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Computerized Data-Based Systems and Productivity Among Professional Workers: The Case of Detectives

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The promise of productivity improvements has always been high in the litany of benefits predicted for computer use in government. Particular attention has usually focused on benefits at the clerical levels, where the "brawny" capabilities of computing are applied by means of large scale and repetitive data processing and office automation. Substantial promise has also been associated with managerial utilization of computing, where its more "brainy" capabilities are employed in management information systems and decision support systems.[1] There has been greater uncertainty, particularly at the empirical level, about the effects of computing on the productivity of those professional workers at intermediate levels in the organizational hierarchy. Such professional workers are widespread in all service industries, whether public or private. This paper undertakes a careful, empirical assessment of the effects of computing on the performance of one such group of professionals—police detectives. In particular, it analyzes the detectives' level of computing use, the productivity effects of computing on criminal investigation activities, and the importance of the context of computing use on the individual-level effects of computing.

Professional workers operate in an information-rich environment where decisions and actions must be based on an appraisal of the best available data and where there are substantial data that might be relevant. The processing of information is so central to the work of some professionals, such as planners, stock brokers, accountants and journalists, that the work seems well-suited to productivity gains from computing. But for many other professional workers, information processing is a more peripheral support task as they provide direct service to clients. Therefore, such professionals as lawyers, social workers, insurance agents, probation officers, health officers, and police detectives have seemed less likely candidates for striking productivity gains from computing.

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Yet, the problems facing service-providing professional workers are not unlike those facing managers and others for whom computerized systems are relevant: (1) the existence of a data base so large that the individual has difficulty accessing and making conceptual use of it; (2) the necessity of manipulation or computation in the process of deriving useful information; (3) the existence of some time pressure, either for the final answer or for the process by which the decision is reached; (4) the necessity of judgment either to recognize or decide what constitutes the problem, or to choose a solution; and (5) the need to facilitate responses to families of problems that are frequent and require direct action as well as decision.[2]

Police detectives are an interesting case study of the impacts of computer-based systems for several reasons. First, detective work is information-intensive in theory and practice; yet detectives are among those service-providing professionals for whom productivity gains from computer technology have seemed less likely. Second, the predominance of highly discretionary field work involving multiple sources and modes of information places detectives low, even among the "street-level" professionals, in the presumed centrality of a computerized system to work. Third, however, police detectives have been supported by some of the most extensive and decentralized computer-based aids available to any professional workers in the public sector. This has been the result of both the general automation of

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law enforcement records and also the provision of specific systems tailored to their investigative tasks. And fourth, detectives seem an illuminating precursor of what other case-oriented professional workers, both within and outside government, will experience with the extension of computing and especially with the rapid spread of microcomputers that enable individual workers to communicate with large organizational data bases. Thus, in the final section of this article, detectives' uses and experiences with computing are the basis of a general characterization of computer-based systems for professional work.

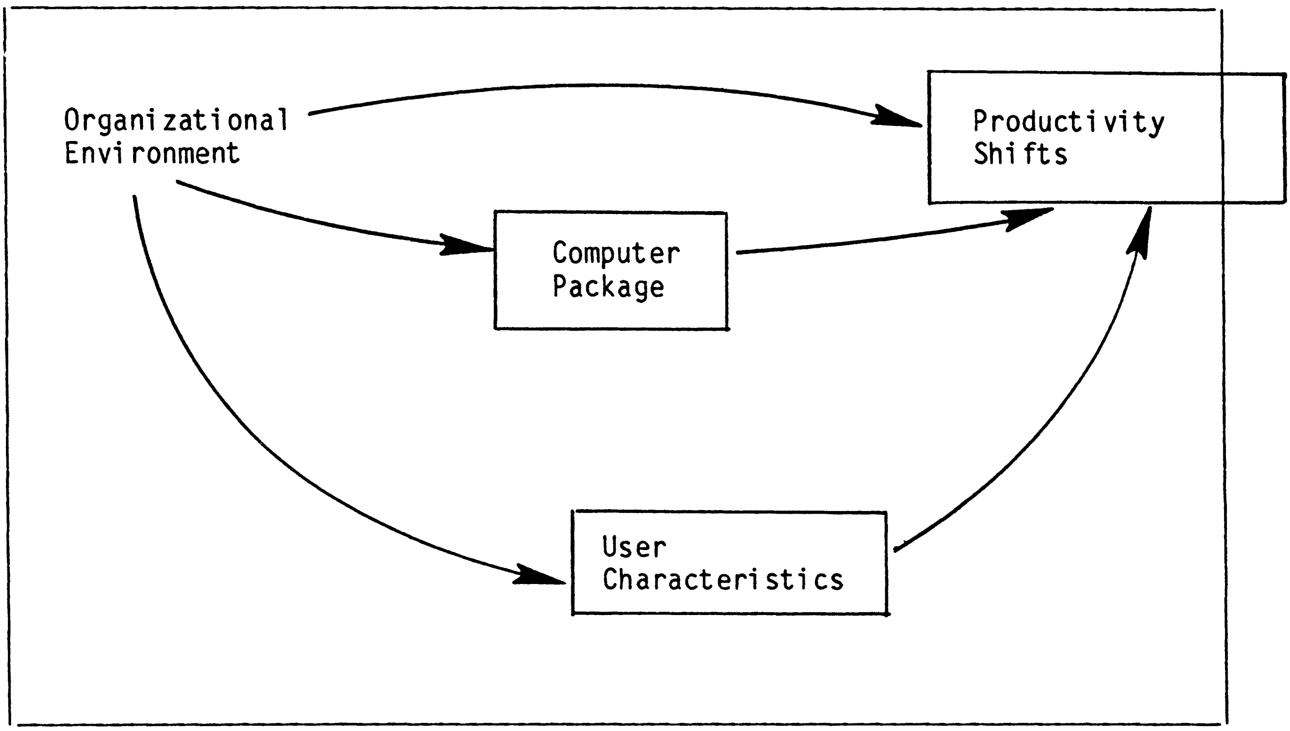
Conceptualization

The central focus of this research is to assess how computer technology has affected the productivity of individual detectives in their work.[3] We treat the concept of productivity broadly here, to reflect an improvement in job performance that involves effectiveness more than efficiency. The performance standards we use to tap detective work center in individual-level impacts of computing on available information and on the number of workable cases, arrests, and clearances. We use detectives' own assessments of the effects of computing on their work and their job performance[4] as indicators of these performance standards.

We view the linkage between computing and the individual detective's productivity at two levels. The first is a straightforward link between the "extent of computer use" by individual detectives and productivity shifts. We expect that detectives' productivity will be greater with higher levels of computer use. The second linkage is rather more complex, involving the effects of the "context of computer use" on productivity. Recent empirical and theoretical literature provides a persuasive case that the adoption, utilization, and impacts of computer technology are highly contingent on the context within which computing operates.[5] In particular, variations in productivity shifts might be contingent upon three elements of the context of use: (1) the organizational environment; (2) the computer package; and (3) the traits of the user (Figure 1).

The *organizational environment* is the broadest context within which the detective uses computing. Organizational factors such as the government's size and complexity, the scale of the service environment, the political climate of the government, and the level of professional practice in the government might influence the relationship between the detective, computing, and detective productivity. On the basis of the existing empirical research, we expect that computing will tend to have more positive effects on the productivity of detectives in environments (and, hence, information environments) that are larger in size and scale and that emphasize professional practices.

FIGURE 1
Conceptual Framework Linking Productivity Shifts and Contextual Elements



The nature of the *"computer package"* (that is, the hardware, software, and personnel involved in the delivery of computing services)[6] available to the detective is, perhaps, the most obvious contextual element that might affect the relationship between computing and the detectives' productivity. We might posit that as the technology is more extensive, more sophisticated, more decentralized, and more routinized, productivity gains attributable to that computer package will increase.

Finally, certain *traits of the individual* detective might also influence that user's capacity to derive these benefits from computing. Among the detective's personal traits, greater computing benefits might be enjoyed by those who are more educated, younger, and more professionally oriented, and thus, more likely to routinize an innovative technology. We also hypothesize that productivity improvements attributed to computing will increase as the user's "socio-technical interface" with computing is more positive, including such features as the user's knowledge and experience with computing and the extent to which the user finds the technical experts responsive to his/her computing needs.[7]

As suggested by our conceptual framework, the technology and the user operate within an organizational environment, and any combination of these three contextual elements might account for variations in the productivity of individual detectives. Hence, we assess both the independent and the interdependent effects of these elements.

Data and Methods

The data are primarily derived from lengthy self-administered questionnaires completed by a random sample of detectives from 40 American municipal governments (drawn in a sample of cities stratified on key technological dimensions such as the level of automation, the sophistication of hardware and software, and the level of centralization in the provision of computing).[8] Of the total sample in the data base, this paper examines 374 detectives who indicated that they use the computer or receive computer-based information.

We ask four questions regarding detectives and computing: (1) To what extent do detectives use computers in their work?; (2) Do the detectives attribute productivity shifts in their own work to the utilization of computers?; (3) Are there systematic associations between detectives' level of computer use and measures of the "output" from the detectives' work?; and (4) Can we account for individual differences in the impact of computing on detectives' productivity by features of their organizational environment, of the computer package available to them, or of their personal traits?

We assess the first two questions by tabular analyses of the responses of the detectives to specific queries regarding the utilization of computing in their work and regarding objective measures of the impacts of computing on their productivity. We assess the third question using Pearson's correlation coefficient, in order to examine whether there is a strong relationship between the individual detective's level of utilization of computing and the kinds of productivity shifts that the detective experiences. Finally, we analyze whether there are systematic relationships between productivity shifts and important features of the context of use of computing. Using factor analysis, we first reduced a comprehensive set of 33 contextual features to three variables representing the organizational environment, five representing the computer package, and four representing the user. We use multiple regression techniques to assess the effects of these 12 contextual variables on detective productivity. (See the Appendix for a fuller explanation of the factor analysis and the regression techniques.)

Findings

Do Detectives Actually Use Computers?

Clearly, the availability of computerized information is a necessary condition for its utilization by detectives. There has been a strong and continuing effort by federal, state, and local government agencies to support the development of police information systems.[9] While few detectives have access to every type of automated police file, the 40 police departments in this study had computer access (batch or on-line) to an average of 6.2 of the 14 major police investigation data files that are automated, and detectives in every department in the study had access at least to state and national computerized data banks on outstanding warrants, criminal histories, and driver's license and motor vehicle registration.[10] These detectives do make quite substantial use of such computer files in their work (Table 1). About two out of five detectives report that they use computer files for *all* of their active cases, and almost two-thirds of the detectives use computers in the majority of their cases. While some do not use the technology, the "average" detective uses computing on about 60 percent of his/her cases.[11]

Do Productivity Shifts Result from Computer Use?

Two categories of productivity improvement can be assessed: (1) improvements in the information available to detectives; and (2) improvement in specific measures of each detective's workable cases, arrests, and clearances.

It is typically assumed that the performance of professional workers will be higher if their information is of higher quality, greater quantity, easier accessibility, and richer manipulability. Thus, for those as information-dependent as detectives, a significant improvement in the information environment due to computing could be viewed as an indirect productivity gain. Our measure of information improvements (Table 2) is an index combining four aspects of the benefits that computing might provide: new information, more up-to-date information, speed in obtaining information, and ease of access to information. More than 80 percent of the detectives

TABLE 1
Utilization of Computing by Detectives[a]

Number of Last Ten Active Cases Where Computer Used:	% of Detectives
0	20
1-4	17
5-9	24
10	39
	100

The "average" detective was assisted by the computer on: 5.94 of the last 10 cases.

[a]374 detectives in 40 municipalities.

TABLE 2
Informational Benefits Attributed to Computing by Detectives[a]

Incidence of Information Improvements from Computing[b]	% of Detectives
Nearly always	29
Frequently	51
Sometimes	16
Almost never	4
	100

[a]N = 374 detectives from 40 municipalities.

[b]This indicator is an index combining and averaging the detective's responses to four questions: (1) The computer makes new information available to me which was not previously available; (2) The computer provides me with more up-to-date information than that available in manual files; (3) Computers have made it easier for me to get the information I need; (4) Computers save me time in looking for information. The values of responses on each question were: Nearly always = 3; Frequently = 2; Sometimes = 1; Almost never = 0. In the table, the ranges on the index are: Nearly always = 3.00-2.50; Frequently = 2.25-1.50; Sometimes = 1.25-.75; Almost never = .50-0.0.

have experienced these information benefits from computing, with strong confirmation of these benefits reported by about 30 percent of the detectives. It is clear, then, that a large majority of the detectives have enjoyed the kinds of improvements in their information-handling environments that are among the most fundamental benefits expected from computer technology.

Table 3 displays our more direct indicators of the effects of computing on detectives' productivity. More than one in three detectives reports that some cases would have been unworkable (that is, cases where further investigation after the initial case report would not have been possible) were it not for the use of computing. About half of the detectives used the computer to link persons in custody to uncleared cases. And nearly two-thirds of the detectives indicated that the computer assisted them in some of their arrests and clearances. [Although not shown in the table, this benefit of computing occurred in the majority of instances (i.e., between 5-10 cases) for 41 percent of the detectives on clearances and 34 percent on arrests.] From a different angle, computing assisted the "average" detective on two-fifths of his/her clearances and one-third of the arrests, helped the detective link one in four in-custody suspects to uncleared cases, and saved one in every five cases from being totally unworkable. While some detectives report minimal effects of computing on their productivity, the most reasonable conclusion from these data is that detectives have experienced major and positive productivity shifts that are attributed to computer technology.

Does the Extent of Computer Use Affect Productivity?

While our foregoing analysis clearly indicates that computing has enhanced the performance of detectives as a group of professional workers, it also indicates that the computer revolution has not touched all the detectives in our sample of police departments; nor has it touched the detectives evenly. Table 4 displays the (Pearson's R) correlation coefficients between the level of utilization of computing, measured as the number of the last 10 actively investigated cases on which computing was used, and the various measures of detective performance. There is a highly significant (in statistical terms) relationship between level of computer use and the effects of computing on every measure of the detective's productivity related to informational benefits, arrests, clearances, and number of workable cases. The linkages are exceptionally strong between computer utilization and the frequency with which computing assists on clearances and arrests.

Table 4 confirms the expectation that detectives who make more extensive use of computing enjoy substantially higher productivity gains from the technology than those who do not. While use of a computer-based decision support system is usually depicted as selective, it is actually the detective who routinely "goes prospecting" on every case, whether or not he/she expects the search to pay off, who reaps greater benefits from the technology than the selective user. Table 4 also provides support for the inference that improvements in the information environment caused by computing are strongly linked with more direct job performance benefits attributed to computing.

Does Context of Use Affect Productivity?

We have now established that detectives do enjoy productivity gains from the use of computer systems in their work and that such gains increase with higher levels of utilization of those systems. But as presented earlier in our conceptual framework (Figure 1), both the technology and the user operate within an organizational environment, and any combination of these three contextual elements might account for variations in in-

TABLE 3
Detectives' Individual Performance Benefits From Computing[a]

Percent of detectives reporting that, on some of their last 10 cases, the computer assisted in:			
Making the Cases Workable	**Arrests**	**Clearances**	**Linkages Between Persons in Custody and Uncleared Cases**
37%	64%	66%	45%
On the last 10 cases, the "average" detective was assisted by the computer on:			
1.8 otherwise unworkable cases	3.6 arrests	4.1 clearances	2.6 in custody linkages

[a]N = 374 detectives in 40 municipalities.

dividual detectives' productivity. Regression analysis was used to determine which, if any, of these contextual elements, and the specific variables that represented them, accounted for variation among the detectives (see Appendix).

Table 5 shows that the context of use does account for a significant amount of individual variation on most of our measures of productivity attributed to computing (row 1). Thirty-six percent of the variation among detectives in the level of *informational benefits* from computing can be accounted for by the explanatory variables.[12] From 10 to 18 percent of the variation among detectives in *individual performance benefits* attributed to computing on arrests and clearances can be accounted for by the explanatory variables. Only the differential impacts of computing on workable cases are not significantly associated with our measures of the context of computing use.

It is clear that the individual elements of the context of use vary in their explanatory power. The nature of the organizational environment does not have much explanatory appeal on any of the productivity measures; at most, only 22 percent of the total explained variance is lost by excluding such variables (row 2a). This is somewhat surprising, since it is reasonable to predict that computerized systems will be especially valuable to detectives in jurisdictions with larger populations, given the greater difficulty of knowing one's field environment directly and personally. Moreover, some version of the size variable is typically the most powerful explanatory variable in contingency analyses of organizational structure and performance,[13] and we have employed two strong measures of size in this analysis. For these reasons, it is particularly surprising that in the three cases where a size variable is significant, greater benefits from computing are associated with governments with *less* complexity. It is difficult to account for this pattern.

The nature of the computer package is quite important in accounting for individual variations in the value of computing. It is the dominant explanatory element in accounting for the impact of computing on arrest and clearance levels, with about half of the total explained variance lost by excluding variables measuring the nature of the computer package (row 2b). In particular, computing improves the productivity benefits to detectives where it is decentralized to users and where it is more sophisticated (row 3b).

The contextual elements with the greatest capacity to account for differences in the effects of computing on detective performance regarding informational benefits and in-custody clearances are the characteristics of the individual user, and, particularly, aspects of the sociotechnical interface between the user, the technology, and the technologists (row 2c). Productivity benefits from computing are higher where the detective is more professional, more experienced and competent with computing, and where the data processing staff is more responsive to the detectives' needs (row 3c).

TABLE 4
Relationship Between Detectives' Utilization of Computing, Informational Benefits, and Performance Measures[a]

	Pearson's r with:	
	Number of Last 10 Active Cases Where Computing Used	Informational Benefits From Computing
Cases unworkable without computing	.34***	.34***
Arrests where computing assisted	.50***	.36***
Clearances where computing assisted	.56***	.41***
Linkages of those in custody to uncleared cases	.39***	.33***
Informational benefits from computing	.36***	

[a]374 detectives in 40 municipalities.
***$p < .001$

TABLE 5
Capacity of Contextual Elements to Account for Between Detective Variation in Productivity Shifts Attributed to Computing[a]

	Informational Benefits	Individual Performance Benefits			
	Information Improvements	Unworkable Cases	Computing Assists Arrests:	Computing Assists Clearances:	Computing Assists Linkages Between Persons in Custody and Uncleared Cases:
1. Total Explained Variance (R^2):	35.8%***[b]	N.S.[c]	14.7%***	17.7%***	10.0%***
2. Percentage of total explained variance (above) "lost" by excluding variables measuring:					
a. Organizational environment	6%		22%	14%	8%
b. Computer package	10		49	55	12
c. User characteristics	77		39	39	77
3. Most powerful explanatory variables:					
a. Organizational environment	– Government complexity*		+ Government professionalism	– Government complexity*	– Government complexity*
b. Computer package	Decentralized computing**		Decentralized computing*** Sophisticated computing***	Decentralized computing*** Sophisticated computing***	Sophisticated computing*
c. User characteristics	+ Evaluation of EDP staff***		+ Evaluation of EDP staff* + User professionalism* + User competency with computing*	+ Evaluation of EDP staff* + User professionalism***	Older user*** + User competency with computing***

[a] N = 374 detectives in 40 municipalities.
[b] *** $p < .001$
** $p < .01$ Statistical significance for regression equation is the F statistic, and for the explanatory variables is the T statistic.
* $p < .05$
[c] N.S. = Not significant.

Discussion

Traditional Images of Computer Support

Taken together, these data yield an intriguing point: the systems-in-use by detectives are at odds with conventional images of the nature and role of computerized systems for professionals and managers. They suggest that a new concept of computerized systems may be warranted for professionals like detectives whose work is primarily case-oriented. We will first review the conventional images of computerized systems for professionals and managers and then introduce another type of system-in-use derived from our empirical analysis of detectives' use of computing.

In general, there are two conventional images of computerized systems: model-based and operations-based systems[14] (Figure 2). The first and most traditional concept, the *model-based system,* is largely tied to the theoretical and professional literature of operations research, management science, and decision science[15] and usually appears under the decision support system (DSS) label. This concept stems from theories which posit "problem solving" as the essence of professional work and prescribe model building as a means of solving problems. Information for decisions, then, is the output of formal analytical models and simulations (e.g., models for police manpower allocation, for projecting service demand, or for forecasting revenues and expenditures). By definition, information use is "selective" in such model-oriented systems because the model prescribes the relevant data and provides "the answer."

Systems based on the problem-solving concept incorporate both the mathematical operations and the data required to support the model. The data and operations are defined by the theory underlying each particular

TABLE 6
Selection of Variables to Represent Aspects of the Three Contextual Elements

Variables	Factors I	Factors II	Factors III
A. ORGANIZATIONAL ENVIRONMENT			
Number of departments in government	.69	.27	.59
Size of legislative body	.67	.29	–.22
Government employees per citizen	.64	.01	–.06
Land area served	–.12	.88	.35
Population served	.46	.51	.10
Partisanship in local politics index	.27	.51	–.18
Reform government structures index	–.36	–.38	.75
Professional practices of government departments index	.10	.10	.58
Central management control index	–.19	.09	.26
Percent Variance Explained	32%	22%	14%

Factor I: Complexity of government
Variable selected: Number of departments in government

Factor II: Scale of service environment
Variable selected: Land area served

Factor III: Government professionalism
Variable selected: Reform government structures index[a]

Variables	I	II	III	IV	V
B. COMPUTER PACKAGE					
Total applications	.97	.01	.01	.05	.22
Level of applications development index	.72	–.03	–.17	.15	.11
Total on-line applications	.72	.17	.10	.13	–.01
Number of technical skills among staff	.56	.11	–.09	.35	–.06
Computing expenditure per capita	.36	.79	.36	.11	.12
Computing budget as percent of government budget	–.06	.74	–.11	.03	.22
Number of computing installations in government	–.04	.04	.77	–.06	.11
Sophistication of operating system hardware	.30	.26	.13	.51	.23
Total core capacity	.51	.24	.42	.53	–.05
Use of computer policy board	.06	–.03	–.08	.46	.02
Year computing began in government	–.26	–.23	–.05	–.27	–.55
Independent computing department	.30	.02	–.39	–.02	–.47
Charges for computing services	.04	.06	.02	–.01	.27
Percent Variance Explained	32%	15%	9%	9%	8%

Factor I: Extensiveness of computing
Variable selected: Total applications

Factor II: Resource support for compuing
Variable selected: Computing expenditure per capita

Factor III: Centralization/decentralization of computing
Variable selected: Number of computing installations in government

Factor IV: Sophistication of computer package
Variable selected: Sophistication of operating system hardware

Factor V: Routinization of computing
Variable selected: Year computing began in government

TABLE 6 (continued)

Variables	Factors I	II	III	IV
C. USER CHARACTERISTICS				
Member of computer application design group	.57	.14	.13	.04
Computer courses taken	.56	.12	.22	.13
Believes does not understand computing	–.56	.02	.02	.04
Interested in computing	.53	.08	.16	–.21
Year of birth	–.01	–.82	.00	.17
Years in type of job	.06	.62	–.01	.03
Years involved with computing	.32	.50	.01	.17
Member of work-related organization	.10	.20	.70	–.06
Recent courses related to work	.11	–.16	.38	.00
Highest educational level	.33	–.03	.34	.27
Evaluation of data processing unit service	–.03	.00	–.01	.48
Percent Variance Explained	24%	16%	11%	10%

Factor I: User's competency with computing
Variable selected: Member of computer application design group

Factor II: User's work experience
Variable selected: Year of birth

Factor III: User's professionalism
Variable selected: Member of work-related organization

Factor IV: User's orientation to data processing staff
Variable selected: Evaluation of data processing unit service[b]

[a]Includes indicators of presence of manager/CAO, extent of at-large elections, power of mayor.

[b]Includes user's appraisal of the quality of computer services and the responsiveness of computing staff to the user's needs.

model and usually are distinctly different from anything found in the current operations and data of the government. Therefore, decision support systems must be built that are separate from the computer applications serving routine government operations and they must be supported by data collection procedures and data flows that are tailored to meet the unique needs of the decision model. The computer package underlying such DSS is one with the capacity to handle many small samples, sophisticated mathematical computations, and large simulations—namely, highly skilled model builders and large computational capacities.

The second type of computerized system, the *operations-based system* (Figure 2), has its heritage in the intellectual and practitioner literature of computer science, information systems, and data processing, and most commonly appears under the label of MIS (Management Information Systems).[16] This conception is supported by research that has found "problem finding" to be an important activity of professionals and managers. The information used in problem finding is defined by extremely simple, nonanalytical models, mainly involving data comparisons—over time, across organizational and geographic boundaries, and between planned and actual achievements. These historical and areal models are illustrated by the many routine reports, exception reports, and ad hoc comparison reports produced in the daily operations of most organizations (e.g., in police, the watch commander's report of criminal incidents and traffic accidents).

Computerized systems based on the problem-finding concept are formed largely from the transaction-oriented applications serving routine government operations. The greater the degree and range of such automated applications within the government, the broader the potential data base from which decision support information can be generated. Exploiting this potential requires technical capacity for integrating data (i.e., across departmental, agency, account, geographic, and other boundaries), storing large data bases, and quickly accessing them for various information requests. The computer package supporting such systems therefore includes highly skilled computer staff, data-base management systems, large storage and core capacities, and online access.

Clearly, systems based on both the traditional DSS and MIS images can be found in public organizations and in the police, as the examples already cited and those listed in Figure 2 illustrate. But neither of these two types of systems corresponds to what we have found to be the primary systems-in-use among detectives. Indeed, the actual systems-in-use are considerably at variance with the traditional images of DSS and MIS, and suggest that a new type of system—the "data-based" system—might be more appropriate for case-oriented professionals.

A New Concept of Computer Support

In contrast to the traditional concepts of DSS and MIS, which are based upon the notion of "selective"

FIGURE 2
Comparison of Types of Computerized Systems

	Types of Computerized Systems		
Attributes	**Model-based**	**Operations-based**	**Data-based**
Activity served:	Problem-solving	Problem-finding	Fact-finding, fact-linking
Type of use:	"Selective," driven by analytic, optimizing models	"Selective," driven by historical and heuristic models	"Prospecting," driven by fact searches and ad hoc hunches
Mode of use:	Indirect through intermediaries	Indirect through intermediaries or computer-based reports	Direct, personal use of terminal
Data used:	Information is generated specifically for the model, usually separate from routine operations and transaction processing	Information is a product of routine operations and transaction-oriented data processing	Information is from operational records, but reorganized to aid linkage; *plus* data gathered explicitly as an information base for the user
Nature of computing package:	Large computational capability, batch or on-line access; simulation and modeling languages; model building expertise	Sophisticated information storage and retrieval, integrated data files and applications, database management, on-line access; computer expertise	Interactive, easy access to multiple data files for both simple and complex retrievals/linkages; database management; professional expertise
Examples:	Traditional DSS: cash flow models, revenue/expenditure forecasting models, manpower allocation models, facility location models	Traditional MIS: integrated financial systems, cost accounting systems, geographic information systems, personnel/payroll systems	Human-Machine Systems: detectives investigation support, case management systems (prosecution, probation, health), case law precedent search, medical diagnosis

use of information, the *data-based system* (DBS) involves various forms of information "prospecting" in order to find and link relevant facts in the analysis of a given case (in such case-oriented fields as criminal investigation, medical care, legal work, welfare work, investment counseling, and so on). Such prospecting involves direct, personal use of a computer terminal to search collections of information, which are themselves a by-product of operational records that have been organized to aid case retrieval and linkage. This use of data-based systems is reflective, guided by the end user's understanding of how such use can support his/her specific information needs. And the computer package for such DBS provides interactive, easy access to the organized information via powerful data-base management software which allows direct manipulation by the user, who brings his/her professional expertise to bear in handling the case investigation.

Computer support for detective investigation provides a good illustration of the data-based system for case-oriented professionals. Detective investigation involves many record searches in many independent files for many different reasons under many varied circumstances. The type of use is best characterized as "prospecting" and is driven by the search for individual facts and by ad hoc hunches about how certain facts might be linked to aid a criminal investigation. Such prospecting is illustrated by three main patterns of use. The first is simple fact retrieval, involving the completely structured use of on-line data bases to search for particular facts about a crime, criminal, or modus operandi. The second use pattern involves more complex, less structured searches with computer support tailored to perform the most frequently occurring searches, such as the search of all field incidents within a particular time period or geographic area, or the search of all individuals with a particular modus operandi. The third use pattern is the most complex and unstructured, involving ad hoc, exploratory search with the aid of a generalized analysis system for search, summary, graphic representation and calculation. It is illustrated by the detective's effort to link clues from a crime with other incidents or facts—for example, to determine whether a late model blue Chevrolet with a partial license plate of NPJ. . . which was observed by witnesses near the scene of a rape can be further identified because it might have been stolen, ticketed for a parking violation in the vicinity of another rape, recently changed hands, owned by someone with an MO similar to that for this crime, or owned by a person subject to a recent field interrogation.

The information used by the detectives is contained in the law enforcement systems of the government—that is, the record-keeping systems which serve patrol officers, watch commanders, and records clerks, as well as detectives. Information also is drawn from special files designed to aid detective investigations and from regional and national law enforcement systems as well as from local ones.

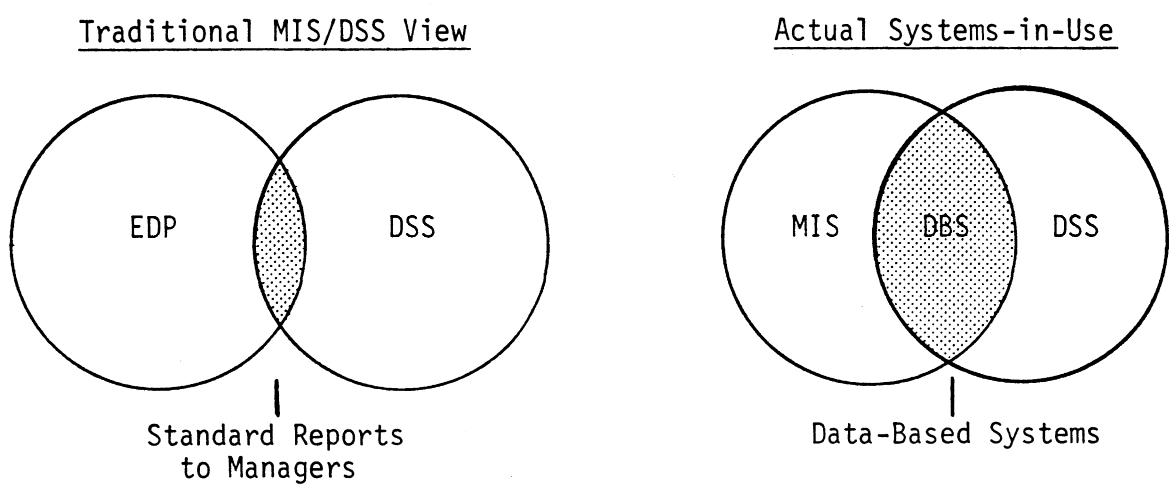
The computer technology supporting the data-based system is moderately sophisticated, mainly involving computers with large storage capacity and on-line, remote access (sometimes interactive access) to the data bases. Search of the data bases is aided by preprogrammed keys on remote terminals, which facilitate routine fact-finding, by special software for frequently occurring searches, and by generalized data-base management software to support ad hoc retrieval and analysis. The computer technology also is decentralized, which, in the context of the police, means: freedom from contention with other departments for access; rapid response on a 24-hour basis; and control over the design and operation of systems by computer professionals oriented toward serving the police. This characterization is consistent with the empirical analysis in Table 5, where sophistication and decentralization of the computer package and a positive evaluation of the responsiveness of EDP staff are the key variables accounting for variance among detectives in the impacts of computing on their productivity. Finally, in contrast to the other two types of systems, which require a user with considerable model and computer expertise, the data-based system requires user expertise in a substantive area (i.e., crime/criminal behavior in the case of detectives) and some expertise in using relatively straightforward computerized systems crafted to meet his/her specific information processing needs. This is also consistent with Table 5, where user professionalism and user competency with computing are associated with greater computing benefits.

The concept of a data-based system is important for several reasons. First, DBS defines the predominant mode of computing among a major class of professional users: caseworkers. Second, data-based systems also seem to constitute a substantial proportion of the use of computing by most professionals and managers, more than either of the other two types of systems. As a result, we question whether current distinctions about computer-based systems give sufficient attention to the data-based type. For example, Alter[17] divides computer-based systems into two types as shown on the left in Figure 3: EDP (or what we call traditional MIS), and DSS (or what we call traditional DSS). Alter further divides the decision support systems into seven types depending upon whether they are more data based or model based.

It is our observation that data-based systems are widespread—they are found not only among DSS, but also in traditional EDP/MIS as well. Dutton and Kraemer[18] describe a form of "management oriented computing" which is characterized by the generation, from the routine automated systems serving the operations of the government, of standard reports and, at times, special reports and analyses for managers. Alter also identifies such use of computing at the intersection of EDP and DSS. However, in contrast to Alter's characterization, we suggest that data-based systems seem to constitute a very large category of systems-in-use that involve direct, reflective information prospecting by the end users of computing. Certainly they are dominant in our current study of detectives, and in our extensive analysis of public sector employees in many roles.[19] Consequently, we draw the domain of data-based systems—the overlap between EDP/MIS and DSS—substantially larger and as a distinctive type, as shown on the right in Figure 3.

Third, the data-based system has implications for worker performance. Our data indicate that the detective who routinely goes prospecting on every case reaps greater benefits from the technology than does the selective user. In support of our assessment, recent behavioral research into human-machine interaction indicates that decision making improves when profes-

FIGURE 3
Types of Computerized Systems



sional users, aided by computer terminals and easy-to-use retrieval software, engage in active prospecting in an information rich environment.[20]

There is considerable reason to believe that the outcome of such human-machine interaction is no less a contribution to productive work than either mathematically optimal solutions to more narrowly defined problems or heuristic solutions to frequently encountered problems. The interaction between a person who possesses intimate knowledge of a case and its context (e.g., local crime patterns/criminals) and a computerized system that instantly provides key information may represent a vast improvement over traditional management science methods.[21] At minimum, advantages may accrue because there is a reduced danger of solving, elegantly and optimally, the wrong problem, or of solving the right problem too late. Additional advantages from data-based systems may result from the easy accessibility to data, the "weight" of the information (i.e., its direct relevance to a decision at hand), and end user learning and reinforcement from frequent successful use of information in the system—critical determinants of whether computer-produced information is actually used for decision and action.[22]

Policy Implications for the Management of Computing

From a policy perspective committed to improving the productivity of professional workers by means of computing, these findings are quite encouraging. There is clear evidence here that computer technology can enhance the productivity of professional workers in the service sector. The kinds of performance benefits associated with detectives in this analysis should be generalizable to other professional workers who undertake similar semi-structured tasks and are dependent on a rich information environment. At minimum, the benefits should be generalizable to other street-level professionals who are engaged in activities that are essentially "case-oriented," e.g., probation officers, lawyers, social workers, prosecutors, court administrators, physicians, investment counselors, and insurance agents. Computing has the capabilities to serve as an integral part of a valuable computerized system for these kinds of workers.

Moreover, this analysis has suggested some of the major conditions that seem to increase the contribution of computer-based systems to professional work. The case of detectives suggests that professional workers will derive greater productivity benefits from computing: (1) if the computer package is more decentralized, so it is under the control of users; (2) if sophisticated computing capacity which permits human-machine interaction is available; (3) if the users have greater competency and experience with computing; (4) if the technical experts are more responsive to the felt needs of the users regarding the design and operation of the computer-based systems; and (5) if users routinely rather than selectively utilize the system. This analysis of detectives reveals that the last three conditions are particularly crucial in increasing the benefits of computing to work performance. That is, while characteristics of the technology importantly influence some productivity benefits of computing, it is characteristics of the end users' interface with the technology and the technologists that most consistently appear as critical determinants of the level of benefits derived from computing. Thus, despite continuing images of the computer as a mechanistic and homogenizing technology, its impact is highly contingent upon the personal and the interpersonal context within which computing is provided and used.

These findings have interesting implications for current experiments with placing microcomputers in the hands of professional workers in government. In general, they support the notion that improved job performance will result. Moreover, microcomputers decentralize both the technology and control over its use directly to the professional worker, while simultaneously providing that professional with access to the organization's data bases. Microcomputers also provide interactive computing capacity locally while providing access to large computational, storage, and networking capacities of mainframes. Both of these characteristics of the technology—its decentralization and its sophistication—correspond to important contributors to greater information benefits and higher productivity among detectives in our study.

Although the computer package is important, the critical variables determining the value of such computing are likely to lie elsewhere. As with the detectives, they involve the characteristics of the users and their interactions with the technology and the technologists. Greater productivity benefits from computing among professionals are generated by the interaction among several factors: (1) the greater the professional workers' experience and competence with computing; (2) the more routinely the professional workers use computing; and (3) the more that technical experts are available and responsive to the needs of professional workers to gain computing competence and experience, to receive help on special computing problems, and to interface their own computing activities with the larger systems and data bases of the organization. These relationships will certainly hold regarding effectiveness performance criteria and, given the value derived from better exploiting the costly technology, they are likely to obtain for efficiency criteria as well.

The importance of expert assistance, in particular, supports the currently popular notion of providing "information centers"[23] within an organization, where professional workers and managers can obtain help in evaluating, procuring, using and maintaining microcomputers and the computerized systems they support. Indeed, this might be the key determinant, since without expert guidance, end user competency and degree of use will be impeded. Thus, for governments that seek to increase productivity among their professionals, the message is clear: buying a batch of micros is simply not enough—both well-crafted data-based systems and responsive staff technicians are needed to provide the context of use within which professionals will enjoy higher levels of payoffs from computerized systems-in-use.

Appendix

In order to undertake a manageable yet comprehensive analysis of the relationships among the organizational environment, the technology and the user, a substantial set of specific indicators for each of the three elements was selected. Then as a variable-reduction technique, each set of indicators was subjected to factor analysis and the variable most representative of each factor was identified for use in the further analysis. In this manner, 33 variables were reduced to three variables representing the organizational environment, five variables for the computer package, and four variables for the user (Table 6).

Regression analysis was then used to determine which, if any, of these variables account for variation among detectives in the extent to which they have experienced productivity shifts due to computing. Several regression procedures were employed. The first examined separately the effects on productivity of the set of variables in each of the three contextual elements. The second procedure entered the organizational environment variables first, since they constitute an existing milieu within which the technology and the user operate and the productivity effects occur, and then entered the technology and user variables. Our tabular presentation of results in Table 5 of the text provides several measures by which to assess the effects of the explanatory variables: (1) the total explained variance (measured as the R^2 statistic); (2) the percentage of that explained variance "lost" if the set of variables for one of the three contextual elements is deleted from the regression; and (3) the most critical individual variables based on a stepwise regression analysis. The statistical significance of each of these measures is also reported. The regression equations for the relevant productivity variables are below.

APPENDIX

	B	beta	F
Information Improvements:			
Government complexity	−.057	−.228	
Centralized computing	−.110	−.224	
Evaluation of EDP staff	.450	.550	
Constant	2.801		7.998***
Computing Assists Arrests:			
Centralized computing	−.671	−.267	
Sophisticated computing	.998	.319	
Evaluation of EDP staff	.640	.151	
User professionalism	1.451	.118	
User competency with computing	.650	.149	
Constant	−3.614		3.459***
Computing Assists Clearances:			
Government scale	−.160	−.065	
Centralized computing	−.828	−.218	
Sophisticated computing	1.044	.192	
Evaluation of EDP staff	.564	.127	
User professionalism	1.053	.226	
Constant	−2.306		4.312***
Computing Assists Linkages:			
Sophisticated computing	.275	.293	
User age	.088	.200	
User competency with computing	1.70	.172	
Constant	6.514		3.131***

Notes

1. Management information systems (MIS) is a concept that has been used both to describe all of the computerized systems in an organization and to signify those systems specifically oriented towards serving the needs of top managers. We use the latter meaning here. Decision support systems (DSS) is a newer concept which, developed out of the confusion over MIS, refers to systems designed to support the largely unstructured decisions of managers and professionals at all levels of the organization. See: G. Anthony Gorry and Michael Scott Morton, "A Framework for Management Information Systems," *Sloan Management Review* 13(1) (January 1971): 55-70; and Peter G. W. Keen and Michael Scott Morton, *Decision Support Systems: An Organizational Perspective* (Reading, Mass.: Addison-Wesley, 1978); Stephen L. Alter, *Decision Support Systems: Current Practices and Continuing Challenges* (Reading, Mass.: Addison-Wesley Publishing Company, 1980).
2. This description is similar to one proposed for managers who would benefit from a computer-based decision support system. See: Peter G. W. Keen, "Decision Support Systems: A Research Perspective," in Goran Fick and Ralph Sprague (eds.), *Decision Support Systems: Issues and Challenges* (New York: Pergamon Press, 1980): 23-44.
3. The existing empirical studies of computing in police agencies primarily treat the department as the unit of analysis. Both Colton and Laudon suggest that automated police intelligence networks, while they might have other organizational effects, also increase the data upon which detectives and patrol officers can draw in determining action regarding a specific individual or case. Kraemer, Dutton, and Northrop conclude that computers somewhat improve the department-level performance of detectives, relative to performance in departments without automation, on such characteristics as workable cases, cleared cases, and time savings in information use. It is not clear from these studies whether the department-level measures are representative of most individuals in a department or whether the aggregated measures mask significant individual-level differences in the impacts of computer technology on detectives. Thus, we attempt to add to this modest empirical base, by analyzing with greater precision and specificity the impacts of computing upon the productivity of individual personnel. See: Kent Colton, *Police Computer Systems* (Lexington, Mass.: Lexington Books, 1978); Kenneth C. Laudon, *Computers and Bureaucratic Reform* (New York: Wiley Interscience, 1974), and Kenneth L. Kraemer, William H. Dutton and Alana Northrop, *The Management of Information Systems* (New York: Columbia University Press, 1981): 113-121.
4. Valid empirical measures of productivity are a difficult challenge in the social sciences, and this is particularly true for something as complex as the role of a particular mode of information over a period of time. Despite some promising exploratory work on quite simple effects of computing, precise measures remain a desirable goal of research. The measures in this analysis seem defensible and interesting ones, although they are obviously imperfect, since all data are self-reported and some ask the respondent to make an appraisal of an effect over time. However, the measures do seem reasonable, and the measures of arrest, clearance, and workable cases have quite strong objective grounding.
5. See, for example: James N. Danziger, William H. Dutton, Rob Kling and Kenneth L. Kraemer, *Computers and Politics: High Technology in American Local Governments* (New York: Columbia University Press, 1982); James N. Danziger and Kenneth L. Kraemer, "The Use of Computers by Public Managers" (Irvine, Calif.: Public Policy Research Organization, 1981); David Dery, *Computers in Welfare* (Beverly Hills, Calif.: Sage Publications, 1981); Rob Kling and Walt Scacchi, "The Web of Computing: Computer Technology as Social Organization," *Advances in Computers* 21 (1982): 2-90; Laudon, *op. cit.*; Henry C. Lucas, *Why Information Systems Fail* (New York: Columbia University Press, 1975).
6. Danziger, *et al., op. cit.,* Chapter 2.
7. Robert Bostrom and J. S. Heinen, "MIS Problems and Failures: A Socio-technical Perspective," *MIS Quarterly* 1(1) (March 1977): 17-32; James N. Danziger, "Technology and Productivity: A Contingency Analysis of Computers in American Local Government," *Administration and Society* 11(2) (August 1979): 144-171; Danziger and Kraemer, *op. cit.*
8. The selection of municipal governments (with greater than 50,000 population), in which the data in this analysis were gathered, was based on a variation of a disproportionate stratified sampling technique. The objective was to select a set of 40 cities dichotomized on six key computer package characteristics: (1) total number of automated applications; (2) degree of centralization of the package; (3) charging policy for computing services; (4) sophistication of hardware; (5) level of integration of data in the system; and (6) extent of user involvement in application adoption, design, evaluation and programming. The selection variables were from data gathered in a survey of all municipalities with greater than 50,000 population conducted by the URBIS Research Group. The sample of 40 cities was selected from a partitioned sample with 2^6 (64) strata, dichotomized to ensure both a distribution on the six key variables and also cases with high scores on each variable. Thus, the municipal governments in the sample had somewhat more "developed" computing than a random sample of governments (circa 1975).

   In each city, members of the URBIS Research Group spent 2-6 person weeks, conducting about 40 lengthy semi-structured interviews gathering operational data, distributing 50-100 self-administered questionnaires, and writing an extensive case-study report. The computer package variables were gathered from interviews and questionnaires with data processing staff. The organizational framework variables were gathered from field work and from U.S. Census data. Among the respondents on the 103-item questionnaire were about 10 detectives, randomly selected from a list of officers in the department. Due to aggressive follow-up, the response rate among detectives was 82 percent. These detective responses were the primary data in this analysis. For further explication of the selection of sites and respondents and data-collection protocols, see Kraemer, *et al., op. cit.,* Chapter 2.
9. Colton, *op. cit.*; Laudon, *op. cit.*
10. Kraemer, *et al.,* pp. 108, 128-130. The 14 major police investigation files that are automated are: criminal histories (includes aliases), field interrogation reports, fingerprints, intelligence compilations, known offenders, modus operandi, owner of motor vehicle, owner of registered firearms, pawn tickets; persons passing bad checks, photograph index, stolen property, stolen vehicles, and notices of traffic/parking violations.
11. More detailed data on the extensive use of computing by detectives are reported in Chapter 3 of James N. Danziger and Kenneth L. Kraemer, *People and Computers* (forthcoming).
12. It is important to note that there might be a response-response bias between the appraisals of the value of computing for informational benefits, on the one hand, and the detective's assessment of the quality of the relationship with the EDP department.

However, there are a great many examples, in the data from which this analysis is derived, of bivariate analyses where the appraisals of computing and the assessment of the data processing unit are unrelated (some evident in this analysis). More broadly, one might argue that a dependent variable measured at the individual-level is most likely to be associated with other variables measured at this level. However, we suggest that these findings reflect more than a methodological artifact. Among the most striking observations in our extensive field research was the enormous individual variation in the use, impacts, and problems experienced by users in comparable roles, even within a given milieu where the users shared an organizational environment and a particular configuration of computer technology. For example, it was common to interview a number of detectives in the same department and have each present remarkably different perceptions not only of how computing affected their individual work, but also of such "shared" factors as the attitudes of their departmental leadership toward the use of computers, the kinds of automated information available, or the orientation of the computer experts toward their department's information needs. While impact measures aggregated to department-level or organization level are interesting and useful, research that treats the individual as the object unit of analysis seems essential for a rich understanding of the impacts of computing.

13. Peter Blau and R. A. Schoenherr, *The Structure of Organizations* (New York: Basic Books, 1971); John Child and R. Mansfield, "Technology, Size and Organizational Structure," *Sociology* 7 (March 1972): 71-91.
14. These ideal types are simplifications designed to focus on key distinctions rather than to describe all varieties of DSS. Interestingly however, and supportive of our characterization, Steven Alter's study of DSS in over 50 organizations classifies them into seven types which he then groups into data- and model-oriented systems. See Alter, *op. cit.*
15. Herbert A. Simon, *The New Science of Management Decision* (New York: Harper and Row, 1960); Russell Ackoff, "Management Misinformation Systems," *Management Science* 2(4) (December 1967): B147-156; and Gorry and Morton, *op. cit.*
16. According to Pounds, "problem finding" is associated with identifying differences between an existing situation and some desired situations, whereas "problem solving" is the process of selecting operators that will reduce such differences. See: William F. Pounds, "The Process of Problem Finding," *Industrial Management Review* 11(1) (Fall 1969): 1-20; Sherman C. Blumenthal, *Management Information Systems: A Framework for Planning and Development* (Englewood Cliffs, N.J.: Prentice-Hall, 1969); Edward F. R. Hearle and Richard J. Mason, *A Data Processing System for State and Local Governments* (Englewood Cliffs, N.J.: Prentice-Hall, 1963); and J. C. Pendleton, "Integrated Information Systems," *Proceedings of the AFIPS Fall Joint Computer Conference,* Vol. 39 (Montvale, N.J.: AFIPS Press): 491-500.
17. Alter, *op. cit.*
18. William H. Dutton and Kenneth Kraemer, "Technology and Urban Management: Power Payoffs of Computing," *Administration and Society* 9(3) (November 1977): 304-340.
19. Danziger and Kraemer, *op. cit.* (forthcoming).
20. See, for example, Alter, *op. cit.,* and Howard C. Kunreuther and Paul J. H. Schoemaker, "Decision Analysis for Complex Systems: Integrating Descriptive and Prescriptive Components," in Gerardo R. Ungson and Daniel N. Braunstein (eds.), *Decision Making: An Interdisciplinary Inquiry* (Boston, Mass.: Kent Publishing Company, 1982): 263-278.
21. This point was brought out by Kunreuther and Schoemaker in experiments with decision making by insurance agents, by Dutton and Kraemer in an empirical study of urban managers, and Keen and Scott Morton in a philosophical and substantive argument. See: Kunreuther and Schoemaker, *op. cit.*; William H. Dutton and Kenneth L. Kraemer, "Management Utilization of Computers in American Local Governments," *Communications of the ACM* 21(3) (March 1978): 206-218; and Keen and Scott Morton, *op. cit.*
22. John W. Slocum, Jr., "Decision Making: An Interdisciplinary Focus," in Kunreuther and Schoemaker, *op. cit.,* 288-292.
23. The information center concept is described in L. W. Hammond, "Management Considerations for an Information Center," *IBM Systems Journal* 21(2) (1982): 131-161.