = 26	
5	Limited diffusion, beginning about mid-way in the period, with a brief span of rapid adoption near the end of the period N = 50	
6	Moderate diffusion with a brief flurry of adoption near the end of the period N = 18	
7	Moderate diffusion with adoption beginning early in the period and continuing at a relatively constant level N = 8	
8	Extensive diffusion with rapid adoption occurring near the end of the period N = 8	
9	Extensive diffusion with first adoptions early in the period and adoption continuing at a high level through most of the period N = 12	
10	Incomplete diffusion with first adoptions occuring late in the period N = 95	

involved in a given activity''[32] and ''might be a basis for predicting the differential effect of automating activities in terms of their impacts for operational performance, decision making, and the municipal work environment.''[33] At the very least we would expect that the different couplings of men and machines, which these information processing tasks represent, are more difficult to implement because they place different demands on an organization's social system efficiency.[34] As implementation becomes more difficult, diffusion might be expected to decrease.

Pervasiveness refers to the ''degree to which an innovation relates to and requires changes or adjustments on the part of other elements'' in the organization.[35] In this study, pervasiveness measures the generality or specificity of the use of an application within an organization. We expect that this innovation attribute would affect how organizational actors perceive an innovation's contribution to the organization and its impact on budgetary allocations.

Communicability of an innovation represents one aspect of ''the degree to which the results of an innovation are visible to others.''[36] The extent of documentation of a computer application is used here to measure the communicability of an application outside of its system of users or developers. We would expect that computer applications that are documented sufficiently so they can be transferred easily to another organizational setting will exhibit greater diffusion than those applications where documentation is insufficient to support its transfer.

Specificity of evaluation is the degree to which an innovation's outputs can be measured objectively. Woodward argues that a ''causal link between technology and organizational behaviour is the degree of uncertainty and unpredictability in the production task.''[37] Honnold and Erickson suggest that specificity of evaluation is a measure of uncertainty about the instrumental value of a technological change.[38] Therefore, we expect that greater specificity of evaluation would enhance the diffusion of applications.

Departure from current technologies refers to the relative differences between newly developed technologies and technologies presently used by organizations in the focal system. When a technology is first introduced into the local government system, how different is it from existing technologies and how does this difference affect its diffusion? Does the ''newness'' of a technology detract from or enhance its diffusion? Generally we expect that the greater the departure of an application from technologies in use, the greater the likelihood that it will be less compatible

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[32] Kenneth L. Kraemer, William H. Dutton, and Joseph R. Matthews, ''Municipal Computers: Growth, Usage and Management,'' *Urban Data Service Report*, 1975, 7(11). Washington, D.C.: International City Management Association. [33] Ibid., p. 32.

[34] See C. Haberstroh, ''Organization Design and System Analysis,'' *Handbook of Organizations* (Chicago: Rand McNally, 1965) and Bayard E. Wynne and Gary W. Dickson, ''Experienced Manager's Performance in Man-Machine Decision System Simulation,'' *Academy of Management Journal*, **18**(1), 1975, 25-40.

[35] Lin and Zaltman, ''Dimensions of Innovations,'' p. 103.

[36] Rogers and Shoemaker, *Communication of Innovations*, p. 155.

[37] Joan Woodward (ed.), *Industrial Organization: Behaviour and Control*. (London: Oxford University Press, 1970), p. 35.

[38] Julie A. Honnold and Patricia E. Erickson, ''Technology and Organization: Measurement Strategies,'' paper presented at the 69th Annual Meeting of the American Sociological Association, Montreal, Canada, August 25—29, 1974.

with current system requirements and therefore less acceptable to potential users, at least initially. However, the fact that an application *was developed* may be prima facie evidence of potentially significant need for the application within the system of users, and therefore it might be more acceptable later despite its current incompatibility.

The relative cost of implementing an innovation is the final attribute explored in this study. In the absence of profitability or return on investment criteria for government organizations, the cost of implementation (but not operation) may be the single most important economic variable in the public sector innovation process. Applications were coded according to whether the cost of implementing the application relative to other applications within a particular department was low, moderate or high. Although the role of cost has received little explicit attention in studies of public sector innovation, we would expect that the greater the costs of implementing a computer application, the less likely it will be diffused widely.

Policy Interventions

The literature on innovation also suggests three policy interventions which are considered here: locus of development, professional communication, and the availability of federal financial assistance.

Locus of development, notably absent in previous diffusion research, reflects one aspect of an innovation's origin. In this study, it refers to the four alternative sources of development of local government computer applications software: federal agencies, manufacturers, other non-local government sources, and local governments themselves. The primary distinguishing feature of these four sources is their centralization vis-à-vis the local government system. Federal sources are viewed as the most centralized sources of development; local governments as the most decentralized sources of development. We expect that the more centralized the source of the innovation, the more likely there will be constant source diffusion, and therefore the greater the diffusion.

Professional communication, a second policy which should influence diffusion, refers to the amount of communication about an application within professional channels. Professional communications media provide a major means of disseminating information on recent technological developments, assessments of particular technologies, and specific experiences with an application. Communication within such professional networks is measured by the number of published articles on an application in three diverse professional publications, the *URISA Proceedings, Datamation,* and *Computer World.*

Availability of federal assistance for the implementation (development or transfer) of computer applications is the third policy investigated here. Federal financial assistance is measured as a dichotomous variable indicating either that no assistance was available for implementation or a given application, or that federal assistance was available. The level of federal assistance to state and local governments for automated information systems, estimated conservatively around $250 million annually,[39]

[39] Ruth M. Davis, "Federal Interest in Computer Utilization by State and Local Governments," *The Bureaucrat,* 1(4), 1972, 349–356.

is sufficiently large that it could reasonably be expected to positively influence the diffusion of computer applications. However, restrictions placed upon the use of some federal funds might dampen the diffusion of some applications. The Law Enforcement Assistance Administration, for example, required until recently that its projects grants be spent only for law enforcement applications on computers dedicated to such applications and operated by uniformed personnel. Furthermore, federal investment frequently is directed towards costly computer applications which are difficult to implement, such as those associated with the USAC demonstration projects.[40]

Research Methodology

Two types of analysis were performed in assessing the relationships between innovation attributes, policy interventions and the diffusion of computer applications among local governments: multiple regression and discriminant analysis. *Multiple regression techniques* were used to analyze the relationships between the independent variables and three unidimensional measures of diffusion: (1) the extent of adoption, (2) the rate of adoption as indicated by the "number of applications adopted per year over the ten most active years of adoption," and (3) the rate of adoption as indicated by the "number of years for the application to diffuse to three percent of the population." The expected relationships between the innovation attributes, policy interventions and *extent* and *rate of adoption* are summarized in Table 2. Signs in the table represent the expected direction of the relationships between the operational indicators. Since

TABLE 2

Expected Relationships Between the Innovation Attributes, Policy and Extent, and Rate of Adoption of Computer Applications

	Extent of Adoption	Rate of Adoption	
Independent Variables	Cumulative percentage of adoptions for an application	Number of applications adopted per 10 most active years of adoption	Number of years for the application to diffuse to 3% of the population
Innovation Attributes			
Task complexity	—	—	+
Pervasiveness	+	+	—
Communicability	+	+	—
Departure from current technologies	—	—	+
Specificity of evaluation	+	+	—
Cost relative to other agency applications	—	—	+
Policy intervention			
Locus of development	—	—	+
Professional communication	+	+	—
Federal financial assistance	+	+	—

[40] Kenneth L. Kraemer, "USAC: An Evolving Governmental Mechanism for Urban Information Systems Development," *Public Administration Review,* 1971, **31**(5), 543–551.

the two operational measures of rate of adoption are inversely related (e.g., a *high* number of adoptions per year and a *low* number of years to diffuse each reflect rapid adoption), the opposite signs for the rate of adoption relationships in Table 2 reflect equivalent relationships. In the regression analyses we controlled for distortion caused by some applications being in the early stages of diffusion by using *only* cases falling in Clusters 1–9 of Table 1, i.e., those which had diffused. The regressions are based on an N of 112.

Discriminant analysis was used to identify relationships between innovation attributes, policy interventions and the multidimensional measure of diffusion—the pattern of adoption. The intent of the analysis was to relate diffusion outcomes (represented by the nine groups in Table 1) to the design of the innovation and the role of policy. Discriminant functions allow us to assess which innovation attributes pose the greatest constraints to computer application diffusion and which policies might be most effective for diffusing particular types of applications.

Whereas the multiple regression analysis attempted to obtain a best fit between a criterion variable and a set of predictors, the purpose of the discriminant analysis was to distinguish among groups of cases using variables on which the groups are hypothesized to differ. The nine patterns of adoption of computer applications (Table 1) served as the criterion variable. In computing the first discriminant functions, all nine groups were used as the criterion and an F-test was computed for the distance measure between groups. The F-ratios indicated that the distance among groups 1, 2 and 3 and between groups 6 and 7 were not significantly different for the predictor variables. Thus, these five groups were combined into two groups and a second set of discriminant functions were derived using only six criterion groups. The results of the discriminant analysis for each of the criterion groupings (i.e., the six and nine groupings) were not substantially different, and therefore the results are reported only for six criterion groups.

Data for both of these empirical analyses were gathered through a 1975 survey of computer applications in 713 local governments. The survey provided an inventory of computer applications software used by governments in cities over 50,000 population and in counties over 100,000 population.

Research Findings

Multiple Regression Analysis. The regression results for each of the diffusion indicators are presented in Table 3. One general observation about the regressions, which we suggested earlier, is that the two operational indicators of rate of adoption appear to measure different aspects of diffusion curves. For example, departure from current technologies is positively associated with both the number of adoptions per year (indicating the greater the departure, the more rapid the diffusion during peak adoption years) and the number of years to diffuse to 3% of the population (indicating the greater the departure, the less rapid the diffusion during the initial years of diffusion). The differences in these two measures point to one possible reason for the inconsistency in previous diffusion finding.[41] These differences also confirm

[41] See Downs and Mohr, "Conceptual Issues in the Study of Innovation" for a discussion of some of the sources of instability in innovation diffusion research findings.

the value of using either multiple indicators or multidimensional indicators as dependent variables in diffusion studies.

The expected relationships between three innovation attributes—departure from current technologies, pervasiveness and specificity of evaluation—are supported by

TABLE 3

Multiple Linear Regressions for Extent and Rate of Computer Application Adoption

	Extent of Adoption	Rate of Adoption	
Independent Variables	Cumulative percentage of adoptions for an application	Number of Applications adopted per 10 most active years of adoption	Number of years for the application to diffuse to 3% of the population
Innovation attributes			
Task complexity	0.00	0.02	0.10
Pervasiveness	0.38‡	0.38‡	—0.16
Communicability	—0.06	—0.06	0.08
Departure from current technologies	0.29‡	0.24‡	0.49‡
Specificity of evaluation	0.25†	0.29†	0.08
Cost relative to other agency applications	0.08	0.11	—0.22†
Policy interventions			
Locus of development	−0.09	−0.03	−0.06
Professional communication	0.12	0.13	0.10
Federal financial assistance	−0.10	−0.09	−0.19*
Constant	−0.03	−8.03	8.58
R^2	0.36	0.33	0.29
F	6.43‡	6.11‡	4.76‡

*$p<0.05$ †$p<0.025$ ‡$p<0.01$

the regression equation. Departure from current technologies is highly significant in each equation. The positive association with the cumulative extent of adoption indicates that an application's initial status vis-à-vis other technologies actually has a positive impact on its acceptance by local governments. The positive association with *both* rate of adoption measures indicates that an application's departure from existing technologies has a dampening effect on its adoption in the initial stages of diffusion but has a positive effect during the peak years.

Pervasiveness and specificity of evaluation have strong positive associations with two of the measures of adoption (extent and peak rate of adoption). Cost on the other hand, is nonsignificant in these two regressions but it positively influences the initial rate of adoption. This later finding reinforces Fliegel and Kivlin's conclusion that cost per se is not a significant negative influence on the rate of adoption.[42] This

[42] Fliegel and Kivlin, "Attributes of Innovations as Factors in Diffusion."

suggests that it probably is necessary to consider cost relative to some perceived or anticipated benefit in order to adequately specify the independent variable. Unlike cost, pervasiveness and specificity of evaluation are significant and influence the likelihood of successful adoption. The collective results of these three attributes suggest that some broader concepts such as risk and uncertainty might underlie differences in the diffusion of computer applications.

It is noteworthy that pervasiveness is positively, and significantly associated with extent of adoption and the number of adoptions per year, but not significantly related to the rate of adoption in the initial years. This suggests that certain applications, for instance, finance applications, are highly valued candidates for automation because they are multifunction or organization-wide. One would therefore expect a high number of adoptions overall. But the multifunction nature of these applications means that implementation is complex and difficult. Therefore, the initial rate of diffusion is slow. Once appropriate "model applications" have been developed, their adoption might be quite rapid. Of course, it also is possible that their adoption will remain slow precisely because they are organization-wide in scope.

Communicability is nonsignificant in any of the regressions. It should be emphasized again that our definition and measurement of the concept is very different from that in most of the literature. The literature refers to the ease of others understanding both the operational and performance aspects of the application. Our measure simply taps the availability of one highly technical form of communication. Yet, the measure of communicability is related to both practice and policy. Practitioners argue that documentation is essential for transfer. Federal and state officials require local governments to document programs developed with their financial aid in order to facilitate transfer. Therefore, the fact that documentation is nonsignificantly but negatively associated with each of the diffusion measures has practical importance.

Few of the expected relationships between the policy variables and the dependent variables are substantiated by the regression equations. The strongest relationship is that between financial aid and initial diffusion (the number of years for the application to diffuse to 3% of the population). The relationships between professional communication and the dependent variables are significant at about the 0.10 level. Locus of development is unrelated. Federal financial assistance appears to have a positive influence in reducing the time span for the initial diffusion of an application. The overall pattern of relationships for federal assistance is consistent with the possible impacts of one type of federal diffusion strategy. The federal government has funded experiments for some applications as a way of demonstrating feasibility and utility. Following limited experimentation and transfer, these federal diffusion efforts are then discontinued on the grounds that normal market mechanisms will prove adequate to complete the diffusion process. Thus, initial diffusion may be speeded, but the long-run rate and extent of adoption may be unaffected.

One reason for the weak relationships between policy variables and diffusion is that policies may not be independent of an innovation's attributes. Particular types of innovations, either because of their implications for advancing the use of the technology or because of their attractiveness from a purely technical standpoint, probably have higher potential for receiving attention in professional circles than other types of innovations. Similarly, federal support may be directed only at applications which are difficult to diffuse among local governments. Three multiplicative terms were entered into the separate regressions to test for this type of interaction: federal assistance × task complexity, professional communication × departure from current technologies; and cost × federal assistance. The addition of these terms led to some improvement in the R^2's, but none significantly improved the overall

TABLE 4

Discriminant Functions for the Innovation Attributes and Policy Interventions

	Function 1	Function 2
Innovation attributes		
Task complexity	0.19	0.14
Pervasiveness	−0.10	0.58
Communicability	−0.14	−0.31
Departure from existing techniques	−0.55	0.45
Specificity of evaluation	−0.11	0.58
Relative agency cost	−0.22	0.18
Policy interventions		
Locus of development	0.19	0.00
Professional communication	0.16	0.00
Federal financial assistance	0.77	0.51
Eigenvalue	0.68	0.32
Canonical correlation	0.64	0.49
Wilks' lambda	0.67*	0.89*

* Significant at $X^2 < 0.05$.

predication of variance. However, it is possible that functional specifications different from those we used might improve the regression results.

Discriminant Analysis. The results of the discriminant analysis are shown in Table 4.[43] Two significant functions were derived when using innovation attributes and policy as the discriminating variables.[44]

In the first discriminant function (Table 4, column 1), the magnitudes of the coefficients indicate that the primary determinants of group membership are departure from existing technologies and federal financial assistance. The opposite direction of the association for these two variables is worth noting. Federal financial assistance is positively associated with group membership which means that the higher the group score, generally, the more extensive and/or rapid the diffusion. Departure from existing technologies is negatively associated with group membership, which means that the lower the group score, generally the less extensive and less

[43] Wilks' lambda, a measure of the discriminating power of the variables, was 0.40 before any discriminant functions were removed. This indicates considerable discriminating power among the innovation attributes and policy variables. The fact that multiple functions were derived for each set of groups is itself significant and will be discussed later.

[44] Several of the variables contribute very little to the discriminating power of any of the discriminant functions. Among the innovation attributes, task complexity and relative agency cost add little discriminating power. The magnitude of the locus of development and professional communication coefficients in each of the four functions are also relatively small. Departure from existing technologies and federal financial assistance are the only two variables significant in each of the four functions.

rapid the diffusion. This first function can be termed *systemic facilitation* since the two significant variables identify the departure of the application from other technologies in use within the system and the availability to all local governments of federal resources for designing and implementing the application.

In the second discriminant function, four variables are about equally significant: pervasiveness, departure from existing technologies, specificity of evaluation, and federal financial assistance. Although federal assistance differs in kind from the other three variables, we term this discriminating dimension *attribute facilitation.* It indicates that the more pervasive, evaluable, and novel the application, the more likely it will be a member of one of the diffusion groups characterized by extensive and rapid adoption.

In addition to providing information on significant factors in the diffusion process, the discriminant functions can also be tested for their ability to classify known group members, i.e., those which have diffused. Table 5 presents the predicted group membership of the applications using the functions derived from the innovation attribute and policy variables.[45] The ability of the discriminant functions to classify

TABLE 5

Diffusion Group Membership of the Computer Applications Predicted by the Discriminant Functions for the Six Group Criterion

Actual Group	No. of Cases	Predicted group membership					
		Group 1	Group 2	Group 3	Group 4	Group 5	Group 6
Diffusing Applications							
Group 1							
(Clusters 1, 2 and 3		31	1	5	1	0	0
in Table 1)	38	81.6%	2.6%	13.2%	2.6%	0.00%	0.00%
Group 2		7	2	17	0	0	1
(Cluster 4)	26	26.9	7.7	65.4	0.0	0.0	0.0
Group 3		14	6	24	5	0	1
(Cluster 5)	50	28.0	12.0	48.0	10.0	0.0	2.0
Group 4		7	0	10	5	1	3
(Clusters 6 and 7)	26	26.9	0.0	38.5	19.2	3.8	11.5
Group 5		0	0	4	0	4	0
(Cluster 8)	8	0.0	0.0	50.0	0.0	50.0	0.0
Group 6		3	0	0	4	0	5
(Cluster 9)	12	25.0	0.0	0.0	33.3	0.0	41.7
Non diffusing applications							
Group 7		5	39	29	1	21	0
(Cluster 10)	95	5.3%	41.1%	30.5%	1.1%	22.1%	0.0%

Percent of grouped cases (Groups 1–6) correctly classified is 44.38%.
Predicted group membership for those applications which are in the *early stages of diffusion.*

[45] Appendix B identifies the applications in each cell of Table 5.

known group members essentially reflects the extent to which the discriminating variables separate the cases into mutually exclusive groups. Applications with known group membership are correctly classified in 44% of the cases.

The discriminant functions also provide a means for classifying cases with unknown group membership, i.e., those which have not yet diffused very much. Applications in Group 7 were initially distinguished from the other applications because they were in the early stages of diffusion and could not be grouped with those applications that had diffused significantly. However, these cases can be classified according to the diffusion group in which they will eventually fall using the values of the cases on the discriminating variables. The predicted group membership of the 95 applications in Group 7 is displayed at the bottom of Table 5.[46]

Summary and Concluding Discussion

Summary

The findings of the regression analysis and discriminant analysis were essentially similar. However, the discriminant analysis provides a more complete picture of the diffusion of computer application in local governments. Discriminant analysis indicated that the diffusion of computer applications is facilitated by both the attributes of the application and system characteristics. This duality of discriminating dimensions may explain some of the lack of consistency in the findings of previous studies on the effect of perceived attributes on innovation diffusion. While the attribute facilitation dimension clearly demonstrated that innovation attributes are significant factors in the diffusion of innovations, the discriminating power of the systemic facilitation dimension indicated that factors independent of an innovation's attributes are sufficient for diffusion.

The structure of the innovation attribute and policy discriminant functions raises some questions about underlying causal processes which, although they cannot be answered here, are worth noting. For example, several causal processes might be plausible given the structure of the attribute facilitation function. One underlying causal process could be described as "need-based." The magnitudes and directions of the variables on the attribute facilitation function could be the result of felt needs, search and adoption among some system members, and subsequent diffusion to other system members with similar felt needs. This appears to us to be the most plausible underlying causal process. If it is, it suggests that the local government system may be quite efficient in assessing and meeting needs for innovation. This optimistic assessment is tempered by the fact that the importance of the pervasiveness and evaluability attributes may also point to a predisposition toward risk minimizing behavior among local government officials. Alternative causal processes may also underlie the systemic facilitation functions. For example, motivated by the availability of federal funding for local use in developing new computer applications, private entrepreneurs may enter the market and encourage local governments to implement incremental adjustments to their existing technologies. On the other hand, local

[46] Appendix C presents the *probability* of group membership for each of the 95 applications.

officials may see the availability of federal funds as an opportunity to add new data processing capabilities to areas where they have previously undertaken considerable systems development. Although the discriminant functions provide a framework within which to consider policy alternatives, the underlying causal mechanisms require further investigation.

Policy Implications

This analysis suggests that to maximize its effectiveness federal support of computing (and probably other local government technologies) must adapt to contingencies created by differences in technologies and changing circumstances as well as take advantage of opportunities to manipulate key variables in the diffusion process. The major contingencies facing federal intervention appear to be when to initiate and when to withdraw support, and for what purposes. Federal financial assistance is likely to be most successful (success being defined in terms of both the diffusion group membership of a technology and the fulfillment of local needs) if it is directed toward technologies which represent a breakthrough from technologies in use and which possess attributes attractive to the target population. Accomplishing this will require some vision for identifying "innovative" technologies with attributes to which local government officials would be responsive. Although this strategy might be successful, it may not be cost effective. Even in the absence of federal assistance, technologies with attributes attractive to system members could be expected to diffuse widely and relatively quickly. Furthermore, assuming that federal objectives may differ or even conflict with local objectives, federal officials are likely to sacrifice the achievement of federal objectives in choosing innovations with attributes that facilitate diffusion and contribute to local government objectives.

In any event, thorough analysis of the local government market would appear to be a prerequisite of federal support. Such an analysis must not only explore in what ways local government technologies are deficient, but it must also explore their needs, responsiveness to particular technologies, and responsiveness to various types of incentives. Where federal objectives for the development of a new technology differ from local objectives, a two-stage program of federal support may be the most effective strategy for intervention. The first stage would emphasize the development of local capabilities in areas related to the technology. The second stage would be directed at technologies that enhance federal objectives, but build local capabilities developed during the first stage.

Research Implications

We noted that Rogers and others have criticized researchers for *selection bias,* i.e., their propensity to select only widely diffusing innovations. In contrast, our population of computer applications included both diffusing and nondiffusing applications. One way of assessing the implications of our selection criterion is to consider two results of this study which differ from those which used only widely diffusing innovations. We found that the communicability of an innovation and communication within professional circles had no significant impact on the diffusion of computer applications among local governments, contrary to the large majority of previous studies. We also found that the availability of federal financial assistance helps to differentiate diffusing from nondiffusing innovations, contrary to Yin et al.'s study of state and local innovations.[47] These differences could, of course, be the result of the set of innovations we studied. However, the possibility that excluding nondiffusing innovations from diffusion research has led to ascribing significance to important variables in the diffusion process clearly cannot be discounted by the results of this study. Further research exploring both diffusing and nondiffusing innovations will be necessary before any firm conclusions can be reached on which variables from previous research are worth retaining because they are truly significant factors in diffusion.

As suggested by Warner, our analysis indicates that *innovation attributes* do play a significant role in an innovation's diffusion. The discriminant analysis indicated, however, that facilitative attributes are sufficient but probably not necessary conditions for innovation diffusion.

Our investigation of the effects of the *origin of the innovation* on its diffusion was limited to assessing the effect of locus of development. The analysis of local government computer applications showed no relationship between locus of development and diffusion patterns. No source of development seems to occupy a "favored" status in the local government computer application market. Because the sources of data processing technology and expertise are relatively extensive compared to other public sector technologies this finding might not be generalizable to other technologies in local government.

The value of curve fitting in diffusion research also was questioned. This study departed from that traditional methodology in favor of using cluster analysis to identify alternative diffusion curves and discriminant analysis to identify key variables in the diffusion process. Several of the diffusion patterns derived from the population of local government computer applications deviated from the S-shaped model and several also suggested the likelihood of constant source of diffusion. The significance of federal financial assistance in the discriminant functions supported the constant source explanation.

Conclusion

Federal financial assistance, innovation attributes, and local government needs may be better predictors of the diffusion of computer applications than interaction among adopters and nonadopters. Furthermore, the discriminant analysis indicated the plausibility of alternative processes of diffusion occurring within the same population of adopters.

At a more general level, our analysis suggests a need for greater emphasis on structural variables in diffusion research, the development of alternatives to sequential models of the diffusion process and the use of diverse methodologies in building

[47] Robert K. Yin, Karen A. Heald, Mary E. Vogel, Patricia De, Fleischauer, and Bruce C. Vladeck, *A Review of Case Studies of Technological Innovations in State and Local Services* (Washington, D.C.: The Rand Corp., February, 1976).

diffusion theory. Development of greater diversity within the field holds promise of increasing the richness of diffusion theory, improving our understanding of diffusion processes, and identifying effective strategies for policy intervention.

APPENDIX A

Operational Definitions of the Innovation Attributes

1. Task Complexity
   Operational definition:[a]
   1 = Record-keeping—activities which primarily involve the entry, updating, and storage of data.
   2 = Calculating/printing—activities which primarily involve sorting, calculating, and printing of stored data to produce specific operational outputs.
   3 = Record-restructuring—activities which involve reorganization, reaggregation, and/or analysis of data.
   4 = Sophisticated analytics—activities which utilize sophisticated visual, mathematical, simulation or other analytical methods to examine data.
   5 = Process control—activities which approximate a cybernetic system; data about the state of a system is continually monitored and fed back to a human or automatic controller which steers the system toward a performance standard.

2. Pervasiveness
   Operational definition:
   1 = Single function
   2 = Multi-function
   3 = Organization-wide

3. Communicability
   Operational definition:
   1 = The documentation for less than 75% of the applications in use is not adequate for transfer.
   2 = The documentation for 75% or more of the applications in use is adequate for transfer.

4. Departure from current technologies
   Operational definition:
   100% minus the percentage of applications in the same task complexity category previously introduced into the local government system.

5. Specificity of evaluation
   Operational definition:[b]
   1 = personal evalution only
   2 = partial measurement (of some aspects of outputs)
   3 = measurements used over virtually the whole output(s), to compare against specification (blueprint or equivalent).

6. Cost relative to other agency applications
   Operational definitions:
   Cost to implement relative to all other applications within a particular department.
   1 = low
   2 = medium
   3 = high

[a] Adapted from Kenneth L. Kraemer, William H. Dutton, and Joseph R. Matthews, "Municipal Computers: Growth, Usage, and Management," *Urban Data Service Report,* 7 (November, 1975). Washington, D.C.: International City Management Association.

[b] D. J. Kickson, D. S. Pugh, and D. C. Pheysey, "Operations Technology and Organization Structure: An Empirical Reappraisal," *Administrative Science Quarterly*, 14 (September 1969), 378–397 at 383.

APPENDIX B

Diffusion Group Membership of Computer Applications Predicted by the Discriminant Functions for the Six Group Criterion

Predicted group membership →

← Actual Group Membership →

	1	2	3	4	5	6
1	Building ID & location file Deed records Land, plat records Animal Control: code violation records Traffic light control Traffic control device inv. Traffic light maintenance scheduling Traffic flow projections Solid Waste: Equipment and manpower allocation Refuse collection scheduling Liquid Waste: Equipment and manpower allocation Location of water facilities Water production records Elec.: Inventory and location files Elec.: Customer inquiry Elec.: Consumption data Gas: Utility accounting Gas: Customer inquiry Gas: Consumption data Health certificates/permits file Health inspection records Insect & rodent inspection Caseworker & social worker case records Public housing assistance data Records on distribution of clothing, eyeglasses, etc. Birth records Death records Marriage records Divorce records Adoption records Library: periodical holdings	Water: customer inquiry	Permits: safety licences Traffic flow data Elec.: Utility billing Elec.: Utility accounting Gas: Utility billing	Welfare: program case records (Homemakers, neighborhood service center, other local agencies)		
2	Purchasing: Bid file DP: Data dictionary Space utilization records Streets and highways maintenance records and scheduling Immunization records Parks and recreation facility inventory Automatic precincting	Engineering design calculations Health education records	Field interrogation report file Firearm registration file Building description records Building inspection records Plaintiff/defendant records Probation records Federal & State grant files Regression for residential property appraisals Regression for non-residential property appraisals Model cities information system Substandard structure reports Building complaint records Design requirement files Construction records and scheduling Water pollution monitoring and records Patient medical and treatment records Cemetery records			

3	Bonded debt & interest accounting Securities & funds records Purchasing: Requisition file Purchasing: Central stores file Commodity price record file Collective bargaining, labor negotiations support Data Processing: debugging routines Building maintenance records Print shop job file Animal licenses Streets and highways inventory, location Solid waste billing Water: vehicle maintenance records	Modus operandi Commercial business activity and sales Right of way file Parks & Recreation accounting Vote counting Vote auditing	Criminal offense file Juvenile criminal offense file Alias name file Stolen vehicles file Motor vehicle registration file Fire apparatus inventory Courtroom calendars and scheduling Court docketing Court disposition file Child support records Expenditure forecasting Revenue forecasting Media mailing list Telephone directory Land use inventory file Building permits Land survey data Solid waste accounting AFDC records Aid to blind records Aid to disabled records Old age assistance records Food stamp records	Cash management/ cash flow analysis Sales ratio analysis Water: inventory & location files General assistance records Circulation records/overdue notices		General accounting
4	Business license records Calculation of real property value, assessing Purchasing: vendor file Computer utilization records Peripheral equipment utilization Water: Utility accounting Water: Consumption data		Uniform Crime Reporting (UCR) Parking ticket file Traffic violations file Wants/warrants file Preparation of vouchers, warrants for city funds Budget monitoring Position classification listing Data Processing: Job accounting Voter registration records Voter mailing list	Nonproperty tax records and billing Tax maps Purchase control (budget as actual) Employee records	Budget preparation	Accounting: cost accounting Motor vehicle equipment file Motor vehicle maintenance records
5			Arrest records Traffic accident file Vehicle maintenance records Jury selection		Other crime reporting system Police: service data (type of call, location, etc.) Program budget preparation Budgeting: Program structure rel. to line-to-line budget	
6	Check reconcilation Tax roll, listing of all property Property ownership list			Property tax records/billing Special assessment and tax records Data Processing: Cust. billing Water: utility billing		Check preparing/ issuing Payroll prep./ accounting Retirement/ pension records Real property records Personal property records

APPENDIX C

Predicted Group Membership for Those Applications which are in the Early Stages of Diffusion Using the Six Group Criterion

Name of Application	Predicted group	Probability of case being in predicted group	Second most likely group	Probability of case being in second group
Police Protection				
Criminal Investigation				
Intelligence compilations	5	0.366	3	0.349
Jail population/custody file	3	0.417	5	0.299
Fingerprint file	2	0.521	3	0.354
Police Operations/Patrol				
Dispatching	5	0.385	3	0.340
Police Administration				
Law Enforcement Manpower Resource Allocation System (LEMRAS)	3	0.472	2	0.226
Other manpower allocation systems	3	0.515	2	0.226
Miscellaneous				
Civil offense file	2	0.561	3	0.317
Bicycle registration file	3	0.548	2	0.188
Fire Protection				
Fire Prevention and Inspection				
Fire hydrant location file	5	0.407	3	0.309
Fire dispatching	3	0.438	5	0.287
Fire investigation reports	5	0.559	3	0.224
Fire Administration				
Fire station locator	2	0.749	3	0.167
Other analysis to determine fire station location	2	0.408	5	0.379
Fire vehicle inventory	3	0.543	2	0.188
Uniform Fire Incident Reporting System (UFIRS)	2	0.446	3	0.377
Other fire incident reporting systems	2	0.474	5	0.306
Service data: type of call, location, time, outcome etc.	5	0.557	3	0.247
Manpower allocation and distribution	2	0.400	3	0.297
Vehicle maintenance records	3	0.394	5	0.321
Courts				
Juvenile Court				
Court case disposition records	3	0.509	5	0.232
Juvenile probation records	3	0.540	2	0.179
Detention records	5	0.422	3	0.313
Other Courts				
Assignment of attorneys, public defenders, prosecutors	2	0.450	5	0.314
Court trustee records	2	0.566	3	0.317
Detention records	2	0.523	3	0.341
Fine, collateral and bail collection file(s)	3	0.436	5	0.310
Alcohol Safety Action Project (ASA)	3	0.450	2	0.303
Other court tracking systems	2	0.651	3	0.188
Prosecution Management Information System (PROMIS)	1	0.167	2	0.167

Emergency Preparedness				
Public shelter location file	2	0.453	3	0.340
Public shelter supply inventory	2	0.445	3	0.337
Budgeting and Management				
Productivity measurement	5	0.720	3	0.160
Program effectiveness measurement	2	0.507	3	0.356
Purchasing Inventory				
Specification file	2	0.372	3	0.341
Personnel				
Applicant/recruiting file	3	0.414	4	0.311
Test records and scoring	2	0.475	3	0.358
Comparative wage and benefit files from other governments	2	0.362	3	0.335
Data Processing				
Data inventory	4	0.346	3	0.281
Geoprocessing				
Geographic Information Systems				
Street Address Conversion System (SACS)	3	0.356	5	0.351
Address Coding Guide (ACG)	3	0.431	4	0.258
Dual Independent Map Encoding (DIME)	3	0.553	2	0.177
Address Matching (ADMATCH, etc.)	3	0.502	2	0.177
Graphics				
Synagraphic Mapping System (SYMAP)	5	0.422	3	0.349
Grid Related Information Display System (GRIDS)	2	0.624	3	0.290
Public Information				
Complaint processing	1	0.633	2	0.265
Public Buildings				
Building maintenance scheduling	3	0.430	2	0.387
Planning and Zoning				
Zoning ordinances	5	0.514	3	0.257
Zoning inspection file	5	0.384	3	0.322
Subdivision inspection file	5	0.384	3	0.322
Capital improvements file	3	0.429	5	0.279
Social Indicators and Community Analysis				
U.S. Census data (population, housing, government)	2	0.572	3	0.316
Demographic data other than U.S. Census	2	0.520	3	0.344
Labor force and employment data	2	0.533	5	0.233
Industrial production data	5	0.655	2	0.267
Neighborhood oriented data file containing mix of above and other socioeconomic characteristics	2	0.400	5	0.366
Urban Development Models				
Population	5	0.668	3	0.195
Land use	5	0.486	3	0.346
Transportation and traffic	5	0.800	3	0.140
Economic	5	0.631	3	0.211
Housing	5	0.716	3	0.177

Name of Application	Predicted group	Probability of case being in predicted group	Second most likely group	Probability of case being in second group
Housing and Urban Renewal				
Housing Programs				
Housing survey data	5	0.562	3	0.275
Public housing occupancy records	5	0.414	3	0.293
Housing construction scheduling	5	0.654	3	0.214
Cost accounting	3	0.492	2	0.346
Urban Renewal				
Relocation data	2	0.601	3	0.240
Certificate of occupancy	2	0.449	3	0.425
Engineering				
Design and Survey				
Soil, foundation analysis data	1	0.372	3	0.306
Maps				
Engineering map identification file	2	0.372	3	0.341
Map generation	2	0.402	1	0.293
Streets and Highways				
Street lighting inventory, location	3	0.343	2	0.307
Sanitation				
Solid Waste Disposal				
Street cleaning, snow removal	2	0.424	3	0.306
Landfill control file	3	0.470	2	0.298
Liquid Waste Disposal				
Sewer line inventory, location	2	0.351	3	0.341
Maintenance records and scheduling	3	0.441	2	0.270
Sewage treatment records	2	0.465	3	0.332
Water Supply				
Pressure regulating system	3	0.456	2	0.376
Maintenance records and scheduling	3	0.328	2	0.319
Utilities				
Electricity				
Vehicle maintenance records	3	0.329	1	0.316
Gas				
Inventory and location files	1	0.716	2	0.186
Vehicle maintenance records	1	0.671	2	0.229
Public Health				
Clinical Services				
Facilities identification and location	2	0.389	3	0.350
Mental health examination and treatment	3	0.356	2	0.314
Lab and X-ray analysis records	2	0.398	3	0.354
Drug treatment records	2	0.398	3	0.354
Communicable disease records	2	0.389	3	0.350

Environmental Health				
Air pollution monitoring and records	5	0.814	3	0.129
Miscellaneous				
School nursing records	2	0.400	3	0.339
Ambulance data	2	0.362	3	0.335
Health information and referral system	2	0.692	3	0.195
Public Welfare				
Social Services information and Referral System	3	0.509	4	0.210
Parks and Recreation				
Facility usage	2	0.362	3	0.335
Facility maintenance scheduling records	2	0.424	3	0.306
Libraries				
Catalog system	3	0.349	2	0.305
Book ordering	2	0.505	1	0.299
Book inventory	3	0.342	2	0.296