MAINFRAME AND PC COMPUTING IN AMERICAN CITIES: MYTHS AND REALITIES

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Both elected officials and professional managers in local governments believe in the value of computers, especially personal computers, to their own work and the work of government. Various academic studies, including the present work, have demonstrated this belief over the years (e.g., Dutton and Kraemer, 1979; Perry and Kraemer, 1980; and Norris, 1989 and 1992). Yet, policy-makers are continually confronted with claims about computing that they find difficult to assess and that occasionally defy rationality. For example, within recent memory it has been claimed that privatization or outsourcing would take the computing problem off the hands of local officials at less cost and that geographic information systems would enable officials to make Solomon-like judgements about such important matters as land use planning (e.g., Richter, 1991; Loh and Venkatraman, 1992; Public Technology Incorporated, 1991). More recent claims are that client-server computing is the new low-cost way to governmental automation (Gagliardi, 1994) and that desktop computers are the means to increase employee productivity and to empower workers to deliver better services to citizens (Greisemer, 1983 and 1984).

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omissions on this analysis.

One of the most persistent claims, which has at least a decade of history, is that the personal computer (PC) can effectively replace larger central computer systems in local governments (i.e., mainframes and minicomputers). For example, it is frequently asserted that, unlike mainframe computing, the introduction of personal computers (PCs) is an easy, low cost solution to automation in government. It is believed that by adopting PCs, latecomers to computing can leap-frog the brain-dead mainframe and minicomputer technologies and still gain all the benefits of these earlier, cumbersome technologies--and then some. All that is needed is basic investment in the technology and the empowerment of workers to use the technology in their jobs. The need for MIS departments will be only to help make the transition and to train users in the new technology. (See, for example, Greisemer, 1983 and 1984; and Voss and Eikemeier, 1984.)

PCs may be all that small local governments or even some small units within larger governments need to conduct their business. However, it is extremely unlikely that even the most powerful and sophisticated PCs on the market today can solve all of the automation needs of local government automation issues. Indeed, recent studies of the life cycle cost of PCs, actual experience with PCs, and recent reports on PC-based client server computing call several of these assertions into question. For example, while the initial cost of PC-based client server computing has been shown to be lower than mainframe or minicomputer alternatives by 20 to 30 percent, the five-year costs of PCs were found to be two to three times as great per employee (Nolan, Norton and Company 1992; Miller, 1993; Ambrosio, 1993; and Insurance Systems Bulletin, 1994). As one observer put it, “Technical support, end-user operations and administration can

end up accounting for 85 percent of the cost of client-server systems on a five year cost-of-ownership" (Moad, 1994). In addition, there are many hidden costs with PCs including pressure from users for the development of additional applications, the cost of linking independent systems developed by user departments with different platforms and operating systems, and the costs of training and support required by user departments.

Over and above the important issue of cost are the real limitations of the power of PCs and the availability of PC applications (Miller, 1994 and Rabinovitch, 1994). After the initial euphoria over useful PC applications like word processing, spreadsheets, desktop publishing and graphics packages, many local governments have found that PCs lack the software and the power needed for the day-to-day operations of government. Consequently, there is a trend among small and medium-sized cities to migrate upward to minicomputers where the power, software and reliability are available (Kraemer and Norris, 1994). Moreover, only small cities have found suitable PC applications for the important business of local government like accounting, purchasing, treasury management, police and fire, engineering and public works, business licensing, urban planning and parks and recreation functions.

Most municipal governments also have discovered that they lack the capabilities to develop such software themselves (Fletcher, Bretschneider and Marchand, 1992). Many of them have learned to their sorrow that the small software services firms with which they contract for custom development lack the market and staying power to improve upon or even support their products beyond the first few years. Finally, city governments have learned that worker empowerment per se is not sufficient for the effective utilization of computer technology.

What is missing is the institutionalization of knowledge and support within city hall. In

his case studies of innovation in cities, Robert Yin noted that diffusion is characterized by three distinct phases: initiation, implementation and routinization or institutionalization (Yin, 1979). The diffusion of PCs, unlike the diffusion of mainframes and minicomputers, appears to be in the implementation or, at best, early routinization stage in most cities, which probably accounts for its lack of institutional supports. Yet, the effective use of the technology requires these supports, and they will have to be provided if cities are to reap the real benefits available through PC computing.

This article examines certain aspects of computing in U.S. cities which use only PCs and compares them with cities that use mainframes or minicomputers as well as PCs. Our aim is to assess whether the two computing environments are functionally equivalent as many of the PC advocates would have it, or whether PC-only environments provide only some of the functions, applications and benefits of their bigger brothers and sisters--the mainframe and minicomputer environments.

FINDINGS

We then compared these two sets of cities in seven areas: extent of automation; categories of end-users; degree of technological sophistication; problems with computers; impacts of computing; and satisfaction with computing.

Extent of Automation

PCs are offered as the solution to widespread automation needs in government because they are easy to install and use, and it is easy to find off-the-shelf applications for them. Indeed, the availability of programming is predicted to speed automation because governments can get

off-the-shelf software rather than having to create applications from scratch. We have already noted that there are many useful off-the-shelf programs for PCs, including those for word processing, spreadsheets, database management, and graphics. However, these are programs for generic office automation functions as distinct from the business functions of government.

If the claim that PCs speed up the automation of governmental functions were true, we would expect to find PC-only sites as extensively automated as Central System sites, if not more so. Table 4 shows a total of 26 functional areas of local government ranging from word processing and office automation to computerization in police and fire, to parks and recreation and the public library. The table shows that in each of these functional areas, Central System cities were more likely to be automated than PC-only cities. Moreover, in all but two areas, word processing and administration/office support, the relationship between computing environment and functional area computerization was statistically significant. Even there, Central System cities were more likely by a few percentage points to be automated than PC-only cities. The percentage difference ranged from approximately 4 percent (spreadsheets) to over 40 percent (engineering).

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However, in most cases, the strengths of the relationships were not especially great. Only geographic information systems, personnel, public works, engineering, planning and community development, fire department and parks and recreation showed even moderate

relationships (over .20) as indicated by the Cramer's V score. In all other cases, the Cramer's V was under .20, suggesting a weak relationship. [1]

Categories of Users

Because PCs are relatively easy to use, it is predicted that they will be used widely throughout city hall--by the highest level managers as well as by the lowliest of clerks or street workers (e.g., Sacco and Ostrowski, 1991, p. 3). However, a number of studies which examined the actual extent of microcomputer use in cities contradict this claim. They conclude that there has been relatively low use by managers and that frequently touted images of the "knowledge executive" (Cleveland, 1985) were seldom found. While some managers do fit the profile of the direct hands-on user, most do not (King, et al., 1992; Kraemer et al., 1993). Moreover, the researchers concluded that "there are sound reasons why it might be appropriate for most executives to continue to delegate much 'hands-on' computer use to subordinates" (King, et al., p. 48). A related study concluded that the "democratization" of computer use that was supposed to be brought about by the PC also did not occur. While PCs were widely distributed in governments, the pattern of distribution was nearly identical to the distribution of terminals on mainframes (Dunkle, et al., 1994).

The results of the present study support these earlier findings. If PC computing led to widespread use throughout the municipal hierarchy, one would expect officials in PC-only cities to use computers at least as much as their counterparts in Central System cities. The data in

Table 5 show that this is not the case. Assistant managers, department heads, technical staff and administrative staff in Central System cities used computers more than their counterparts in PC-only cities, and the differences were statistically significant. With the exception of technical staff, however, the Cramer's V scores suggest that while the differences were statistically significant, they were not strong. The data also show that the difference between managers in Central System and PC-only cities was not statistically significant.

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Technological Sophistication

The increasing power and sophistication of PCs is used by some to argue that organizations which adopt PCs can advance rapidly and join the ranks of the most technologically advanced. We have already shown that PCs have some important limitations with regard to software applications available for many governmental functions. Similarly, some advanced technologies cannot run effectively on PCs either because they require greater power and other capabilities not available with PCs, or require staff and expertise not commonly found with PCs. Two current examples are full-blown GIS (geographic information) and AFIS (automatic fingerprint identification) systems. A rough assessment of the technological sophistication of PC environments can be found by comparing the extent to which PC-only cities and Central System cities have adopted leading edge computer technologies. The cities were asked whether they had adopted or were planning to adopt 23 leading edge technologies. The findings show, first, that relatively few cities have adopted many of these technologies . Only

seven of the 23 listed technologies had been adopted by more than 15 percent of the responding cities (Table 6). Second, Central System cities were far more likely to have adopted advanced information technologies than PC-only cities. And, in all cases, the differences were statistically significant. In three cases, the Cramer's V scores suggested modest relationships (.19 for e-mail; .20 for portable computers; and .21 for scanners).

- TABLE 6 GOES HERE -

A third finding is that, at the time of the survey, cities were not considering future adoption of advanced technologies with any great momentum. For five of the seven technologies, fewer than 25 percent of Central System cities were considering adoption, and none of the technologies were being considered by as many as 25 percent of the PC-only cities. Moreover, with the exception of portable computers, fax boards and scanners, Central System cities are more likely to be considering future adoption of these technologies than PC-only cities.

The cities were also asked if they had adopted local area networks (LANs). Here again, if the rhetoric about PC computing is correct, we would expect to find a far greater level of adoption of local area networks in PC-only cities (Table 7). We would also expect PC-only cities to show a greater adoption of LANs because these cities have a relatively greater need for PC networking than cities with central systems. This is because in central system, the technology involves terminals or PCs that are connected to mainframes or minicomputers whereas, without LANs, PCs operate as stand-alone devices in PC-only cities.

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The data do not support these expectations. Slightly over 48 percent of Central System cities had LANs and slightly over 50 percent of PC-only cities had LANs. The difference was not statistically significant.

Problems with Computers

The PC is a newer and simpler technology that is easier for employees to learn to use, whereas central systems usually require technical staff to operate them. The PC is usually operated in a stand-alone mode rather than networked, so there is less difficulty in determining whether problems that develop are on the PC, the network, or a shared file server than is the case with mainframes and minicomputers. Because they are relatively inexpensive and easy to learn to use, PCs have been more readily adopted by city staff than resisted. Consequently, PCs are often said to be relatively free of problems with equipment, vendor support, staff training and system use that have sometimes plagued central systems.

To test this proposition, the cities were asked eight questions about problems with computers. The questions concerned training, equipment performance, equipment reliability, vendor service, software availability, resistance to use, system under-utilization, and resistance to organizational change. (Table 8).

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In all cases, fewer PC-only cities reported experiencing problems with their computers (PCs) than did respondents from Central System cities whose organizations had both central systems and PCs. In those cases (i.e., software availability, training and under-utilization), the percentage differences were fairly substantial; in the remaining five areas, the percentage differences were smaller. In all cases, the differences were statistically significant, but weak. The Cramer's V scores were all below .20 and in five cases below .10. This suggests that while PC-only cities, predictably, experience fewer problems with their systems, the differences are not as great as might be expected from the rhetoric.

Moreover, the reported differences make perfectly good sense. For example, concerning software availability, the fact is that a far greater range of software is currently available for PCs than has been true historically for minicomputers and mainframes. Moreover, this software is for both general purpose users (e.g., computer aided drawing and mapping) and highly sophisticated activities (e.g., geographic information systems). PC hardware is also less sophisticated and complex than mainframe and minicomputer equipment. Much of the PC software is also more user friendly, is generalizable rather than task specific, is easier to learn and is often supported by a wide array of training programs (e.g., offered through private sector organizations, community colleges and the like). All of this would suggest that PCs would experience less user resistance, less under-utilization, fewer complaints about reliability and performance and would have relatively less need for vendor service and training.

What is really remarkable about these data, however, is not the existence of the differences but their relatively small magnitude and the weak Cramer's V score. Thus, even though the data favor PC installations, they do so only marginally.

Impacts of Computer Use

It has been argued that mainframes and minicomputers had limited impact on government because computing was centralized, mainly applied to the financial area of government and accessed primarily by the priesthood in the MIS department. By contrast, the significance of the PC was that it would allow computing to be decentralized or distributed--available to managers, analysts and staff throughout the government. This broader availability would allow computing to be used for functions beyond finance, like police, fire, public works, planning and more. The advent of the PC would change the MIS priesthood into more of a support and service organization focused on user department needs. Consequently, the impact of PCs on government would be far more positive than the impact of central systems, especially in areas like personal productivity, employee creativity, analysis and decision-making, quality of work life and service delivery (Griesemer, 1983, 1994; Sacco and Ostrowski, 1991). If the PC environment is indeed superior, then reported impacts in PC-only cities should be superior to those reported in Central System cities.

The cities were asked 11 questions about the impacts of computers in their organizations (Table 9). Because of the way in which the survey instrument was constructed, we can provide a comparison of the answers, but not a statistical test of significance of the differences between PC-only and Central System sites.

- TABLE 9 GOES HERE -

Nevertheless, three things are notable from the data. First, the impacts of computing were viewed quite favorably by the respondents regardless of type of site. These cities clearly felt that the impacts of computers within their organizations were largely (indeed, almost exclusively) positive. This finding is consistent with the results of studies of computer impacts for 20 years (see, for example, Danziger and Kraemer, 1986).

Second, for all but one of the impacts, the differences favored PC-only cities. Third, in only three of the 11 impact areas (enhance creativity, enable in-depth analysis, and improve morale) was there a difference greater than seven percent between Central System and PC-only sites. Here, 36.3 percent more PC-only cities agreed that computers enhance creativity, and 12.9 percent said that computers enable in-depth analysis, and 15.1 percent said they improve morale. In the other eight cases, the differences between Central System and PC-only cities ranged from 1.2 percent to 6.1 percent. These data suggest that in terms of perceived impacts, the PC-only computing environment is only marginally superior, if at all, to the central system environment.

Satisfaction with Computing

Given the litany surrounding PCs , one would expect that cities using them would show greater evidence of satisfaction with PCs than would cities using central systems. While the survey did not provide us with a direct measure of the cities' satisfaction with the type of computing environment they had chosen, we can use two questions to provide a surrogate

measure. The cities were asked to rate their experiences with PCs and also to indicate the extent to which they planned to purchase additional computer equipment. If cities were not satisfied with their computing environments, we would expect that dissatisfaction to show in their answers to these questions. That is, they would not rate their experiences positively and would not be likely to purchase additional equipment. Additionally, answers to these questions will enable us to detect differences in levels of satisfaction between Central System and PC-only cities. Because of the way the question was constructed, however, we can provide comparisons of answers but not a statistical test of the significance of the differences between Central System and PC-only cities.

The data suggest that these cities are quite satisfied with both central systems and PCs. To begin with, there were virtually no differences between Central System and PC-only cities over their experiences with PCs (Tables 10 and 11). About nine out of ten of both types of sites (91.4 percent Central System cities and 89.1 percent PC-only cities) said that PCs met or exceeded their expectations. While the difference is statistically significant (at the $p = <.05$ level), the Cramer's V score of .07 suggests a very weak relationship.

When Central System cities rated their experiences with minicomputers and/or mainframes, more than eight in 10 (83.4 percent) indicated that these systems had met or exceeded their expectations. Although a few percentage points lower than the ratings given by both Central System and PC-only cities of their experiences with PCs, a better than 80 percent rating for central systems is strongly positive.

While the vast majority of cities said that central system and PC-only computing met or exceeded their expectations, greater differences occurred in these cities levels of dissatisfaction. Here, 14.0 percent of the Central System sites said that central systems failed to meet their

expectations. This compares quite unfavorably to the 4.6 percent of Central System and 5.4 percent of PC-only sites that felt that PCs did not meet their expectations.

- TABLES 10 AND 11 GO HERE -

Another indicator of the satisfaction with computing environment can be found in the extent to which a city plans to purchase additional computer equipment. As indicated in Table 12, there is virtually no difference between PC-only and Central System cities in this regard. Half of Central System cities compared with 47 percent of PC-only cities indicated that they would purchase additional computers within the next two years. Nearly 23 percent of Central System cities said they would purchase the same amount of computer equipment as did 24.2 percent of PC-only cities, and 27.1 percent of Central System cities said they would purchase less computer equipment as did 28.8 percent of PC-only cities.

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Discussion

These data strongly suggest that the rhetoric surrounding the adoption of PC computing exceeds the reality of that computing. This is true in virtually every area examined, including the breadth of functions automated, the types of users, the adoption of leading edge technologies, problems associated with computing, impacts of computing, experience with computers, and

projected purchases of computer equipment.

Computers have been used by cities since the 1950s. Nevertheless, their successful diffusion continues to be a matter of interest and concern to elected officials and public managers alike. Successful diffusion of a new innovation is not simply a matter of the adoption and spread of technology. It also involves knowledge of how to use, maintain, manage and innovate with the technology, the availability of skilled and experienced professionals, and the creation of institutions to foster those processes and people (Gerrity and Rockart, 1986). For the most part, the introduction of PCs into city governments has failed to develop these requisites, whereas the earlier adoption of central systems did develop them. Indeed, these requisites for PCs are more likely to have been developed in cities with central systems than in those with PCs only.

The data and analysis in this article have shown that in cities with central systems, the technology is generally more sophisticated, is more widely diffused within the various functions of city government, and is used by a greater proportion of managers and professionals than in PC-only cites. Despite all of the disapprobation heaped upon central systems and the MIS departments which tend them, the impact of these systems on city hall is viewed positively overall and, also, favorably in comparison with PC-based systems. Finally, central systems appear to be institutionalized within city governments while PC-only systems are only routinized.

Given these foregoing results, why is there such a discrepancy between the images and reality of central systems and PC-based computing? There are many answers, but one has to do with the stage of each innovation in city hall. Computing in the mainframe and minicomputer era developed incrementally over a 40 year period. During that time, the MIS function became institutionalized within city hall. MIS budgets became a regular part of the resource allocation

processes within government. The MIS department became an institutionalized source of technical expertise and a provider of day-to-day computer services. It also became a champion and promoter of user needs for new or improved applications.

By contrast, the PC revolution came rapidly and recently. It began less than a decade ago for most cities, and unless in the context of a centralized system, PCs usually came with few of the supports provided with the earlier technology. PCs came with general purpose packaged software but rarely with software tailored to the specific functions of government. PCs also came with a minimum of support staff--usually a few people to install the PCs, give initial training in their use, and later connect them via local area networks.

In most PC-only cities, a broad based support function for PCs has not yet been institutionalized. What exists is an ad hoc, small group of people, usually scattered among the user departments and depending heavily upon informal networks and the willingness of particular individuals to help one another. Sometimes, support is provided by a departmental "computer guru"--a user-turned-computer-specialist who has displaced organizational goals and no longer performs his or her original job function. Even when support is institutionalized in a PC support group, it is usually small in size and heavily focused on operational issues. Planning, training, migration, consulting and broader functions are generally missing. By comparison, central systems are far more likely to have highly-developed and well-institutionalized support functions, usually centralized within a department charged with carrying out these functions.

A clear implication of this research is that PC-only cities might gain a greater measure of the benefits of PC computing if they enhanced the support provided for these systems. For example, one of the key roles provided by PC support groups is training. Research by Northrop,

et al., (1994) showed that training can help employees to gain greater benefits from computer use by increasing their computer literacy and assisting them to overcome the limitations of application software.

Another factor that may help to account for the modest differences found here is that the current generation of central system hardware is much easier to use and more reliable than earlier generations, and a wider range of software is available for it. In other words, central systems, for the most part, are just not as bad as their detractors would argue. They are also far more powerful and versatile than PCs, or than PC advocates might acknowledge. One of the many positive, if unintended consequences of the PC revolution has been the improvements in mainframe and minicomputer hardware and software technology. Indeed, *both* central systems and PCs have improved incredibly over the past decade. Hence, it is increasingly difficult to find significant end-user differences in their use. A second implication of these findings, then, is that the value of central system computing should not be so easily dismissed.

City size is also important to our understanding. Larger cities have unquestionably greater needs for computing, including advanced computing, than do smaller cities. Larger cities also have larger budgets and are more likely to be able to afford larger, more sophisticated, more expensive computer systems, including both central systems and PCs. Thus, larger cities will on average have bigger, better, more extensive, and more advanced computer systems. They will also be more likely to have fully developed MIS support capabilities. Smaller cities won't.

None of these findings deny the importance and value of PC computing in cities. However, they should serve as a cautionary note. Sometimes, false or misleading rhetoric is used by vendors, managers and users to justify particular approaches to computing. Consequently,

local government policy-makers and managers can get caught up in the religious-like fervor of PC "true believers," be misled by departmental managers seeking to control more of their own domain, or become entangled in power struggles between user departments and the MIS department over control of computing resources. These findings should serve as a caution to those whose advocacy of PC-only computing would allow rhetoric to exceed reality. As good as PC-only computing may be, it is not always an acceptable substitute for a central system. And, central system computing is clearly not the technological mastodon that some of its detractors would claim.

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