Organizational Adoption of Microcomputer Technology: The Role of Sector

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Microcomputer and work-station technology is the latest wave in computing technology to influence day-to-day operations in business and government organization. Does sector affect adoption of this new information technology? If so, how? Utilizing the data from a large comparative national survey of data processing organizations, this proposition was examined. The results confirm that after controlling for other factors such as organizational size, experience with computer technology, current investment in computer technology, procurement practices, and the task environment of the organization, the sector an organization operates within has a major differential effect on adoption of microcomputer technology. Public organizations have more microcomputers per employee, a result that is potentially due to a more information intensive task environment and the potential use of microcomputer technology as a side payment in lieu of salary. The latter factor derives from lower wage rates faced by public employees.

Microcomputers—Public sector—Adoption decisions—Diffusion—Public-Private companies—Organizational environment

1. Introduction

Computer technologies are being adopted and incorporated into nearly all organizations. Gantz (1986) found that computer terminals and word processors have reached the same per capita penetration level, in a few decades, as the telephone took to achieve in 75 years. Some (Gardner et al. 1989) have concluded that the adoption of computer-based terminals represents perhaps the most rapid diffusion of technology in history.

Not only are organizations of all sizes and shapes adopting computer technologies, but an important trend of the last decade has been the increasing adoption and diffusion of microcomputers or personal computers (*PCs*). According to the General Services Administration (*GSA*), all white-collar government employees would have an intelligent terminal or PC by 1990 (Paschke and Getter 1989). The Office of Technology Assessment (OTA) has predicted, "by the mid-1990s nearly every office

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will have at least one computer, just as nearly all offices now have telephones" (OTA 1985, p. 15).

Though computers, regardless of size, are fundamentally the same, the diffusion of microcomputers and work stations represents an important major departure from previous forms of computer technology. The most important characteristic is that smaller computers permit decentralized computing on a scale previously unanticipated. Such a shift has significant implications to information and computer management in organizations (King 1983). Another important characteristic of microcomputer technology that differentiates it from earlier computers, is that it comes in a smaller, cheaper and less complex "computer package," thus making it possible for individuals and smaller subunits of an organization to adopt.[1] Previously, decisions to obtain or modify organizational computing associated with mainframe or minicomputers required more centralized decision processes.

Why then, did some organizations more readily adopt this new form of computing? Did specific organizational characteristics lead to greater penetration of microcomputer technology? Of particular interest in this paper is whether public organizations or private organizations have embraced microcomputer technology more completely. The focus of this paper on the effect of sector is motivated by several concerns. First, there exists substantial theoretical and empirical literature to suggest that important differences in organizational environment and management are generated by sector. A large amount of work in public administration (Rainey et al. 1976; Bozeman 1987, 1988; Moe 1988; Coursey and Bozeman 1990) and growing literature in management (Fotler 1981, Perry and Rainey 1988, Schwenk 1990) has argued that business organizations face a different environment than government organizations leading to observable differences in organizational behavior and management. Some of these arguments have been applied to the management of computers in organizations (Bozeman and Bretschneider 1986), with some empirical validation (Monsour and Watson 1980, Bretschneider 1990).

A second argument for focusing on sectoral differences is that the existence of sectoral differences has not been readily acknowledged as an "important" issue by many management scholars, thus resulting in the need for further empirical evidence on the nature and extent of such differences (Bozeman and Bretschneider 1986). And finally, empirical existence of differences between sectors impacts the success of managerial prescriptions. At the very least, differences should require modification of many managerial prescriptions typically based on results from only one sector (Pearce et al. 1985).

The central issue addressed here is whether the difference in organizational environment faced by public and private entities results in different levels of penetration of microcomputer technology. If, after accounting for those factors considered to be the major contributors to organizational penetration of microcomputer technology, sector continues to be significant, then some revisions in our theories of organizational

[1] The concept of a "computer package" (Danziger et al. 1982) views the hardware, software, and human resources necessary to make a computer function as a unitary concept. This view is important because often the initial cost of hardware and software is only a fraction of the true cost of computing for an organization. The advent of the microcomputer dramatically reduced the total cost of the "computer package," and not just the hardware component.

innovation, as well as some revision in our prescriptions on how to promote innovation, will be necessary.

The next section develops a basic model for adoption of new microcomputer technology and formally presents a series of hypotheses including one on the effect of environment on the adoption process. Section three provides a brief discussion of the data, the data collection procedures, and the operational measures used to test the hypotheses. Results of estimating the model and interpretation of results are given in Section 4. Section 5 includes a discussion of several alternative explanations for observed sector differences. The paper concludes with a summary section including some implications of the results.

2. Adoption Model for Microcomputers: Some Hypotheses

The diffusion or contagion model (Rogers and Shoemaker 1971) is the typical starting point for studying innovation and diffusion of new technologies. This model is based on communications and contact between individual actors in a fixed population and has been successfully applied to a wide array of organizational and MIS adoption processes (Zaltman 1973, Zmud 1982, El Sawy 1985, Huff and Munro 1985, Lee 1986, Raho et al. 1987, Munro et al. 1987). Although typically operating at an aggregate level, this model focuses attention on cumulative adoptions over time, and has also been the basis of differentiating why some individuals and organizations adopt early and others later.

An alternative to examining the cumulative process of diffusion over time is to focus attention on the level of penetration for a particular innovation at a point in time. Differential levels of adoption in a cross-section can then be explained by characteristics of the innovation, the environment and the organization, with various factors acting as either facilitators or inhibitors to the adoption process (Feller 1980, Huff and Munro 1985, Lind et al. 1989). Since microcomputer technology is often acquired by multiple, independent, individual decision making within the organization, this approach links environmental and organizational factors to the atmosphere in which these individual decisions are being made. Consequently, the model explains aggregate adoption—the sum total of the individual decisions within the organization—in terms of the facilitating and inhibiting characteristics of the innovations, organization and environment.

Since the central question of interest in this paper is whether public and private organizations have reacted to microcomputer technology differently, this section of the paper will develop a 'standard' model of the adoption decision as a form of control within the context of a passive observational study. Penetration rates are the outcome from the quasiexperiment and sector acts as the treatment condition (Cook and Campbell 1979).

General Influences

One important *environmental factor* affecting adoption is the market. Taking an economic market perspective, microcomputer technology represents the newest wave of information technology, a version of computing technology which has a clear price advantage over early forms of information technology. Microcomputers are low-cost substitutes for larger, existing organizational computing systems. This is particularly true when looking at interactive minicomputer systems adopted in the 1970s. This suggests that the more heavily invested an organization is in minicomputers and older forms of interactive information technology, the less likely it is to adopt microcomputers. At the same time, microcomputers can be networked with large centralized computers to enhance the productivity of both systems. This suggests that the presence of networking and large centralized computers could act in a complementary fashion, enhancing the desirability of purchasing microcomputers. Application of this market approach suggests several hypotheses:

(1) *The more existing organizational information technology is substitutable for microcomputer technology, the slower will be the diffusion of microcomputers.*

(2) *The more existing organizational information technology is complementary to microcomputer technology, the faster will be the diffusion of microcomputers.*

The use of the market perspective is valuable because it integrates environmental factors with characteristics of the innovation. At the same time, specific characteristics of the organization affect the willingness of the organization to obtain microcomputers (Lind et al. 1989). We can divide *organizational variables* into facilitator and inhibitor factors. For example, prior experience with information technology generates capacity within the organization to deal with newer forms of the technology. Consequently, we expect organizations with greater experience working with computer technology to be more likely to adopt newer forms of the technology. Thus,

(3) *As an organization obtains more experience with information technology, the more likely it is to adopt newer forms of the technology.*

Another organizational facilitator is the presence of appropriate forms of slack resources. As an organization makes large commitments of resources to computing, it is more likely to have slack computing resources (e.g., human resources). These slack resources may be committed to manage the integration of new information technologies and in some sense could be viewed as a necessary prerequisite to adopting microcomputers. The absence of such resources makes adoption of new information technology more difficult. Thus,

(4) *As organizations commit larger amounts of resources to computing in general, they generate slack capacity that enhances the potential for managing the adoption of new computer technologies.*

Internal organizational procedures can also constrain or facilitate the ability of an organization to adopt new information technologies. In particular, bureaucracy and internal red tape can slow down the diffusion of new technologies into an organization. Procurement rules directly reflect the degree to which an organization will face procedural constraints. Consequently,

(5) *The greater the extent of red tape involved in procurement, the less likely an organization is to incorporate new information technologies.*

Influence of Sector

The general influences discussed above are fairly standard factors associated with innovation and adoption. Though important, they must be viewed as a background or series of control variables to the more central issue, the role of sector.

Government and business organizations operate in distinct settings. As suggested in the introduction above, there is both theoretical (Wolf 1988) and empirical evidence that government organizations are different from business organizations. Several major studies funded by the National Science Foundation in the 1970s began from the premise that public organizations tended to be less innovative than private firms for a variety of reasons, such as the monopolistic character of public sector provided services, "perverse" incentive systems among public organizations, accountability to a highly diverse set of clients, and strong civil service rules and unions (Feller 1980, Eveland et al. 1977, Feller and Menzel 1977, Feller et al. 1974, Hayes 1972, Lambright et al. 1975). Though none of these original studies tested this proposition or were comparative in design, this perspective has left its mark on current views of innovation in public organizations.

Some empirical studies have specifically examined factors affecting rates of adoption of computer technology by government organizations. Such factors have included the size of an organization's information-processing environment (Norris and Webb 1983) and the degree of governmental professionalism (Danzinger and Kraemer 1986). The influence of both of these factors was supported in a study of a sample of local government units in Georgia (Brundney 1988). These findings, while useful and helpful in building our knowledge base about adoption, are limited to the extent that they have focused only on local governments. Moreover, success of implementing computing in organizations has been found to be most correlated with an organization's commitment to advanced technology (Kraemer et al. 1981, Kraemer and King 1986). All of the above studies, though, suffer from their inability to make cross-sector comparisons.

The general factors developed above in hypotheses 1–5 capture the essential factors found to influence adoption of computer technology in government as well as those in business. The question remains, after controlling for these influences, will governments behave differently than businesses? Many of the factors, such as extent of slack resources and bureaucracy, that might normally differentiate government from business have been accounted for, so what remains to suggest differences would occur? Taking the perspective that the major distinctions are captured we can generate a classic example of a null hypothesis:

(6) *There are no significant differences between public and private organizations with respect to adoption of new information technology after controlling for existing organizational computing, experience with computing, slack resources and level of bureaucracy.*

An important caveat associated with any study including a cross-section of governments, particularly state government organizations, is that differences across states due to government structures, laws and geography must be accounted for. Clearly organizations operating in Nevada and New York are affected by the differences associated with different state laws. This is likely true for private organizations as well when considering the effect of differential taxes and access to resources represented by geography. Consequently, the analysis presented here also includes a control for location.

3. Data

Previous empirical work regarding computers in government has focused on either local government (Kraemer et al. 1981) or the federal government (Caudle 1988). Typically this work has not systematically compared public and private organizations, though sometimes conclusions are drawn from empirical work that has focused primarily on private organizations. This study differs and expands upon previous research in two important ways: (1) a stratified sampling design was used to collect data from both public and private organizations, and (2) the public organization subsample was drawn exclusively from state government agencies. The basic unit of analysis was the organization, though the survey was directed at the data processing director.

Data Collection

The sample of public data processing organizations was obtained as a part of the National Study of Information Resources Management in State Government (Caudle et al. 1989). This study was completed in association with National Association of State Information Systems, Inc. (NASIS). NASIS representatives in each state were asked to provide a list of data processing managers. A final list representing over 40 states was compiled. To insure maximum representation and to improve the coverage for states that had provided only fragmentary lists, additional names were gleaned from various published directories. The final result was a sampling frame containing 1,361 data processing managers in state government.

The Directory of Top Computer Executives was used to develop the sampling frame for private organizations. The two-volume directory contains information on data processing units for over 10,000 public and private organizations nationwide. A random sample of 1,395 private organizations was selected from the directory. This sample was not stratified by state but rather by type and function of the organization: manufacturing and services, banking, diversified financial, insurance, retail, transportation and utilities.

Separate, but overlapping, survey instruments were developed for the two sampling frames.[2] Both instruments were pretested,[3] and the results of the pretest were incorporated into a final survey instrument. As part of the survey process, all individuals in both sample frames were sent alert letters. One week later, the first wave of the survey was sent, including a reminder letter. After three weeks, a second and final mailing was sent to all nonrespondents, which included a reminder letter and a second copy of the survey.

During the six-week period between mailing the alert letters and two weeks following the second mailing, a large number of phone calls was received about the survey. All calls were routed to the survey director in order to ensure consistency in responses. One of the most frequent concerns expressed was whether there was a deadline for responses. In order to maximize response rate, no deadline for responses was

[2] Over a period of three months initial drafts of both surveys were produced. The following steps were used in developing the initial instruments: (1) literature review of MIS, IRM and Public Administration Research; (2) review of previous surveys conducted on MIS and IRM practices in government; and (3) review of survey research literature.

The actual integration of the information into survey instruments was accomplished by an iterative process of drafting a version, passing out copies of the draft for written comments, followed by group meetings to discuss changes and additions. The final draft was reviewed by experts in MIS, IRM, and survey research from both the School of Information Studies and the Maxwell School's Technology and Information Policy Program.

[3] A random sample of 100 managers was drawn from each of the two mailing lists in order to conduct a pretest survey. The pretest consisted of an alert letter sent one week before the initial mailing of the surveys. A single follow-up mailing to all nonrespondents was done three weeks after the first mailing. The second mailing included copies of the survey instruments. The pretest was useful in identifying problems with question wording and survey length. The pretest results also highlighted the need for mostly closed-ended questions in the survey.

indicated to any callers. Other phone inquiries included questions about who was the most appropriate individual to complete the survey and whether it was appropriate for the particular agency or company to respond when only a few microcomputers were currently being used. In all cases callers were encouraged to respond to the surveys, regardless of the level of computer activity within their respective agency or firm.

Overall, 1,005 surveys were received for a total response rate of 36%. The breakdown by strata include 622 usable public sector surveys for a response rate of 44.5%, and 383 private sector surveys for a response rate of 27%. There were no statistically significant differences in response rates between the pretest and the final survey. The samples generated were sufficiently large to permit statistical analysis, although the low response rates suggest potential problems of selection bias.[4]

A Formal Model

One model for organizational adoption of microcomputers considers existing investment in computer technology coupled with the view that microcomputers are a less expensive alternative to existing forms of organizational computing. The extent of previous experience with computing, slack resources and the extent of bureaucracy and red tape reflect organizational factors which also affect adoption. Given these variables, we hypothesize that no differences due to sector should then emerge. Finally, all of the variables identified will also interact with the overall size of the organizations (DeLeon 1981).

Thus the basic model considered for explaining differential levels of microcomputers between organizations is

$$\text{micros} = f(\text{investment, experience, slack resources, bureaucracy/red tape, size, sector, state}).$$

To control for the effects of size, all variables were analyzed in per capita terms using the number of full-time equivalent personnel in the agency or company.

Three dependent variables were defined: the number of stand-alone microcomputers per employee (DIFUSE1), the number of networked microcomputers per employee (DIFUSE2) and the number of all microcomputers per employee (DIFUSE3). Though significant variance is possible in terms of capacity and use across microcomputers, access is necessary for use. Consequently, the number of microcomputers per employee reflects the penetration of this form of information technology into the organization and potential access to this technology. Both penetration of and access to microcomputers should be directly related to use. Table 1 provides summary information about the distribution of the dependent variables. Note that a significant number of organizations indicated no microcomputer and all three of the

[4] Several forms of analysis were used to test for selection bias. The geographic distribution of the public sample by state did not represent the same geographic distribution found in the sample frame. This was not deemed a significant problem given that the above hypotheses are independent of geographic distribution. The private sample was compared with its sampling frame in terms of both geographic distribution and distribution of type of business. No differences were identified between the two.

More sophisticated approaches to identification and modeling of selection were attempted using the Heckman procedure (Judge et al. 1985, 779–785). Unfortunately, little information beyond geographic distribution and function was available for nonrespondents, dramatically limiting the efficacy of these approaches. No significant evidence of selection was found when applying these approaches.

TABLE 1

Descriptive Analysis of Dependent Variables Organizational Penetration of Microcomputer Technology (Computers per Employee)

Stand-alone Microcomputers		Networked Microcomputers		Total Microcomputers	
Number of Cases	Percent of Zeros	Number of Cases	Percent of Zeros	Number Zero	Percent of Zeros
829	205 (24.1%)	829	407 (49.1%)	829	122 (14.7%)

Distribution of Nonzero Cases

DIFUSE 1 Midpoint		Freq.	Cum. Freq.	DIFUSE 2 Midpoint	Freq.	Cum. Freq.	DIFUSE 3 Midpoint	Freq.	Cum. Freq.
0.05	*********************	426	426	****************	311	311	********************	408	408
0.10	***	58	484	*	15	326	***	57	465
0.15	**	34	518	*	15	341	**	37	502
0.20	*	19	537	*	14	355	*	26	528
0.25	*	15	552		9	364	**	31	559
0.30	*	13	565	*	10	374	*	18	577
0.35	*	14	579		7	381	*	23	600
0.40		4	583		3	384	*	20	620
0.45		8	591		4	388	*	15	635
0.50		5	596		5	393	*	11	646
0.55		5	601		4	397	*	11	657
0.60		5	606		5	402		9	666
0.65		2	608		0	402		2	668
0.70		1	609		2	404		2	670
0.75		2	611		5	409		7	677
0.80		2	613		3	412		6	683
0.85		1	614		0	412		2	685
0.90		7	621		4	416		9	694
0.95		1	622		2	418		5	699
1.00		0	622		2	420		3	702
1.50		1	623		0	420		2	704
2.00		1	624		0	420		1	705
2.50		0	624		0	420		0	705
3.00		0	624		2	422		2	707
	100 200 300 400 Frequency			100 200 300 Frequency			100 200 300 400 Frequency		

distributions were highly skewed. One small organization in Texas reported a large number of networked microcomputers: the number of micros per employee was over eight. Subsequent analysis demonstrated that this case had an undue influence on the results and was removed as an outlier. Sensitivity analysis—including and deleting other observations reporting more than one micro per employee—had no effect on the results, so they were left in the sample.

Current investment in computer technology was measured by the number of mainframes, both internally or externally available to the agency or firm (BASE1), and the number of stand alone and networked minicomputers available, either internally or externally to the organization (BASE2). These variables are expected to reflect various complex economic incentives both accelerating and decelerating the process of penetration.

Experience with computing was defined by the number of years the organization has had a computer (TTIME). The level of resources committed to computing was measured by the number of full-time equivalent data processing personnel (DP). Personnel reflect resource commitments, more than hardware and software, which tend to be one-time expenses. The more data processing staff, the greater the likelihood of slack computing resources. Thus this variable is the measure of slack computing resources within the organization.

Measures of bureaucracy and red tape focused on the organization's internal procurement process. The variables were measured in terms of estimates of the number of weeks between a data processing manager's purchase request and completion of the purchase. These procurement process variables included purchase requests for low-priced equipment, costing under $1,000 (LOW), and equipment costing more than $1,000 (HIGH). Though generally delays in procurement process should inhibit adoption, longer delays for higher-priced equipment could create incentives towards obtaining microcomputers because of their lower costs. It is also likely that the effects of such time delays will have nonconstant returns so that both a linear and quadratic term for each is present in the model.

The variable representing sector was operationalized as a binary variable with a value of one for governmental agencies and zero for businesses (PUBLIC). The sample represents 45 different states, so that a series of 44 binary variables are included within the model to account for the effect of location. Appendix 1 summarizes the definitions for all these variables.

4. Results and Discussion

Many of the organizations responding to the survey indicated they did not have any stand-alone or networked microcomputers.[5] The value for the dependent variable in such cases is zero, which results in a censoring or a truncation of the distribution for the dependent variable (Judge et al. 1985). Assuming a linear relationship between the independent and dependent variables in the presence of a censoring or truncation problem, application of ordinary least-squares estimation results in biased and inconsistent estimates. Consequently, both ordinary least-squares estimation of the linear model and maximum likelihood estimation of a tobit model (Judge et al. 1985) were applied to the data. The results are presented in Table 2. Although the

[5] For stand-alone microcomputers there were 205 organizations reporting zero, and for networked microcomputers 409 indicated zero. When considering the sum of stand-alone and networked microcomputers, only 172 respondents indicated no microcomputers.

TABLE 2

Linear and Tobit Regression Coefficients for Diffusion of Stand-alone, Networked and Stand-alone plus Networked Microcomputers Model

Variable	Linear Model			Tobit Model		
	Stand-alone	Networked	Both	Stand-alone	Networked	Both
PUBLIC	0.0743***	0.0826***	0.1569***	0.1028***	0.1483***	0.1945***
STATE#	0.0000**	0.0000	0.0000***	0.0000	0.0000	0.000*
HIGH	0.0510	−0.0445	0.0065	0.0412	0.4539	0.1928*
HIGH2	−0.0021	0.0024**	0.0003	−0.0013	−0.9637**	0.0027
LOW	0.0776	0.2184	0.2960	0.0535	1.5583***	0.3101
LOW2	−0.0192	−0.0726**	−0.0917**	−0.0120	−1.5357**	−0.0901*
DP	0.1180***	0.2732***	0.3912***	0.1214**	0.3997***	0.3961***
TTIME	0.1106**	−0.0575	0.0530	0.1103*	−0.4290***	0.0425
BASE1	1.2565***	0.6014**	1.8579***	1.3818***	0.3766	5.0609***
BASE2	−0.0697	−0.0401	−0.1098*	−0.1466**	−0.2176	−0.1927**
RMSE	0.178	0.197	0.245			
F-STAT.	4.852***	2.920***	7.258***			
ADJ. *R*2	0.197	0.110	0.286			
SAMPLE 829	829	829	829	829	829	829
LOG-LIKELIHOOD				−55.3	−281.0	−150.2

* Statistically significant at the 10% level.

** Statistically significant at the 5% level.

**** Statistically significant at the 1% level.

\# State effect is based on the use of 44 separate dummy variables. Aggregate effects tested based on change in the log-likelihood function for Tobit Model with and without dummy variables. Standard *F*-test used for Linear Model.

overall results from both forms of estimation are similar, particularly when considering the total number of microcomputers, there are some interesting differences. The principal difference is that application of the tobit model suggests that the influence of bureaucracy and red tape are incorrectly estimated in the OLS version of the network model only. Interpretation of the coefficients from a tobit model are more difficult (see Judge et al. 1985, 783–784), so we will focus primarily on the significance and direction of effects.

The *existing investment* in computer technology (BASE1 and BASE2) has both a positive and a negative effect on adoption. The signs of the coefficients are consistent with the view that existing interactive (minicomputer) technology (BASE2) would be viewed as a substitute good and therefore inhibit diffusion, while highly centralized mainframe computers (BASE1) would act as complementary goods. When considering the adoption of stand-alone microcomputers, the negative effect of minicomputers is significant, while in considering networked microcomputers, neither effect is significant.

Stand-alone microcomputers do not directly compete with main-frames and have a potential complementarity with large computers. This complementarity is reflected in the significant positive relationship between BASE1 and the penetration of stand-alone microcomputers. Minicomputer technology, on the other hand, tends to be newer and more interactive. Smaller than traditional mainframe computers, minicomputers are also more likely to be dispersed, either as a physical system or through telecommunications and time-sharing operating systems. All of these characteristics tend to make minicomputers a substitute good for microcomputer technology. A substitute good (minicomputers) already in place within the organization will tend to retard the adoption of the newer technology (microcomputers). This is probably also fueled by desires on the part of the organization to recapture capital outlays associated with purchasing these newer computers. Despite the view of economists that "sunk costs" are forever sunk, most organizations are extremely reluctant to obtain new equipment when older systems are still viewed as functional. The direction of these relationships are consistent in all three models, though not significant for networked microcomputers.

The *experience variable* (TTIME) affects aggregate adoption of stand-alone computers in a positive fashion but negatively influences adoption of networked micros. This suggests an interactive relationship between experience and computer technology. This should come as no surprise given the historical effects associated with adoption of different waves of technology. Organizations which began using computing during the 1960s will reflect the experience of the large IBM-style mainframe systems, while those beginning in the 1970s will reflect more interactive minicomputer technology. Again, higher levels of existing investments in a technology viewed as both serviceable and a substitute are more likely to hinder adoption and penetration of microcomputers.

The measure of *slack computing resources* (DP) has a positive effect on the adoption of microcomputers. This indicates that those organizations having more slack resources exhibit greater penetration of microcomputer technology. When considering both stand-alone and networked microcomputers together, this factor is statistically significant in both the tobit and OLS versions of the model.

Procurement policy/bureaucracy seems to inhibit diffusion. Both OLS and tobit estimation generates net negative effects indicating that as the time it takes to process a purchase increases the level of penetration declines. This was true for both low and high-priced equipment. Apparently, the $1,000 break between low-priced and high-priced equipment was not sufficient to generate a differential effect. Given that even the most basic microcomputer unit cost more than $1,000 this seems reasonable. Any delay in procurement acts as a barrier. Low price acquisition is potentially a greater barrier since this reflects support costs such as service contracts, and supplies like computer paper and printer ribbons, and diskettes.

The variable *state* which controls for location has some limited value in explanation. It is significant at the 10% level in the overall model.

Regardless of the form of estimation for the model, the effect of *sector* is consistently positive and statistically significant ($p < 0.01$), with typically the highest level of significance of all the variables.[6] This strongly suggests that public organizations have experienced greater adoption and diffusion of microcomputer technology than private organizations. Since the major focus of this paper is sector differences, these are important results. Having demonstrated an empirical difference, explaining these results, though, may not be as easy. There are potentially many, both competing and complementary explanations for these significant differences.

Three possible explanations are: (1) government organizations deal with a task environment which is more information intensive than business organizations, thus requiring larger investments in information systems technology; (2) governments made lower initial investments in computer technology than businesses, thus creating a greater initial demand for the cheaper substitute form of information technology once it became available; or (3) other, nontask or market-related differences due to sector created different responses to microcomputer technology. Each of these explanations is considered further.

5. Explaining Sector Differences

Governments are More Information Intensive than Businesses

The level of information technology adopted is expected to be affected by the nature of the principal tasks and mission of the organization. Cooper and Zmud (1990) have proposed a model in which information technology adoption is a function of the compatibility of task and technology characteristics. In order to consider the effect of organizational mission and technology on the penetration of microcomputers, we disaggregated the sector variable into a categorical variable with 15 different levels, one for each business and agency function (*Business:* Manufacturing and Services, Banking and Financial Services, Insurance, Utilities, Retail and Others; *Government:* Health, Education, Commerce and Regulation, Criminal Justice, Transportation, Environment, Human Services, Employment Services, and Support Services). The differences in function provide a mean of differentiating task environment for the organization.

The categories were unique to sector; consequently, the data are organized into a nested design, where function is nested within sector (Neter et al. 1985).[7] Using the linear model and OLS estimation, the 15-level functional variable was nested within

[6] The p-value can be used to indicate relative importance of a variable in a multiple-regression model, in the same way standardized coefficients, elasticities and t-statistics do.

[7] In terms of experimental design the two variables SECTOR and FUNCTION are perfectly collinear, thus a nested model requires that the higher-level variable, PUBLIC, be modeled as a main effect, and FUNCTION be handled as an interaction with PUBLIC, but having no main effect terms of its own.

TABLE 3

Linear Model Including Functional Breakdown, Nested Within Public-Private Difference (F-Statistic, P-Value)

	Stand-alone		Networked		Both	
	F-Stat	*P*-Value	*F*-Stat	*P*-Value	*F*-Stat	*P*-Value
PUBLIC	27.08	0.0001	19.02	0.0001	54.21	0.0001
FUNCTION (PUBLIC)	1.02	0.4330	1.43	0.1379	1.67	0.0637
STATE	1.45	0.0315	1.27	0.1180	2.45	0.0001
HIGH	0.55	0.4593	0.73	0.3933	0.02	0.8774
HIGH2	0.23	0.6327	0.55	0.4586	0.06	0.7993
LOW	0.36	0.5492	3.04	0.0815	3.46	0.0632
LOW2	0.48	0.4876	5.31	0.0215	5.69	0.0173
DP	4.91	0.0270	27.95	0.0001	35.16	0.0001
TTIME	5.19	0.0229	1.05	0.3069	0.70	0.4041
BASE1	22.79	0.0001	2.29	0.1308	22.34	0.0001
BASE2	1.37	0.2414	0.66	0.4181	2.31	0.1293
Quadratic LOW*	0.30	0.5871	2.27	0.1326	2.64	0.1047
Quadratic HIGH*	0.57	0.4508	0.74	0.3904	0.02	0.8823
RMSE	0.176		0.197		0.241	
F-STAT	4.090		2.590		6.220	
$R2$	0.266		0.186		0.355	
ADJ. $R2$	0.201		0.114		0.298	
SAMPLE	825		825		825	

* These *F*-Statistics test the hypothesis that both linear and quadratic terms associated with HIGH and LOW are simultaneously significant.

the sector variable. Since we wish to focus attention on the effect of function as nested within sector, many of the statistics flow from the linear model applying OLS estimation. Therefore, the results must be viewed as exploratory, given the censoring problem in the original data. Table 3 summarizes the results for estimating the revised model. Functional differences are significant to adoption in the overall model at the 10% level, but they add only marginally to the explanatory power of the model. Even after adding function as an additional control to the basic model, the sector effects continue to be the strongest factor effecting adoption.

Table 4 presents the results of calculating conditional mean adoption rates from each model's fitted values using the mean values for each independent variable (Neter et al. 1985). These conditional means are organized by subgroup within PUBLIC and FUNCTION and sorted by magnitude. The mean number of microcomputers per employees, after controlling for the other independent variables in the model, is consistently higher for all of the government subgroups. The groupings strongly suggest that government agencies tend to behave similarly to each other but differently from businesses.

It is interesting to note that the types of business activities that are traditionally viewed as information intensive (finance and insurance) are the highest among the business groupings. The group designated "other" is a residual class, but tends to be dominated by firms which are in some way associated with computers, telecommunications and information services. Based on this exploratory comparison of condi-

TABLE 4

Analysis of Conditional Means of Dependent Variable by Sector and Function (Each Variable Is Sorted by Magnitude)

Stand-alone Microcomputers				Networked Microcomputers			Total Microcomputers		
Level of Function	Level of Public	*N*	Mean	Level of Function	Level of Public	Mean	Level of Function	Level of Public	Mean
Retail	Private	23	0.00474934	Retail	Private	0.00207972	Retail	Private	0.00682907
Utilities	Private	63	0.01605641	Manufacturing	Private	0.00254124	Utilities	Private	0.02691177
Manufacturing	Private	35	0.02482565	Banking/finance	Private	0.00596100	Manufacturing	Private	0.02736688
Insurance	Private	53	0.03976161	Utilities	Private	0.01085536	Banking/finance	Private	0.05015461
Other business	Private	43	0.04331031	Insurance	Private	0.02196549	Insurance	Private	0.06172710
Banking/finance	Private	80	0.04419360	Other business	Private	0.02335715	Other business	Private	0.06666747
Transportation	Public	41	0.10216586	Human services	Public	0.05469236	Employment	Public	0.17500939
Employment	Public	47	0.10835222	Environment	Public	0.06089638	Human services	Public	0.17560889
Criminal justice	Public	91	0.11218820	Transportation	Public	0.06169403	Environment	Public	0.20074279
Human services	Public	52	0.12091653	Employment	Public	0.06665717	Support services	Public	0.24103686
Support services	Public	77	0.12932621	Health	Public	0.08230822	Health	Public	0.27310975
Environment	Public	55	0.13984641	Support services	Public	0.011171066	Criminal justice	Public	0.27444940
Commerce/regulat	Public	97	0.17561535	Commerce/regulat	Public	0.13344451	Commerce/regulat	Public	0.30905986
Education	Public	32	0.18960242	Education	Public	0.15550965	Education	Public	0.34511207
Health	Public	35	0.19080154	Criminal justice	Public	0.16226121	Transportation	Public	0.16385989

tional means, the groups of information-intensive business firms are grouped closest to government agencies. This suggests that some of the differences between public and private organizations may be related to the nature of organizational mission. Business firms that are information intensive have patterns of microcomputer adoption more like governmental agencies than less information-intensive business organizations.

Governments Were Underinvested in Computer Technology

If government units had systematically underinvested in computer technology, then the advent of the microcomputer would generate an opportunity for these organizations to enhance their level of computer technology and at a much lower cost. Essentially, this argument is one of suppressed demand. Historic underinvestment could provide a strong motivation to rapidly obtain microcomputer systems.

Though our model includes current level of investment in older forms of computer technology, the initial levels could be systematically biased. Table 5 presents the group means for the computer-investment variables based on the linear model presented in Table 3. These results demonstrate that this sample of businesses tends to have smaller existing investments per employee in mainframe computers, suggesting that government had not underinvested in older computer technology. Government may have overinvested in information technology relative to businesses.

This comparison is limited since the variables only count the number of central processing units (cpu) and not the actual capacity of those units to carry out various operations. Unlike microcomputers, the variance across mainframe and minicomputer cpu is large. This comparison also suffers from being a post-hoc review of investment after six years of purchasing microcomputer technology. The actual investment pattern in 1981 and 1982, when microcomputer technology became widely available, could have been quite different. Nevertheless, the comparison suggests that historical underinvestment in older forms of computer technology is not likely to have been a major contributor to the differences in diffusion patterns between public and private organizations.

This result suggests that sector differences associated with rapid adoption of microcomputers may not be limited to only microcomputers. The higher levels of older technology could in fact suggest that sector differences have led to more rapid and deeper penetration of computer technology in government for each wave of technology. It even suggests that governments overinvest in computer technology relative to business.

Nontask Related Sectoral Differences

Clearly, the nature of organizational technology or task environment is important. The extent to which an organization's task environment is information intensive does affect the extent to which that organization will embrace new information technologies. Government organizations, particularly state government agencies which lie between the federal government and local governments, are likely to act as information conduits and thus have information-intensive task environments. Economic theory (Wolf 1988) suggests that certain functions are better performed by government than markets, particularly if positive external benefits are possible. Government as an information repository is one possible example of this. In the way government investment in transportation networks to facilitate industrial development in

TABLE 5

Means for Existing Investments in Mainframe and Minicomputer (Computer per Employee)

Level of Function	Level of Public	*N*	BASE1 Mean
	Mainframes Computers		
Retail	Private	23	0.00057609
Manufacturing	Private	35	0.00170096
Utilities	Private	63	0.00171102
Insurance	Private	53	0.00308562
Banking/finance	Private	80	0.00468535
Other business	Private	43	0.00570132
Human services	Public	52	0.00596651
Health	Public	35	0.00752454
Transportation	Public	41	0.01014521
Commerce/regulation	Public	97	0.01060422
Employment	Public	47	0.01219436
Environment	Public	55	0.01291052
Support services	Public	77	0.01567440
Education	Public	32	0.01647890
Criminal justice	Public	91	0.01995463
	Minicomputers		
Human services	Public	52	0.00783502
Environment	Public	55	0.00783516
Utilities	Private	23	0.01124873
Retail	Private	23	0.01124783
Insurance	Private	53	0.01316259
Manufacturing	Private	35	0.02097514
Education	Public	32	0.02201589
Commerce/regulation	Public	97	0.02248614
Health	Public	35	0.03265312
Other business	Private	43	0.03966110
Employment	Public	47	0.04968085
Banking/finance	Private	80	0.07284306
Support services	Public	77	0.18150973
Transportation	Public	41	0.28802885
Criminal justice	Public	91	0.30153066

the last 100 years, current government investment in information networks and data repositories are facilitating economic activity today. Government provision of these services provides positive external benefits beyond simply providing them through the private markets, thus suggesting that governments are more information intensive.

Nevertheless, the extent of differences between government and business organizations with regard to the adoption of microcomputer technology cannot be completely explained by the information intensity of the task environment. We have also noted that government organizations in our sample had higher levels of investment in older forms of computer technology. While useful in discounting a suppressed demand hypothesis for sector differences, the different patterns in adoption of older forms of information technology suggest that these differences are not necessarily only evident in adoption of microcomputer technology.

An additional explanation for public sector "innovativeness" is that differences due to sector create different environments requiring different managerial responses. Bretschneider (1990), for example, suggests that government's greater reliance on noneconomic criteria for purchasing hardware and software reflects these differences. Some specific differences are that government managers face more constraints to action, such as greater red tape and more levels of oversight. Consistent wage-rate differentials between government and business organizations also exist, particularly in the computer field (Ludlum 1990).[8]

One effect of these additional constraints is that nonmonetary rewards are often provided as side payment and amenities in public organizations. Microcomputers could be used as such side payments, especially given they are low priced one-shot items. This type of nontask related difference could also help explain the disparity between public and private adoption of microcomputers.

6. Conclusions

Three separate issues are addressed in our conclusions; the extent to which these results suggest modifications in the theory of innovation and adoption, particularly with regard to information technology; how such modifications impact current practices of information systems management; and directions for future research the empirical results suggest.

Theory

This paper has investigated the diffusion process for microcomputer technology in both government and business organizations. The results strongly suggest that government agencies have invested more heavily in microcomputer technology than business organizations. These results have at least partially controlled for the differential effects of organizational size, procurement process, existing investments in computer technology and experience with computer technology. Several alternative explanations of this result were considered, including the degree of information intensity associated with organizational mission, levels of prior investment in earlier forms of computer technology and differences due to nontask effects of sectoral differences.

As other researchers have suggested, the study of innovation and adoption for information systems technology requires consideration of both organizational environment (Bretschneider 1990) and task environment (Cooper and Zmud 1990). Both macro and micro factors heavily influence individual and aggregate adoption decision making. These results also suggest that nontraditional market factors such as side payments in public organization can also be powerful motivators for adoption. This further suggests that we may have to reorient our view of public organizations with regard to their ability and willingness to adopt new information technology. It is not necessarily the case, however, that innovativeness results in any operational efficiency, especially if the new technology is being used primarily as a side-payment to employees.

[8] This article reports on an industry-wide annual salary survey, based on 1,500 respondents. This, like most large scale salary surveys of data processing professionals, demonstrates that government and education have the lowest average salaries. This is most pronounced when looking at higher level jobs.

Practice

Empirical demonstration of sectoral differences for information management has important implications for the practice of information systems management, particularly in government. Typically, research focused on generic models lead to prescriptions of a generic nature. The failure to recognize sectoral effects have lead to generic solutions in other settings, usually with catastrophic results.[9] These results suggest that at least for information systems management, there may be some reason why government can not be run exactly like a business. Lower wage rates may lead to the use of low-cost end-user computer technology as a side-payment while differences in task environment may push government IS managers toward early adoption of new technologies.

Future Research

The results of this study suggest several important research issues. If government organizations are more information intensive this may suggest that government has some special roles to play in terms of building information infrastructure in the next decade. The earlier development of NSF net and current development of the National Research and Educational Network (NREN) illustrate how the federal government has viewed such activity as generating positive economic external benefits beyond those possible solely from private investment. But beyond the network infrastructure, governments at all levels have traditionally been the major repositories of information about society, such as census and vital statistics data. This is a fertile area for both positive and normative theory development and testing. What is and what should be the role of government, generally and specifically by agency, with regard to the collection, storage and access of data as a resource for themselves and as a part of a societal information infrastructure?

Another important direction suggested by this work is to focus attention on the independent and interactive effects of organizational environment and task environment on management of information technology. It is interesting to note that over 10 years ago, Ives et al. (1980) identified organizational environment as a relevant dimension for studying MIS but found very few dissertations incorporating environmental variables in their studies. A cursory review of the major IS journals today suggest that things have not changed much. The results here not only suggest that differences in environment are important in managing the adoption of new information technology, but that it may be one of the most important factors. This is clearly an issue for future research.*

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[9] US Federal Government Civil Service reforms of the early 1980s were based on standard prescriptions of motivation theory and market incentives found in business. Many researchers feel the net effect of those reforms were negative because they did not take into account significant differences in why people 'selected' public service careers and how politics influences personnel decisions in government (Pearce et al. 1985).

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Appendix 1

Definition of Variables

Mainframe Computers	
Available Within the Organization	INCPU1
Available External to the Organization	OUTCPU1
Stand-alone Minicomputers	
Available Within the Organization	INCPU2
Available External to the Organization	OUTCPU2
Networked Minicomputers	
Available Within the Organization	INCPU3
Available External to the Organization	OUTCPU3
Stand-alone Microcomputers	
Available Within the Organization	INCPU4
Available External to the Organization	OUTCPU4
Networked Microcomputers	
Available Within the Organization	INCPU5
Available External to the Organization	OUTCPU5
Total number of FTE employees	PERSONT
Procurement/Bureaucracy/Red Tape	
Number of weeks to obtain high-priced equipment (over $1,000)	BUYHIGH
HIGH = BUYHIGH/PERSONT	
HIGH2 = HIGH × HIGH	
Number of weeks to obtain low-priced equipment (over $1,000)	BUYLOW
LOW = BUYLOW/PERSONT	
LOW2 = LOW × LOW	
Experience	
Number of FTE data processing staff	PERSOND
DP = PERSOND/PERSONT	
Number of years have had computer	TIME
TTIME = TIME/PERSONT	
If government variable equals 1 otherwise variable equals 0	PUBLIC
Diffusion Variables	
DIFUSE1 = (INCPU4)/PERSONT	
DIFUSE2 = (INCPU5)/PERSONT	
DIFUSE3 = DIFUSE1 + DIFUSE2	
Investment Variable	
BASE1 = (INCPU1+OUTCPU1)/PERSONT	
BASE2 = (INCPU2+INCPU3+OUTCPU2+OUTCPU3)/PERSONT	
Location/State	
44 Separate binary variables to represent 45 different states	

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