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Computing policies and problems

A stage theory approach

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Computing policies have been considered a major mechanism for reducing and preventing the emergence of problems in computing operations. The authors examine the relationship between computing policies and problems, and formulate a theory of the interactions between problems, policies and commitment of resources for computing activity. The data presented are from an international comparative study of computing operations and impacts in 40 US and 16 other cities.

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[1]See the Appendix for details of the study cities and the variables used in the analysis For further information on the studies and findings, see K L Kraemer and J L King, *The Dynamics of Computing*, Columbia University Press, New York, forthcoming,
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Computing policies have been considered a major mechanism for reducing and preventing emergence of problems in computing operations. The rationale, based largely on the experience of industrial management, is that policy is the primary means of executive leadership to gain and maintain effective and efficient control of operations. This perspective assumes that alteration of management policy and the local computing environment will reduce problems and improve computing operations by increasing resource base, political and social support for computing, technical efficiency, client responsiveness, and user interaction and participation in computing provision.

The data presented here are from an international comparative study of computing operations and impacts in 40 US cities (called the URBIS cities) and 16 cities in nine other developed nations, called the Organisation for Economic Co-operation and Development (OECD) cities.[1] Earlier analysis of URBIS data has shown that problems with computing are ubiquitous among the computer-using organizations studied, but also that there is substantial variance among the cities studied in types and levels of problems experienced.[2] However, earlier research concentrated on identifying relationships between computing policies and impacts, so the true extent to which computing policies affect problems has been unknown.

Moreover, there is reason to expect that environmental factors might influence the level of problems a computer-using organization suffers. The city environment can be expected to affect computing problems because computing, like other city government activities, is affected by socioeconomic and political characteristics that are critical features of city environment. For example, larger cities that adopted computing early might be expected to have low levels of problems because they have more fully adopted the technology and worked out the early problems of adaptation Similarly, political conditions that bring about large, centralized or even regional centres providing computing to large numbers of users might result in fewer resource and capacity problems due to economies of scale.

Methodology

The analytical framework of this study is shown in Figure 1. A distinction

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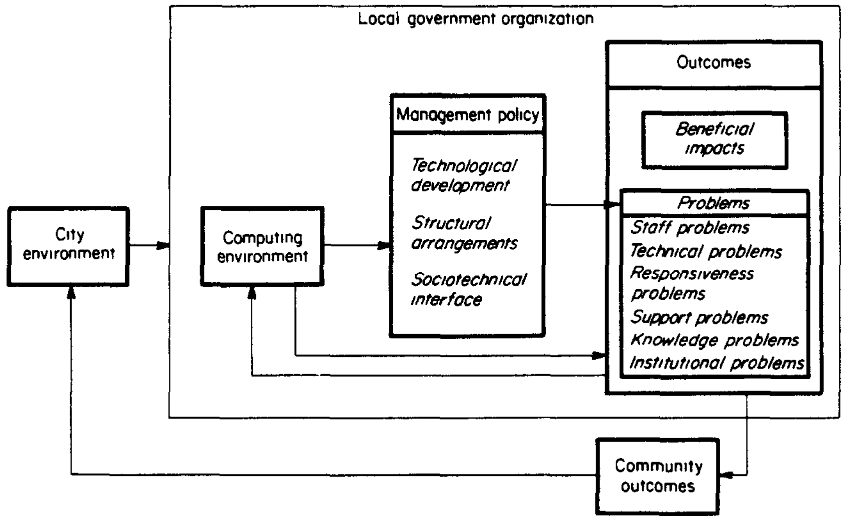

Figure 1. Framework of analysis

can be made between the extra-organizational city environment, made up of factors that are seldom under local government control (eg city population or growth rates), and the intra-organizational environment of the local government itself. Within the local government that uses computing, there are three major components: computing environment, computing management policy, and outcomes.

Policies take three forms: technological development, structural arrangements, and sociotechnical interface. Outcomes of computing include both beneficial impacts and problems. This article concentrates on computing problems, so beneficial impacts are not discussed.[3] The problems of computing generally remain within local government itself, although sometimes problems are created for citizens in the community as well. These components of the computing milieu of local government feedback into one another to create a dynamic cycle of development. The measures making up these variables in the URBIS and OECD studies are presented in Appendix A.

City environment

The city environment is likely to affect problems with the technology. Some cities might be required, as a matter of state or central government, to participate in shared computing arrangements among all cities within a region, whereas others might be free to choose shared, local or both arrangements. Some cities, because of their small size and limited expertise, might have to join with a larger government or a shared centre to obtain computing services. Other cities might have to adopt multiple independent computing installations because their size, complexity, multiplicity of functions, and historical political-administrative fragmentation do not permit any other means of obtaining computing services. Thus, city environmental factors sometimes determine how a city shall obtain computing services regardless of what politicians, managers or users might want.

In these instances, therefore, electronic data processing (EDP) problems can be said to be determined by the city environment and uncontrollable by either management policy or the shape of the computing environment. Environmental factors which might affect EDP problems include the size of the community, its social complexity and its growth, as well as national and regional governmental policies regarding

Continued from page 198
Local Government and Information Technology, Organisation for Economic Co-operation and Development, Paris, 1978

[2]K L Kraemer, W H. Dutton and A Northrop, *The Management of Information Systems: Implementation Policy for Computing in American Local Government*, Columbia University Press, New York, 1981.

[3]See Kraemer and King, *op cit*, Ref 1

computing arrangements or service requirements. Variables used here are limited to city size (population) and city wealth (size of government budget).

Computing environment

The computing environment is the technical and professional infrastructure that provides the necessary foundation for computing in the city The major variables here are size of the computing operation measured as EDP staff size; level of staff development (percentage of programmers/analysts compared to other computing staff); the city's length of experience with computing; and the extensiveness of computing's application.

Management policies

Problems with computing are sometimes viewed as highly dependent upon the state of technological development in the organization.[4] The most common approach of technical experts is to pursue a technological fix. Thus problems with computing are often approached by advocating the further development of the technology A common claim is that 'the pay-offs are just around the corner'. Once computer technology is developed to its full capacity, the benefits of the technology will be realized to their greatest extent and the problems attendant to the technology will be minimized. Thus local governments must keep up with the state-of-the-art and maintain a highly sophisticated computing capability. Variables tapping this sophistication include the number of terminals used, the extent of online capability, the degree of data linkage among data files (a measure of integration), and the degree of report sophistication.

Another perspective suggests that problems with the technology are dependent on the structural arrangements which govern its use.[5] Reorganization is therefore a basic response to problems with the use of technology. Common structural remedies are the centralization or decentralization of computing, a change in the recipients of data processing reports, or the creation of interdepartmental policy boards to govern computing This perspective assumes that problems with technology largely stem from organizational arrangements affecting the locus of control over computing resources. Reorganization might then create better conditions for managing the technology and thus for minimizing problems. Variables include the centralization of facilities (eg single *v* multiple installations), decentralization of control over computing priorities, and presence of a policy board for computing management.

Another factor which might shape computing problems is the way in which technology has been integrated into the organization. It has been suggested that the successful implementation of computing might be contingent on how the users interface with the technology. For example, to what extent are they provided with orientation and training for computer use and development? Are they skilled enough to utilize the technology? This perspective suggests that computing problems might best be addressed by training or changing the way in which users interface with the technology. But computing problems also might be addressed by changing the way in which data processing staffs interact with the users. Analysts and programmers might be employed by the user departments, or they might be employed by the computing installation but assigned to specific user departments. EDP staff might be sensitized to the impacts

[4]C F. Gibson and R Nolan, 'Managing the four stages of EDP growth', *Harvard Business Review*, Vol 52, No 1, January/February 1974, pp 76-88, J C Pendleton, 'Integrated information systems', in *Proceedings of the Fall Joint Computer Conference*, AFIPS Press, Montvale, NJ, 1971

[5]R F Powers, *An Empirical Investigation of Selected Hypotheses Related to the Success of Management Information Systems Projects*, University of Minnesota, 1970; Henry Lucas, *The Analysis, Design, and Implementation of Information Systems*, McGraw Hill, New York, 1976, J L. King, *Centralization v Decentralization of Computing. An Empirical Assessment in City Governments*, Public Policy Organization, University of California, Irvine, CA, 1978.

and problems which changes in computing arrangements can create for users and to the potential conflicts between their commitment to professionalism and to client service. Thus, computing can be integrated into the organization by changing the attitudes, behaviour and interactions of the providers as well as users of data processing services. Variables include the extent to which city management personnel are involved in computing management, the extent of user involvement in system design, and the orientation of individuals at different management levels to computing.

Computing problems

Computing problems refer primarily to problems with computing experienced by users and managers that rely on the technology. There are seven kinds of problems measured in the study.

Staff problems concern difficulties in the EDP staff-user interface, focusing on inadequacies of the data processing staff rather than of users, and involving poor communication, insensitivity to users, and 'professional' rather than 'client service' values. Staff problems are viewed as a failure of data processing managers and staff in dealing with their interpersonal and professional relationships.

Technical problems concern unreliability of computer hardware, software and services in day-to-day, routine operational performance of computing. Technical problems are viewed as a failure of EDP managers and staff in the management and operation of their own internal operations.

Responsiveness problems concern the flexibility of data processing services and systems for handling requests for special information, service or modifications to existing computerized systems. Responsiveness problems are viewed as a failure of data processing to adequately deal with the needs of managers and users.

Resource problems concern lack of sufficient staff, budget, hardware, software, data or other resources needed to satisfy the demand for EDP services. These problems are a constraint on data processing that lies outside the control of data processing managers.

Support problems concern unacceptance of data processing within the government, whether that acceptance is based on an understanding of EDP or not. Lack of support is viewed as a failure of EDP management to build good relationships with government officials and staff.

Knowledge problems refer to managers' and users' lack of understanding about the potentials and limitations of computing (eg uncertainty about whether and how to use computing and how to adapt to its job impacts). Knowledge problems are due to failure of EDP management to orient and train managers and users adequately for adaptation to computing in their jobs. They relate to support problems in that lack of adequate knowlege may lead to unrealistic expectations about what the computer can do, and to manager and user resistance to computerization. Knowledge problems were measured only in the OECD cities.

Data for this article were derived from responses of chief executives, department heads and division heads in 40 URBIS cities and in 16 OECD cities to questions about problems, constraints and satisfaction with computers and data processing. In the URBIS cities the responses were to Likert-type, close-ended queries in a questionnaire, whereas in the OECD cities the responses were to open-ended queries by field investigators. Four hundred and eighty one local officials responded to the URBIS survey and 134 responded to the OECD interviews.

Data on management policies and computing environment were derived from city data processing managers' responses to questions about arrangements for the management of computing and about computing budgets, staff, equipment, software, operations and applications [6] The data on the city environment were derived from background information requested from each city, from case reports on each city, and in the case of URBIS cities, from secondary sources such as the *City and County Databook*. The data on computing problems were collected from respondents in each city, whose responses were aggregated to form a 'city level' score for each problem variable

Indices of management policies were developed which represent the technological, structural, and sociotechnical interface policies, the computing environment and the city environment. A correlational design was then used to assess the statistical relationship between the policy and environment factors and indices of computing problems. Multivariate regression techniques were then used with the URBIS data to sort out those factors most explanatory of different types of computing problems. Taken together, these correlations and regressions were used for analysis of the relationships between environment, policy, and problems, and for developing a grounded theory about stage development of computing environments.

[6]As used here, policy refers both to 'articulated policy' and to '*de facto* policy' The former is indicated by data processing managers' responses to queries about what policies they follow for example, whether the city charges for computing, uses policy boards or involves user in design *De facto* policy is indicated by the data processing managers' responses about factual conditions of the computing environment, for example, whether the data processing installation has experienced an increase in the number of CPUs, a change in development priorities, or undergone a major reorganization (change in location, department status, consolidation, decentralization)

Table 1. Correlates of computing problems in the URBIS cities.

	Staff	Technical	Responsiveness	Resources	Support
City Environment					
Size of population	0 21	0 34[a]	0 32[a]	0 31[a]	0 19
Government operating budget	0 14	0 17	0 33[a]	0 25	0 12
Computing environment					
Total EDP staff	0 20	0 28[a]	0 36[a]	0 46[a]	0 05
Percent programmers-analysts	0 23	0 16	0 01	0 00	−0 02
Year EDP began in city	−0 36[a]	−0 33[a]	−0 18	−0 25	0 12
Degree of automation	0 30[a]	0 14	0 23	0 39[a]	0 00
Degree of functional automation	0 27[a]	0 17	0 15	0 20	0 06
Technological development					
Number of terminals	0 29[a]	0 26[a]	0 25	0 51[a]	0 09
Online computing capability	0 16	0 05	−0 04	0 06	0 02
Degree of data linkage	0 14	0 06	−0 01	0 20	−0 17
Degree of report sophistication	0 40[a]	0 19	0 33[a]	0 42[a]	0 15
Structural arrangements					
Single installation	0 08	0 01	−0 14	0 23	−0 04
Decentralized control of priorities	0 17	0 20	0 07	0 23	0 00
Policy board used	0 35[a]	0 36[a]	0 31[a]	0 21	0 17
Sociotechnical interface					
CAO involvement in management of computing	0 12	0 01	0 09	0 00	−0 24
Department head involvement in management of computing	0 14	0 40[a]	0 17	0 34[a]	0 12
User involvement in design of applications	0 38[a]	0 11	0 17	0 02	0 29[a]
CAO orientation to computing	−0 14	0 40[a]	0 17	0 34[a]	0 12
Department head orientation to computing	0 17	0 30[a]	0 19	0 31[a]	0 20
Section head orientation to computing	0 14	0 06	0 28[a]	0 17	0 25

Note a Pearson correlations significant at the 0 05 level

Management policies and problems

In analysing technological development, the technical sophistication of computing is significantly associated with computing problems. Specifically, the degree of data linkage, the number of online terminals and the sophistication of computer reports tend to be associated with all computing problems in the URBIS cities and with resources and technical problems in the OECD cities (see Tables 1 and 2). Thus, it is not the lack of technical sophistication in computing that is associated with computing problems, but the presence of highly sophisticated computing. Note, however, that for some OECD cities the lack of technical sophistication is associated with computing problems. Specifically, batch processing, independent data files and low report sophistication are significantly associated with responsiveness, staff, support and knowledge problems (Table 2).

Structural arrangements for computing are significantly related to computing problems, though there are important differences between the URBIS and OECD cities in the arrangements used for computing One difference has to do with the use of shared versus purely local computing installations. The OECD cities, many of which use shared computing arrangements, tend to have particular difficulty with responsiveness, staff and knowledge problems (Table 2) Specifically, shared installations are highly correlated with insensitivity of EDP staff to problems they create for users, lack of user involvement in the design of systems, communication problems between EDP staff and users, inadequacy of systems, inflexibility of systems, lack of potential pressure/support for computerization and lack of knowledge about how departments staff should adapt to computerization in their jobs (see Table 3).

Table 2. Correlates of computing problems in the OECD cities.

	Resource	Technical	Responsiveness	Staff	Support	Knowledge
City environment						
Size of population	0 01	0 31	−0 36	−0 47[a]	−0 37	0 01
Government operating budget	0 16	0 22	−0 12	−0 37	−0 48[a]	−0 02
Computing environment						
Total EDP staff	0 30	0 28	−0 12	−0 49[a]	−0 56[a]	−0 23
Percent programmers-analysts	−0 11	0 52[a]	0 01	0 14	−0 53[a]	0 58[a]
Year EDP began in city	0 23	−0 30	−0 18	0 47[a]	0 20	−0 39
Degree of automation	0 45[a]	0 33	−0 43[a]	−0 32	−0 29	−0 15
Degree of functional automation	0 37	0 33	−0 49[a]	−0 19	−0 46[a]	−0 17
Technological development						
Number of terminals	0 25	0 32	−0 22	−0 46[a]	−0 52[a]	−0 25
Online computing capability	0 00	0 20	0 08	0 03	−0 46[a]	−0 22
Degree of data linkage	0 28	0 24	−0 43[a]	−0 49[a]	−0 42[a]	−0 10
Degree of report sophistication	0 17	0 67[a]	0 23	−0 22	−0 33	0 30
Structural arrangements						
Regional installation	−0 13	−0 01	0 67[a]	0 69[a]	0 17	0 52[a]
Decentralized control of priorities	−0 28	0 06	−0 08	0 19	0 10	0 24
Sociotechnical interface						
CAO involvement in use and development	0 28	−0 11	−0 25	0 00	−0 31	−0 22
Department head involvement in use and development	−0 06	−0 31	−0 63[a]	−0 19	0 07	−0 23
CAO involvement in management of computing	0 03	−0 26	−0 40	−0 67[a]	0 07	−0 12
Department head involvement in management of computing	0 23	−0 15	−0 60[a]	−0 07	0 08	−0 21
User involvement in design of applications	−0 31	0 11	−0 38	−0 44[a]	−0 46	0 13
CAO orientation to computing	0 56[a]	−0 13	0 12	0 17	−0 40	−0 14
Department head orientation to computing	0 58[a]	−0 11	0 01	−0 10	−0 30	−0 28
Section head orientation to computing	0 54[a]	0 17	−0 02	−0 16	0 09	−0 12

Note [a] Pearson correlations significant at the 0 05 level

Shared installations experience fewer resource problems such as limited machine and staff capacity.

It appears that the shared installations have adequate technical capacity but might not have the 'right' capacity or might not sufficiently manage that capacity to deal effectively with the needs of the individual municipalities and departments served by the centres. Moreover, the lack of knowledge about how department staff should adapt to computerization in their jobs and the lack of local political pressure/support for computerization might be due to the shared arrangement. On the one hand, municipal staff might not be able to develop knowledge about how to adapt successfully to computerization because the technical expertise to assist them resides in a remote centre. On the other hand, because political leaders have 'bought into' the shared arrangement, they might not exert the political pressure/support to develop local capability or to pressure the shared installation to be more responsive and helpful.

Another difference in structural arrangements has to do with the use of EDP policy boards. In theory such boards and committees should reduce computing problems because they provide an opportunity for management and users to participate in decision making about computing services. Yet, the use of policy boards is significantly associated with high staff, technical and responsiveness problems in the URBIS cities (Table 1) [7] It is also associated with high resource and support problems

The sociotechnical interface is significantly related to computing problems, particularly the client participation and training strategies. These presumably would reduce staff and responsiveness problems, but they are frequently associated with major computing problems in the URBIS cities. For example, high levels of management and user involvement and management and user training are positively associated with *all* computing problems in the URBIS cities.

The OECD cities exhibit two different patterns of relationships. On one hand, high levels of management involvement and management and user training are positively and significantly associated with resource and cost problems. Client participation should not result directly in resource and cost problems *per se*, but it might simultaneously increase client demand for computing and client awareness of resource limitations for satisfying their demands. In other words, participation may simply heighten managers' and users' awareness of resource and cost problems, irrespective of the factual basis of their perceptions. Our data do not allow further testing of this idea.

[7]The OECD questionnaire and case reports did not contain data about EDP policy boards

Table 3. Computing problems associated with shared installations in the OECD cities.

Type of problem	Shared installation
Staff problems	
EDP staff not sensitive to problems they create for users	0 69[a]
EDP staff does not involve users sufficiently	0 74[a]
Communication problems between EDP staff and users	0 36
Responsiveness problems	
Inflexibility of systems	0 42[a]
Inflexibility/inadequacy of national systems	0 69[a]
Support/knowledge problems	
Lack of political pressure/support	0 38
Staff adaptation	0 59[a]
Resource problems	
Limited machine capacity	−0 45[a]
Too few EDP staff	−0 34

Note [a]Pearson correlations significant at the 0 05 level

In closer keeping with expectations, low levels of management and user involvement and management and user training are associated with greater responsiveness, staff, support and knowledge problems. Cities that are smaller, less experienced, less automated and share computing exhibit such problems. It is likely that greater client participation and training reduce the incidence of problems with EDP staff, responsiveness, support and knowledge in cities with shared computing, as well as cities that are small and inexperienced with the technology.

The computing environment has different impacts in the URBIS and OECD cities, but in both it tends to be an important factor in generating problems. In the URBIS cities a high commitment of the government to data processing (large staffs, computing capacity and budgets), early adoption of computing by the government, and a high degree of computer automation (both in terms of total number of applications and the number of departments served by computing) tend to be associated with greater staff, technical, responsiveness and resource problems.

For some OECD cities, a high level of commitment to data processing and a high degree of computer automation are related to greater resource, technical and cost problems. The year computing was adopted has no relationship to computing problems in these cities. In contrast, for other OECD cities, a low commitment to data processing and a low degree of computer automation are associated with responsiveness, staff, support and knowledge problems. The length of time that a computing installation has been in operation appears to be an important factor in problem generation, but varies in its effect. Early adoption is related to staff and support problems whereas later adoption is related to responsiveness and knowledge problems.

Uncontrollable features of the city environment, such as city size and wealth, are also related to computing problems. Size is particularly important but it operates differently in the URBIS and the OECD cities. In the URBIS cities, larger cities tend to have more computing problems whereas smaller cities tend to have fewer problems. Technical, responsiveness and resource problems are all significantly related to the larger cities. In the OECD cities, size tends to discriminate between the kinds of problems experienced by a city. Larger cities tend to have resource and technical problems whereas smaller cities tend to have responsiveness, staff and support problems.

Patterns of computing problems

At the most general level, the analysis indicates that different problems tend to be associated with different kinds of cities, and the patterns are different from URBIS and OECD cities. In the URBIS cities, all problems tend to be associated with cities that are larger, that have computing environments characterized by early adoption of computing, large EDP capacity and high levels of automation; management policies emphasize high technical sophistication, local computing arrangements with a policy board for coordination, high client participation and high management and user training. Support problems are the most weakly associated with these characteristics and also tend to be the least frequent category of problems in the URBIS cities (Table 1).

In contrast, URBIS cities with few problems tend to be smaller, have computing environments characterized by recent adoption, moderate EDP capacity and moderate levels of automation; management policies emphasize low sophistication, local computing arrangements, no policy board, low client participation and low management and user training These cities probably have few computing problems because the technology's use within the government is limited as yet to only a few departments, which can be adequately served by current computing capacity, and because relations between EDP and these departments are simple and direct. It is also likely that department users' expectations about computing are relatively modest and that their experience with computing in the past has been positive or at least not critically disruptive

In the OECD cities, the problems tend to split along two categories of cities (Table 2). Resource and technical problems tend to be associated with cities that are larger, that have computing environments characterized by earlier adoption of computing and larger staffs, and that have management policies emphasizing high automation and sophistication, locally developed and locally controlled computing, high management involvement but low user involvement and high management and user training. In short, these cities appear to have a high current demand for computing (as evidenced by high automation) but limited resources for satisfying that demand and, probably as a result, many technical problems in day-to-day service provision It is also possible that their client-oriented management policies account for their lack of problems with responsiveness, staff, support or knowledge.

In contrast, responsiveness, staff, support and knowledge problems tend to be associated with OECD cities that are smaller, that have computing environments which adopted either early or late, but which also have small EDP staffs, and that have management policies emphasizing low sophistication, shared computing arrangements and less local control over computing, and low client participation (low management and user involvement and training) The problems of these cities are directly associated with their shared computing arrangements, probably because shared installations greatly increase the number and complexity of relationships among all the demands and actors party to the arrangement. Shared installations are also physically remote from many of the departments they serve which probably creates specific difficulties in responsiveness and communication and undoubtedly increases the 'social distance' which users feel with respect to data processing. Staff problems are likely to be high because the EDP staff is somewhat independent, insulated from local managers and users, and insensitive to the impacts their decisions have upon the departments they serve Finally, many shared installations serve to implement large nationwide or statewide 'standard' applications among cities and do less development of 'tailored' applications. The standard applications are not likely to serve all cities equally well, and are likely to be oriented more towards serving national and regional needs than local needs. Standard applications are also more difficult for local governments to change in the short run, if they can change them at all

The fact that among the large URBIS cities and the larger, locally controlled OECD cities management policies are positively related to the presence of all categories of computing problems is puzzling More detailed examination to determine whether computing problems simply are endemic, whether management policies cause problems, or whether problems cause management policies is called for. The formal analysis presented below was limited to URBIS cities because the URBIS data-base supports more detailed analysis; where appropriate, the experience of the OECD cities is also introduced.

The data above indicate that management policies that are expected to *reduce* computing problems are highly associated *with* problems. High technical sophistication is significantly associated with computing problems despite the assumption that these cities have greater experience with the technology and greater technical capacity for problem-free implementation. Structural arrangements, particularly the use of policy boards and interdepartmental committees, are also positively associated with computing problems, even though these are a means for airing difficulties, developing priorities for dealing with them, and improving both coordination and communication between EDP staff and the operating departments. The sociotechnical interface, especially extensive user involvement and intensive user training, are both positively and significantly associated with problems, again, contrary to the belief that client participation in decision making about computing would reduce problems by helping data processing services to provide greater attention to user needs.

Since these data are only cross-sectional, one must ask in which direction the causal relationship lies. Do management policies cause computing problems? It is possible that the policies might contribute to computing problems, or exacerbate them, but it seems unlikely that they generate the problems in the first instance. Rather, the management policies found in the larger URBIS and OECD cities are probably a response to computing problems in an effort to ameliorate them. Unfortunately, this interpretation seems at odds with the findings. One would expect to find that the policies had ameliorated the problem, but we find problems and policies together. This raises the possibility that policies are instituted to reduce problems, but that on the whole they do not. If this is true, then either the policies are ineffectual at reducing problems, or problems arise to meet the threat of policies

Foundations of a stage theory

It has been noted that outward signs of computing departments' behaviour are identifiable according to the time the department has been in operation.[8] The data presented above also indicated a relationship between the presence of problems and the length of time an organization has been using computing. It seems too simplistic to attribute presence or absence of problems to length of time which computing has been a part of an organization's activity, but the strength of the finding coupled with the interactions of other policy variables indicates that time may be a major factor in the presence of problems as an enabling agent; ie it takes a certain amount of time to get to any given level of growth.

When all of the findings are considered, it seems likely that management policy being related to problems both in the 'right' (theoretically expected) and 'wrong' (unexpected) directions is due to differences in the cities' 'stages' of EDP growth and development. Each stage has associated with it certain characteristics of the computing environment, computing problems and management policy (see Table 4).

Stage I, which we call introduction and conquest, is partly illustrated by the OECD cities with shared computing arrangements, but also applies to cities with service bureaus of their own initial computing installation. Stage I cities are recent adopters with little or no computing capacity and

[8] Gibson and Nolan, *op cit*, Ref 4, R. Nolan, 'Managing the computer resource a stage hypothesis', *Communications of the ACM*, Vol 16, No 7, July 1973, pp 399-405

staff expertise (although they might have remote access to such resources through a shared computing installation or service bureau). These cities have a few computer applications operational, usually in batch mode, and these applications serve only a few city departments. Application growth is slow because of start-up costs and because local knowledge about the technology is limited and/or concentrated. Consequently the demand for computing is low and it is centred around the perceived needs of the resource controllers, usually for finance and administration applications.

As might be expected, these cities have problems generating support for the technology, partly because of the lack of users' and managers' knowledge about its potential application. In cities served by service bureaus or a shared facility, the lack of support might also be due to the failure of the centre to adequately tailor applications to local users' needs because the economies of centre operation (and perhaps the 'charter' of the organization) dictate that standard rather than custom applications be developed.

Stage I cities also have staff problems because EDP staff have not yet learned how to communicate with users, do not conduct user orientation and training, and in the case of service bureaus and shared facilities, may be physically remote from the users. Responsiveness problems might result from EDP staff who are inexperienced in the various functional areas, or who feel compelled to develop standard rather than tailored applications, either one of which reduces their ability to respond to special requests and modifications from users after the systems are built.

Stage II, which we call experimentation and expansion, is illustrated by the small and moderate-size URBIS cities. Stage II cities are 'middling' adopters with moderate local computing capacity and staff expertise

Table 4. Stages of EDP growth indicated by URBIS and OECD data.

Growth stage	Computing environment	Computing problems	Management policies	Illustration
I Introduction and Conquest	Recent adopters Low local computing capacity and staff expertise Few applications, usually batch, in a few departments Slow application growth Computing located in finance department, a shared facility, or a service bureau	Moderate to major problems with responsiveness, staff, support and knowledge	No local policy board Low or 'remote' manager and user involvement Low orientation and training for managers and users Control of computing is in the hands of the 'owner' of computing resources Use shared facility, service bureau or small local installation	Smaller OECD cities with shared computing
II Introduction and Establishment	'Middling' adopters Moderate local computing capacity and staff Slack computer resources Rapid application growth and expansion to many depatments Computing located in finance or independent department	No problems or moderate problems with EDP staff, technology, responsiveness and resources	No local policy board Low to moderate involvement of users Low to moderate orientation and training of managers and users Technology expanded and moderately upgraded Control of computing under the chief executive	Small and moderate-sized URBIS cities
III Competition and Regulation	Early adopters Large, sophisticated computing capacity and technical staff; being overloaded Many sophisticated applications in many departments Application growth is marginal, in areas already developed Extensive demand for maintenance and modification of equipment, software, applications Computing located in an independent department	Moderate to major problems with EDP staff, technology, responsiveness and resources No support problems	Use policy board or interdepartmental comittee Centralize computing in a local installation High management and user involvement Intensive management and user orientation and training Control of computing shared between chief executive and policy board Advanced technology is used	Larger URBIS and OECD cities

They have recently upgraded capacity and have slack computing resources relative to current demand; consequently, they are engaged in extensive applications development in many departments. These cities also tend to have moved the computing installation out of finance into an independent computer department intended to serve all departments and agencies of the government.

Few problems with computing exist in the Stage II cities. Earlier problems have been worked out, so experienced users are relatively satisfied with computing. New users are enthusiastic, even promotional, about the computer's potential as they anticipate the new applications coming into existence. While slack computing resources might not be large, they are still sufficient to handle some increase in demand. Management policies for some user involvement and for some orientation and training are instituted or continued. Control of computing decisions is in the hands of the chief executive, but no policy board is instituted to give departments a say in development. The technology is expanded and upgraded moderately in sophistication.

Stage III, which we call competition and regulation, is illustrated by the larger URBIS and OECD cities. Stage III cities are early adopters which now possess large, sophisticated computing capacity and technical expertise in a single central computing installation, perhaps with a few smaller satellite installations. However, these cities also have many sophisticated applications serving many departments and, consequently, both computer and staff capacity are likely to be overloaded. The large number of existing applications places heavy demands on the EDP staff for maintenance and modification, so few resources are available for additional new development. Competition among departments for the available maintenance and development of resources is likely to be intense and the data processing operation is likely to be caught in the middle.

Many kinds of problems with computing arise in this environment of limited resources and competition. Communication problems develop between EDP staff and users. Given the complexity of the EDP operation and the tension among departments, EDP staff might even try to insulate themselves from user demands and problems. Consequently, EDP staff do not respond well to user requests for special information, for application modification or for new applications development. Technical problems develop as the EDP staff try to make equipment and procedural adjustments aimed at more efficient operations.

As a means of dealing with these problems, the Stage III cities form a policy board or interdepartmental committee for resolving conflicts in priority among the departments and for focusing attention on problems between EDP and staff users. These cities begin to involve managers and users more in decision making about computing arrangements, in the design of new applications and in orientation and training courses for computer use. They also decentralize analysts and programmers in an effort to improve responsiveness and staff relations. And they might try several technological fixes, such as multiprogramming or upgrading the CPU, for dealing with their shortfall in capacity.

Dynamics of the stages

This interpretation produces an empirically-based 'stage theory' of EDP growth and development. While the stage notion is not original to this study, the empirical basis for this specific theory is original and results in better specification of the basic stage theory.[9]

The 'stage' of a particular city is determined by characteristics of its computing environment, such as how long it has been using computing, level of computing resources (budget, equipment, staff), degree of automation, and degree of change and growth. Different computing problems are associated with different computing environments and, therefore, with different stages of growth. Management policies are introduced into this 'computing environment-problems mix' in an effort to change the computing environment and ameliorate the problems. Thus, each stage of growth also tends to be characterized by certain management policies which are more or less appropriate for the environment-problems mix at that stage If inappropriate management policies are introduced at any stage, one would expect these policies to exacerbate current problems and create new problems. At minimum the misapplication of management policy represents a misuse of resources and creates opportunity costs for the computing installation and the govenment.

The stages of EDP growth also might be associated with different characteristics of the city environment, but more as a matter of historical accident than as a deterministic result. The 'stage' notion implies that each stage is a discrete step, that the stages proceed in sequential fashion, and that all cities pass through all steps at one time or another, although the passage might be longer or shorter for some cities than for others. In fact, however, the earliest computers were expensive and limited in capability such that their initial use was feasible only in the largest cities These cities also tend to be at more advanced stages of EDP growth today. However, a more advanced stage of EDP growth is not necessarily associated with size; small and medium-sized cities can also be at the advanced stages.

Policy and problem mixes

Some support for the argument that different 'policy-problem mixes' exist can be gleaned from the results of regression analysis of the URBIS cities' problems. The URBIS data are rich in detail, so several new management policy and computing environment variables have been included in the subsequent analyses in an effort to obtain better specification of the factors related to problems. The total set of variables included is shown in Table 5 The regression results for each group of problems are discussed next.

First, EDP staff-user interface problems tend to be associated with a computing environment where structural arrangements are being implemented (Table 6). Involvement of an interdepartmental board in decisions about applications development and priority accounts for 23% of the variance among the cities, and reorganization of EDP (change in location, department status or centralization/decentralization) accounts for an addition 9% of the variation. Moreover, staff problems also tend to be associated with places that have implemented training for managers in the operating departments – another strategy for improving EDP staff-user relations. The fact that staff problems are also associated with places that have had computing for some time and that have sophisticated computing indicates that these policies probably have been implemented as a response to staff problems. That is, staff problems are more likely to arise in places that adopted computing early and have sophisticated

[9] The stage notion was posited earlier by Nolan, *op cit*, Ref 8 See also Gibson and Nolan, *op cit*, Ref 4, and R L Nolan, 'Controlling the costs of data', *Harvard Business Review*, March/April 1979, pp 115-126

Table 5. Pearson correlations between computing problems and computing policies and environments in the URBIS cities.

	Staff	Technical	Responsiveness	Resources	Support
City environment					
Size of population	0 21	0 34[a]	0 32[a]	0 31[a]	0 19
Government operating budget	0 14	0 17	0 33[a]	0 25	0 12
Computing environment					
Year installation began	−0 34[a]	−0 33[a]	−0 18	−0 25	−0 12
Percent of government budget allocated to EDP	0 04	0 28[a]	0 02	0 18	0 08
Total EDP staff in installation	0 20	0 28[a]	0 36[a]	0 46[a]	0 05
Percent of EDP staff who are programmers/analysts	0 23	0 16	0 01	0 00	−0 02
Degree of automation	0 30[a]	0 14	0 23	0 39[a]	0 00
Degree of functional automation	0 27[a]	0 17	0 15	0 20	0 06
Lapsed hours/week computers operational	0 24	0 31[a]	0 30[a]	0 55[a]	0 05
Technology					
Amount of core capacity	0 18	0 33[a]	0 34[a]	0 53[a]	0 04
Number of terminals	0 29[a]	0 26[a]	0 25	0 51[a]	0 09
Online computing capability	0 16	0 05	−0 04	0 06	0 02
Degree of data linkage	0 14	0 06	−0 01	0 20	−0 17
Multiprogramming capability	0 00	0 15	−0 01	0 28	−0 09
Degree of report sophistication	0 40[a]	0 19	0 33[a]	0 42[a]	0 15
Change in vendors in last 2 years	0 23	0 13	0 12	0 16	−0 01
Increase in the number of CPUs in last 2 years	0 08	0 49[a]	0 25	0 01	0 17
A change in size of CPU, a significant upgrading, in last 2 years	−0 06	0 14	0 11	−0 07	0 20
Structure					
Degree of structural change in last 2 years	0 16	0 14	0 01	−0 19	0 02
Change in development priorities for new systems	0 20	0 23	0 19	0 31[a]	0 08
Single installation	0 08	0 01	−0 14	0 23	−0 04
Decentralized control of priorities	0 17	0 20	0 07	0 23	0 00
Presence of policy board	0 35[a]	0 36[a]	0 31[a]	0 21	0 17
Interdepartmental board involvement in application development	0 48[a]	0.28[a]	0 30[a]	0 19	0 10
Board activity in computing centre policies	0 34[a]	0 29[a]	0 14	0 22	0 11
User involvement					
CAO involvement in management of computing	0 12	0 01	0 09	0 00	−0 24
Department head involvement in management of computing	0 14	0 40[a]	0 17	0 34[a]	0 12
User involvement in design of applications	0 38[a]	0 11	0 17	0 02	0 29[a]
Degree of user involvement in computing centre policies	0 42[a]	0 26[a]	0 30[a]	0 20	0 12
Programmers employed by EDP but located in user departments	0 01	−0 27	0 12	0 08	−0 30[a]
Training of department heads by EDP	0 45[a]	0 23	0 19	0 36[a]	0 00
CAO orientation to computing	−0 14	0 15	−0 02	0 20	−0 05
Department head orientation to computing	0 17	0 30[a]	0 19	0 31[a]	0 20
Section head orientation to computing	0 14	0 06	0 28[a]	0 17	0 25

Note [a]Pearson correlations significant to the 0 05 level

computing because these places simply have more extensive and complex relationships with the operating departments in the government. Managing this environment of extensive complexity therefore requires the adoption of structural and training policies.

Second, technical problems are more likely to be present in a policy environment where a technological fix is being effected (Table 7). The dominant policy associated with technical problems is a recent increase in the number of CPU's in the computing installation, accounting for 24%

Table 6. Regression results for EDP staff-user interface problems in the URBIS cities.

Independent variable	Dependent variable: EDP staff-user interface problems Zero-order correlation	Beta weight	Variance explained
Interdepartmental board involvement in applications development	0 48	0 30	23%
Degree of report sophistication	0 40	0 39	15%
Degree of structural change in past two years	0 16	0 46	9%
Year installation first began	−0 34	−0 30	9%
Training of department managers	0 45	0 30	6%

Note R = 0 78, Total variance explained = 62%

Table 7. Regression results for technical problems in the URBIS cities.

Independent variable	Dependent variable: technical problems Zero-order correlation	Beta weight	Variance explained
Increase in number of CPUs	0 49	0 63	24%
Degree of report sophistication	0 19	0 48	13%
Programmers employed by EDP but located in user departments	−0 27	−0 44	15%
Percent of government budget allocated to EDP	0 28	0 35	11%
Presence of a policy board	0 36	0 31	9%

Note R = 0 85, Total variance explained = 72%

of the between-city variation. The degree of report sophistication, an indication of the general level of sophistication in the computing environment, explains an additional 13% of the variation. Interestingly, decentralization of analysts and programmers is negatively associated with technical problems. That is, cities that have decentralized their EDP staffs have fewer technical problems. Furthermore, cities with technical problems have large budgets (a size indicator) and use EDP policy boards.

These findings indicate that cities having technical problems are larger and more sophisticated; they probably also have more automation. They use policy boards for dealing with computing issues but do not use a strategy which appears effective in reducing problems – decentralizing EDP staff. They probably have upgraded their CPU's to handle the high demand for services present in large cities, in the process, they might also have contributed to technical problems while the upgrading was being effected. Consequently, the technological fix might be both a response to demands of a complex computing environment and, in the process, a generator of new technical problems.

Third, responsiveness problems tend to occur in computing environments which are essentially conservative. Although none of the factors explain much of the variation, responsiveness problems are associated with large EDP staff, a recent upgrade in CPU, no change in equipment vendor and no use of multiprogramming, but some user involvement in EDP decision making (Table 8).

These computing installations can be characterized as conservative because while they have large staffs and large computer capacity, they do not use multiprogramming which could increase their ability to respond to special requests for information, or modifications to existing applications. Moreover, while they involve users in decision making about overall EDP arrangements, there is no indication that they work closely with users on a day-to-day basis where more responsiveness problems occur.

Table 8. Regression results for responsiveness problems in the URBIS cities

Independent variable	Dependent variable: responsiveness problems Zero-order correlation	Beta weight	Variance explained
Total staff in EDP installation	0 36	0 62	13%
User involvement in computer centre policies	0 30	0 40	8%
Multiprogramming capability	−0 01	−0 55	7%
A change in size of CPU, significant upgrading in last 2 years	0 11	0 35	9%
Change in vendors in last 2 years	−0 14	−0 24	5%

Note R = 0 65, Total variance explained = 42%

Fourth, resource problems tend to occur in computing environments with a capacity overload. The dominant factor associated with resource problems is the number of hours per week that the computer operates; around-the-clock operation is associated with resource problems and explains 31% of the variation between cities (Table 9). Other factors which indicate capacity overload are the use of multiprogramming capability, the juggling of development priorities and a small proportion of analysts and programmers in the EDP installation These three factors are positively associated with resource problems and explain an additional 27% of the between-city variation. Resource problems also tend to occur in sophisticated computing environments.

Sorting out policy from environmental factors, these findings suggest that resource problems occur in computing environments characterized by sophisticated applications and by few EDP staff for the development of new applications or for maintenance of old ones. To maximize the efficiency of computer and staff resources, these installations operate around the clock, use multiprogramming techniques and juggle development priorities for new systems.

Conclusion

Problems with computing appear to be endemic to the technology's use in cities. Although the kinds and intensity of problems experienced by cities vary, all cities have some problem with computing. The specific kinds of problems that a city experiences seem to be related to the city's stage of EDP growth. Each stage is characterized by distinctive characteristics of its computing environment, computing problems and management policies. Different computing environments generate different kinds of computing problems and different kinds of management policies for dealing with these problems.

The presence of certain management policies in the cities could be expected to be associated with low computing problems, yet the analyses presented here show the opposite. Management policies that are expected to reduce computing probems are frequently highly associated with the presence of problems in the city. However, this does not necessarily mean that management policies cause computing problems Both the stage theory of EDP growth and the regression analyses presented above suggest that certain policies are a response to problems rather than a cause. Moreover, the existence of certain logical 'policy-problem mixes' in the cities suggest that specific policies are being effected in an effort to ameliorate the problems.

Table 9. Regression results for resource problems in the URBIS cities.

	Dependent variable: resource problems		
Independent variable	**Zero-order correlation**	**Beta weight**	**Variance explained**
Hours per week one or more computers operational	0 55[a]	0 38	31%
Degree of report sophistication	0 42	0 50	13%
A change in development priority for new systems	0 31	0 45	8%
Percentage programmers/analysts in installation	0 00	−0 59	7%
Multiprogramming capability	0 28	0 52	12%

Note: R = 0.84, Total variance explained = 71%

Appendix

Details on surveys and variables

The 56 cities surveyed in the URBIS and OECD studies are listed in Table A1. The OECD survey consisted of interviews with a variety of local government officials in different local government positions Variables were selected from the responses to questions located in the different interviews The methodology utilized provided data at the individual level and the city level. All analysis was done at the city level To obtain city-level scores the responses from the department head and section head were aggregated The set of city-level EDP Problems Indices were obtained from hand coding each city based on the responses of the CAO, department heads and section heads to the open-ended question 'What constraints do you have upon fuller exploitation of the computer's potential for your department?' This method was necessitated because so few responses were elicited within each level of the government hierarchy Also, given that each respondent in the local government levels would be involved in computing differently, it was expected that by combining all with responses, assigning equal weights to each response and summating the responses within each category, a 'representative sampling' of EDP problems within the city would result By the summation of the number of times a particular problem-category occurred, some differentiation (although crude) of the extent of each problem category within the city would also be provided Below are listed the indices of EDP problems encountered by users that were developed

The Staff Problems Index measures the extent to which the city is experiencing problems in the interface between the computing staff and user staff, focusing primarily on inadequacies of the computing staff to deal with the needs of users

The Technical Problems Index measures the extent to which the city is experiencing technical reliability difficulties of the hardware and software systems in day-to-day operations

The Responsiveness Problems Index measures the extent to which the city is experiencing difficulties arising from inflexibility of the computing resource of the city to accommodate needs and changes of the user environment.

The Resource Problems Index measures the extent to which there are problems of storages of sufficient monetary, staff, hardware, data or other computing resources within the city

The Support Problems Index meaures the extent to which there is an unwillingness within the city organization to accept and support computing activity

The Knowledge Problems Index measures the extent to which there is a lack of user understanding as to what the abilities and constraints of computing and computing staff are in the city

The URBIS Project consisted of two phases of data collection and multiple levels of respondents. In the first phase of the project, a census was carried out of all cities with 50 000 or more population and all counties with 100 000 or more population The second phase of the URBIS project consisted of a stratified random sample of 40 cities in which different functional tasks of the city were investigated *vis-à-vis* the use of automated processing. In addition, all installations were surveyed again with a similar but not identical questionnaire to the first phase Finally, a mail-back questionnaire (user core) was distributed to purposively selected respondents within the departments of the city (including departments which did not use or seldom used automated processing)

Both Phase I and Phase II of the project produced data at the individual level, the city level and the installation level In analysing the URBIS data with the OECD data, one constant level of analysis was selected – the city level This involved making certain decisions

Table A1. Cities surveyed in the URBIS and OECD studies

URBIS cities	
Albany, NY	Milwaukee, WI
Atlanta, GA	Montgomery, AL
Baltimore, MD	New Orleans, LA
Brockton, MA	New Rochelle, NY
Burbank, CA	Newton, MA
Chesapeake, VA	Oshkosh, WI
Cleveland, OH	Paterson, NJ
Costa Mesa, CA	Philadelphia, PA
Evansville, IN	Portsmouth, VA
Florissant, MO	Quincy, MA
Fort Lauderdale, FL	Riverside, CA
Grand Rapids, MI	Sacramento, CA[a]
Hampton, VA	San Francisco, CA
Lancaster, PA	Jan José, CA[a]
Las Vegas, NV	St Louis, MO
Lincoln, NB	Seattle, WA
Little Rock, AR	Spokane, WA
Long Beach, CA	Stockton, CA
Louisville, KY	Tampa, FL
Miami Beach, FL	Tulsa, OK
Kansas City, MO	Warren, MI
OECD cities	
Vienna, Austria	Duisburg, FR Germany
Vareloese, Denmark	Nurtingen, FR Germany
Aarhus, Denmark	Jonkoping, Sweden
Helsinki, Finland	Leeds, UK
Gagny, France	Torbay, UK
Montpellier, France	Calgary, Canada
Toulouse, France	Maebashi, Japan
Backnang, FR Germany	Nishinomiya, Japan

Note [a] These cities were also surveyed, although not originally selected as part of the 40-city URBIS Phase II population The data from these cities were included in the analysis, while data from two other cities in the list (Quincy, MA and New Rochelle, NY) were excluded from analysis because they did not have a level of computer use sufficient for some studies concerning the aggregation methods used for the URBIS data The problems indices were constructed based on the factor analysis of responses shown in Table A2

Staff Problems Index Three items were used for the index: 'Data processing staff are more interested in working on new computer uses rather than making improvements in ones we now use'; 'Data processing staff are more intrigued with what the computer can do than with solving the problems of my department'; and, 'Data processing staff confuse our conversations with their technical language'

EDP Technical Problems Index Two of the items in this index were taken from a list of problems presented to the respondent with the following instructions: 'Below are listed problems sometimes associated with data processing in local government. Indicate for each whether this has been a problem in your department, agency or office within the last year'. The technology-related problems were: 'Foul-ups in day-to-day computer operations', and 'Frequency technical and organizational changes in data processing service'. The third question used for this index was: 'Please rate the quality of the data processing services provided to your department, agency, or office'.

EDP Responsiveness Problems Index. Three of the items were taken from a list of problems presented to the respondent with the following instructions: 'Below are listed problems sometimes associated with data processing in local government. Indicate for each whether this has been a problem in your department, agency or office within the last year'. The three responsiveness related problems were. 'Slow response of data processing to requests for information', and 'Computer-based data not available for the analysis of specific questions or problems', and, 'Difficulty in getting priority in using the computer'

EDP Resource Problems Index Two items were taken from a list of problems presented to the respondent with the following instructions 'Below are listed problems sometimes associated with data processing in local government. Indicate for each whether this has been a problem in your department, agency, or office within the last year' The resource-related problems were 'High cost of computer use', and, 'Difficulties in accessing computer-based data gathered or held by other departments and agencies'. Again, the factor analysis in Table A2 provided selection guidance

EDP Support Problems Index Support for computing was measured by two user core questions: 'In general, computers and data processing have failed to live up to my expectations', and, 'Within the next five years, computers will greatly improve the operations of this government'

Table A2. Factor loadings for dimensions of computing problems in the URBIS cities.

			Type of computing problem		
Questionnaire items	**Staff**	**Technical**	**Resource**	**Responsiveness**	**Support**
Data processing staff are more interested in working on new computer uses rather than making improvements in ones we now use	0 94[a]	0 28	0 06	0 02	−0 19
Data processing staff are more intrigued with what the computer can can do than with solving the problems of my department	0 81[a]	−0 04	0 00	0 19	0 14
Data processing staff confuse our conversation with their technical language	0 59[a]	0 21	0 27	0 24	0 15
Frequent technical and organizational changes in data processing services	0 01	0 82[a]	0 17	0 06	−0 04
Foul-ups in day-to-day computer operations	0 24	0 76[a]	0 04	0 32	0 05
Quality of data processing services provided	0 26	0 43[a]	−0 06	0 36	−0 01
Difficulties in accessing computer-based data gathered or held by other departments/agencies	0 20	−0 06	0 92[a]	0 32	0 05
High cost of computer use	−0 03	0 24	0 54[a]	0 10	−0 18
Slow response of data processing to requests for information	0 08	0 11	0 20	0 35[a]	−0 03
Difficulty in getting priority in using the computer	0 14	0 30	0 04	0 67[a]	−0 10
Computer based data not available for the analysis of specific questions or problems	0 28	0 13	0 29	0 52[a]	0 23
In general, computers and data processing having failed to to live up to my expectations	0 21	−0 01	−0 13	0 33	0 71[a]
Within the next five years, computers will not greatly improve the operations of this government	−0 07	−0 01	−0 09	−0 21	0 56[a]
Variance explained (%)	33	14	11	10	8

Note· [a]These items represent a single factor