1986

THE DEMOGRAPHICS OF SOFTWARE MAINTENANCE MANAGEMENT

E. Burton Swanson
University of California

Cynthia M. Beath
University of Minnesota

THE DEMOGRAPHICS OF SOFTWARE MAINTENANCE MANAGEMENT

E. Burton Swanson
Graduate School of Management
University of California

Cynthia M. Beath
School of Management
University of Minnesota

ABSTRACT

Organizational demographics is proposed as a promising analytic technique for understanding a central problem of information systems (IS) management, the problem of the maintenance of the application system portfolio. This problem is viewed as occurring in significant part as a consequence of the effects and interaction among distributions of individual characteristics of both the application systems and the members of the IS staff. To examine this proposition, a sample of eighteen IS organizations is described in demographic terms, and regression equations are developed to explain variance in maintenance problems associated with the installed portfolios. The results provide support for the proposition, with implications for management and for further research.

INTRODUCTION

The problem of managing the mature information systems (IS) organization has been increasingly recognized as a problem in managing an application system portfolio, an aggregate of related systems and services (McFarlan, 1981; Nolan, 1979, 1984). During the early years of many IS organizations and, in particular, during rapid growth phases, management attention was often lavished on individual systems under new development. The successful development of these new systems, however, has resulted ultimately in the accumulation of an installed base which requires significant maintenance and continued development resources (Boehm, 1983). The manager of the mature IS organization has thus come to recognize the necessity of viewing these systems in the aggregate, i.e. as a portfolio of systems in various states of production.

The mature IS organization has also come to face an increasingly large, complex user community with both complementary and competing information requirements. A focus on any one segment of this user community has accordingly become increasingly difficult. Again, the consequence is that IS management has to balance its efforts in meeting these diverse user needs, with the consequence that the portfolio point of view has been reinforced.

Further, issues of staff assignment, turnover and replacement have come to prominence in mature IS organizations, and the IS staff itself is increasingly viewed in aggregate terms.

In consequence, managers of mature IS organizations attend to the relationships and interdependencies among their varied systems, users, and staff, with respect to the overall problem of effective and efficient IS management. For this reason, studies of problems associated with individual systems (see, e.g. Lientz and Swanson, 1980) or individual staff members (e.g. Couger and Colter, 1983) are, while helpful in their own terms, unlikely to suffice for contemporary management purposes. Analyses at the aggregate, organizational level are required beyond those at the individual levels.

Organizational demography (Pfeffer, 1983, 1985) offers a promising means of analysis at the aggregate level, and provides explicit linkage to analyses at the individual level as well. The demographics of any organization refer to its composition in terms of basic member attributes such as age, sex, educational level, length of service or residence, and race (Pfeffer, 1983). Such demographics reflect the aggregation of individual characteristics of members of the organized population. But in addition, they reveal properties of the unit as a whole, reflecting the composite and distributional properties of these same members (Wagner, *et al*, 1984). For this reason, demographic studies offer a superior means of analyzing certain organizational problems, e.g. employee turnover, in that significant problematic aspects at the individual and aggregate levels may be reconciled.

While research in organizational demography is relatively recent, a number of illustrative published studies exist. Pfeffer (1983) provides a helpful review which focuses in particular on the distribution of organizational service length (characterized by its central tendency and dispersion) as a demographic variable of importance. Among those studies reviewed is that of Katz (1982), who investigated the communication behaviors and performances of 50 R&D projects, and found both communication intensity and project performance to be significantly and curvilinearly related to the service length composition of the project group. A still more recent study is that of Wagner, *et al*, (1984), who examined turnover among top manager groups in 31 Fortune 500 companies, and found it inversely related to the company's financial performance, and positively related to the sociometric distance among managers in the group. A comparable study is that of Terborg and Lee (1984), who found personnel turnover in a sample of 65 retail stores to be largely predictable in terms of organizational demographics and job opportunities in the local labor market. In the case of each of these studies, important organizational consequences were identified by focusing the study at the aggregate level of analysis.

The suggestion of the present paper is that organizational demography, because it focuses on relationships among aggregates, is especially promising as a means for understanding the problems of IS organizations.

Beyond theory, practicing IS managers should also find demographic analysis appealing in that its prescriptions are particularly sensitive to current realities faced, in terms of aging portfolios, staffs with varying skills, and users with highly variable levels of IS sophistication.

In the section which follows a theoretical sketch is given for the application of demographic analysis to IS organizations. Subsequent sections describe the application of the concept to the study of software maintenance problems in a sample of eighteen IS organizations.

THEORY

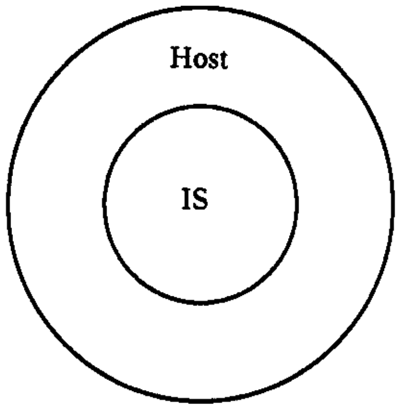
The problems of IS management in general, and software maintenance management in particular, can best be understood by placing them in the context of a basic task model sketched as follows.

A Basic Task Model

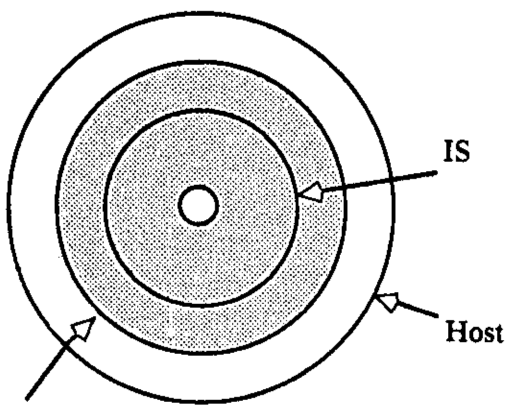
The information system (IS) organization is regarded as one component of the host organization which it serves, a relationship which may be simply portrayed as in Figure 1a, in which the task of the IS organization is represented by the area bounded by the smaller circle, which is wholly contained within the larger circle representing the task of the host organization.

The principal service of the IS organization is provided by its application system portfolio, which is understood here to be an organized assemblage of computer-based software and procedures to support automated data gathering, organizing, and processing, and reporting and action-initiating applications in the host organization.

The organizational tasks associated with the application system portfolio consist of system design, development, implementation, opera-



1a. The IS Task as a component of the host organization task.



The Portfolio (Shaded)

1b. The task of application development, maintenance and operation as shared between the IS and host organizations.

Figure 1. A Basic Task Model.

tion, maintenance and use. These tasks are shared between the IS and user components of the host organization, as portrayed in Figure 1b, The appropriate nature of this sharing and, in particular, the involvement or noninvolvement of user organizations in system design, development, and implementation, is a topic which has received substantial attention in the IS literature (e.g. McLean, 1979; Ives and Olson, 1984).

Thus, from the viewpoint of the model, the total task associated with the application system portfolio is regarded as a set of subtasks allocated among systems and between the IS staff and the system users. Furthermore, it is the individual and collective characteristics of systems, staff, and users, that provide the basis for the allocations of subtasks. This suggests a working hypothesis:

> The central problem of IS management, the problem of the management of the application system portfolio, occurs in significant part as a consequence of the effects and interaction among distributions of individual characteristics of (i) the application systems themselves; (ii) the members of the IS staff; and (iii) the users of the application systems.

Thus, the problem of software maintenance is viewed as shaped by certain fundamental "IS demographics," i.e. distributions of individual characteristics associated with three populations: the application systems themselves, the members of the IS staff, and the users.

Recall that any distribution has a mathematical form, describable by a mean and a variance (or other measures of central tendency and dispersion). Both measures are likely to be of significance. Imagine, for example, a company which built a portfolio of accounting applications between 1970 and 1986, and another which built the same portfolio between 1977 and 1979. The mean system ages of the portfolios might be identical, but the variance in system age of the first portfolio would be much larger than that of the second. More important, the maintenance tasks of the first portfolio would probably be more varied and more demanding.

Consider the difference in skills required to maintain ten applications built between 1965 and 1975 compared with ten built between 1975 and 1985. The age variance may be the same in both cases, but the mean age of the first portfolio is twice that of the second. Even a few years can make a considerable difference with respect to the technological environment, use of development productivity techniques, and even the system architecture, all with major implications for the maintenance task.

Composition, the proportion of a distribution that is above or below some criterion, and cohort effects, characterized by lumpiness in the distribution, can also be revealing. A single Assembler language program, for example, isolated in an otherwise high level language portfolio, may be more problematic for maintainers than two dozen Assembler language programs.

As a first step in exploring our working hypothesis, the current research focuses on characteristics of the application systems and the IS staff, leaving consideration of user characteristics for the future. In terms of Figure 1b. we begin our examination with the study of the inner half of the portfolio task, that part carried out by the IS staff. In the two sections which follow, relevant distributions of individual characteristics of the application systems and the IS staff are presented and discussed.

Distributions of characteristics of the application systems

Among the potentially significant distributions of application system characteristics are those associated with: life cycle phase (in particular, development versus maintenance phases), age, size, growth rate, location of origin, language, structure, documentation, application domain, features, and operational base.

In the case of life cycle phase, it is a commonplace, though relatively unstudied, observation that new system development work and maintenance work differ significantly. New system development may be substantially buffered from the day-to-day problems of user organizations, in contrast to system maintenance which is often conducted in direct response to these same problems. As a result, maintenance work can be more subject to fragmentation, variability, and frequent interaction with users. It has been characterized as inherently less motivating to IS professionals (Couger and Colter, 1985). Thus the amount of system development work compared with system maintenance work can be consequential for the division of labor among the IS staff (Swanson and Beath, 1985).

System age is also known to be of importance to maintenance. Older systems are more difficult to maintain, in part because their architectural integrity diminishes over time, complicating their repair and extension (Brooks, 1975; Lientz and Swanson, 1981). Further, the maintenance of any system is made easier by first hand knowledge of its original development, which itself decays with age. Lastly, as noted earlier, the diversity of knowledge required to maintain a group of systems of varying age is also greater.

System size is significant in that larger systems are more problematic to maintain, primarily because of the greater degree of complexity which they typically involve (Lientz and Swanson, 1981). Additionally, to the extent that sizes of systems vary substantially within a portfolio, the substitution of work assignments is complicated, making maintenance work assignments yet more problematic.

Development origin of systems within a portfolio is also considered important in maintenance. Apart from systems developed by the IS organization itself, systems may be obtained from other locations and units within the host organization and adapted locally, they may be custom developed by an external organization under contract, or they may be purchased "off the shelf." These alternatives vary substantially in the extent to which the development task is carried out or shaped by the IS organization. Because experience in original development provides important knowledge for subsequent maintenance, the maintenance task should be more difficult where the systems have not been developed within the IS organization. Further, multiple places of origin may pose additional problems in the form of increased maintenance task diversity.

Distributions of characteristics of the IS staff

Among the potentially significant distributions of IS staff member characteristics are: job position, length of service, age, sex, education, professional associations, prior job experience, and training received.

Length of service in any organization is a variable of recognized demographic importance, as has already been mentioned above. In the case of the IS organization, this distribution may assume yet further importance. Because the task of the IS organization focuses centrally on its application system portfolio, composed of individual systems varying in age, the corresponding length of service of the staff is equivalent to the necessary base of experience for system maintenance. From previous research, problems with any system's maintenance are known to be more severe where the system must be maintained by those who were not involved in its original development (Lientz and Swanson, 1980). Thus, the greater the overall length of service in the IS organization, the lesser should be the problems of maintenance on the whole. Variance in length of service is also relevant, in that it may be matched to variance in the ages of the systems maintained.

The level of education of IS staff members is also of potential consequence with respect to problems in maintaining the application system portfolio. On the one hand, the higher the level of education, the greater the professional competence brought to the task. On the other hand, higher levels of education are also associated with high career achievement aspirations, for which maintenance work may be a mismatch (Couger and Colter, 1985). Thus, variance in the level of education of staff members, because it provides diversity of background which may be matched to diversity of the task itself, may facilitate the overall work assignment process.

The prior job experience of IS staff members is of similar relevance. In particular, the positions held immediately prior to joining the IS staff provide an important basis for importing new knowledge into the IS organization. Prior positions include those in other IS units in other host organizations, as well as user positions within the host organization. As with level of education, the greater the prior job experience of the IS staff, the greater the level of competence which should be brought to the IS task. Diversity in prior job experience should be valuable in facilitating the overall work assignment process.

Formal on-the-job training of the IS staff should also be a significant factor, as with the background factors of education and prior job experience. Such training typically focuses on the current skills needed by the staff, given its background and its on-going IS experience. In general, the greater the level of training provided the staff, the greater should be its competence. Diversity of training should also be useful, especially when tailored to comparable diversity in the overall IS task.

Summary

Problems in the maintenance of an IS organization's application system portfolio are thus viewed as understandable in terms of distributions of individual system characteristics (life cycle phase, age, size, location of origin) in conjunction with distributions of staff member characteristics (length of service, prior job experience, education, training). Measures of both central tendency and dispersion associated with these distributions should accordingly be of significance to the explanation.

The research methodology for an exploratory empirical examination of this particular restatement of our working hypothesis is described next.

RESEARCH METHODOLOGY

A research project directed toward the study of application software maintenance was recently undertaken. The project was designed to build upon work previously reported (see Lientz and Swanson, 1980). As one part of the more recent study, a set of twelve cases was developed. These cases focus on the comparative maintenance environments of IS organizations, and on alternative management strategies for maintenance, including alternative approaches to organization design, task definition and assignment, work technique, and policies for coordination and control.

In developing the twelve cases, a set of standard questionnaires was employed, as were on-site interviews, and reviews of organizational documents. A common protocol was used throughout in assembling both quantitative and qualitative data.

Participating organizations included six based in Southern California, and six dispersed over the rest of the United States. Together, the twelve organizations constitute a diverse lot, including four high technology manufacturing companies, two food and beverage producers, an oil company, a retail grocery company, a defense firm, a public utility, a research and development laboratory, and a university. In addition, six other organizations completed the questionnaires used in the research. These data augment the primary data collected, providing a convenience sample of eighteen.

Two questionnaires were used to gather the data employed in the analysis. The first questionnaire focused on the IS organization; among the data solicited were distributions of staff member characteristics as described in the section above.

The second questionnaire focused on the application system portfolio; among the data solicited were distributions of system characteristics as described in the section above. For both staff member and system characteristics, the data gathered were substantially objective and, therefore, comparatively reliable. The use of follow-up interviews to validate the questionnaire data in twelve of the eighteen cases contributed to overall data integrity by reducing method variance.

Also included in the second questionnaire was a question in which the IS manager was asked to evaluate 26 candidate problems (e.g. "turnover of maintenance personnel") in maintenance of its application system portfolio on a five-point scale ranging from 1, "no problem at all," to 5, "major problem." Based on previous research use of this same question (Lientz and Swanson, 1981), which produced six factor indices describing the overall maintenance problem, scores on these indices for the respondents were com-

Table 1: Research Variables and Measures

I. Maintenance Problem Factors	Mean	Std.Dev.	Min	Max
User Knowledge Problem	.227	.410	-.320	1.113
Programmer Effectiveness Problem	.488	.601	-.538	1.700
Product Quality Problem	.484	.379	-.167	1.182
II. The Application System Portfolio	**Mean**	**Std.Dev.**	**Min**	**Max**
Portfolio size (Number of current operational systems)	52.6	41.7	7	171
Portfolio growth rate (Net increase in portfolio size over last year)	.102	.097	-.034	.286
Maintenance proportion of total extended portfolio (Current portfolio size as a proportion of all systems under maintenance and development)	.877	.086	.714	1.000
Mean system age (In years)	6.9	2.5	2.8	11.5
Variance in system age	20.1	10.4	2.1	36.2
Median system size (In programs)	43.1	42.9	1	150
Quartile range of system size	105.8	98.3	1	315
IS-developed proportion (proportion of the portfolio that was internally developed)	.717	.286	.250	1.000
III. The Information Systems Organization Staff	**Mean**	**Std.Dev.**	**Min**	**Max**
Staff size (Number of current applications staff)	95.5	69.2	7	266
Staff growth rate (Net increase in staff size over the last year)	.003	.148	-.280	.375
Mean staff member service length (Years in IS organization)	5.1	2.1	2.1	10.7
Variance in staff member service length	19.8	9.9	4.0	38.1
Experience proportion (Proportion of staff with immediate prior job experience)	.742	.223	.286	1.000
Mean staff member education level (Years of college education)	3.5	0.7	2.3	4.4
Variance in staff member education level	2.9	1.2	0.6	4.9
Mean staff member training level (Annual days of on-the-job classroom instruction)	10.6	4.0	3.5	17.1
Variance in staff member training level	34 .5	17.6	1.9	63.4

puted. The three most significant of the six indices, those associated with the problems of user knowledge, programmer effectiveness, and product quality, are used here.

Three groups of measures were thus employed in the present research. The first group comprised three indices of problems in the management of software maintenance, employed as the dependent variables in the analysis. The second group consisted of eight variables associated with the application system portfolio: three measures reflecting the overall size, growth rate, and maintenance proportion of the application system portfolio, and five measures associated with distributions of individual system characteristics of age, size, and development origin. The third group consisted of nine variables associated with the staff: two measures reflecting its size and growth rate; and seven measures associated with distributions of individual staff member characteristics of length of service, immediate prior job experience, education, and training. Table 1 summarizes the variables, and includes relevant descriptive statistics.

An exploratory examination of the above working hypothesis, in terms of the limited data from the study described, was conducted by means of correlation and regression analyses. The nature of these analyses, and their results, are presented next.

RESULTS

Because the present sample of IS organizations is not obviously representative of any particular population, the results to be presented cannot easily be assessed as to their external validity. Nevertheless, it is possible to compare the present sample with the random, representative sample from the earlier Lientz and Swanson (1980) study. Specifically, the sample means for the three problem factors in the present study can be compared to the norms established in the previous study (as suggested, for example, by Mitchell, 1985). When this is done, a simple difference of means t-test shows that the present sample differs significantly (at the $s = .05$ level) from the norms on all three factors. And, it may be concluded, the present sample finds maintenance to be more problematic, than does the reference sample. Given the cooperation solicited in the present convenience sample, this is perhaps to be expected. It does suggest special caution in interpretation of the present findings, however.

Correlation analysis was next undertaken as a first step in the analysis of relationships among the variables.

Correlation Analysis

First-order correlations among the 20 research variables were computed, resulting in 180 coefficients, 32 of which were statistically significant at the $s \leq .05$ level. These correlations are presented in Tables 2, 3, and 4. Because the number of significant associations substantially exceeds that which would be expected from chance alone, it may be concluded that the variables are as a whole interrelated. The reader is reminded that an unknown few of the individual significant associations are no doubt due to chance alone, however. For this reason, it is the pattern of relationships, more than any individual relationship, which is of principal interest.

In the following tables it can be seen that the means and variances of system age, staff member service length and staff member training are positively associated. This can be attributed, in part, to the fact that these three distributions are anchored at their low end at zero. It is noteworthy, however, and supportive of our interest in demography that sometimes these same means and variances correlate with the remaining variables in different ways. For example, staff size is negatively related to the mean staff member education level, but positively related to the variance in staff member education level. That is, larger staffs in this sample are educationally more diverse, though less well educated on average.

Additional plausible explanations for the associations are posed in the next four sections, in part to demonstrate the potential of demographic analysis. Because these first-order associations are not controlled in terms of other variables, no inference as to direct association will be made.

System Characteristics	2	3	4	5	6	7	8
1. Portfolio Size		.43 s=.04					
2. Portfolio Growth Rate							
3. Mean Age			.73 s=.00	.45 s=.03			
4. Var Age							-.39 s=.05
5. Proportion Maintenance							
6. Median System Size							
7. Range System Size							
8. Internal Development							

Table 2. Associations Among System Characteristics.

Associations among distributions of system characteristics

From Table 2 we note that the number of systems in the portfolio is positively associated with the mean age of these same systems. Larger portfolios thus tend to be more mature, due in part to the passage of time during the process of application accumulation.

The mean age of the systems maintained is also positively associated with the maintenance proportion of the total extended portfolio. That is, as a portfolio grows over time the maintenance proportion of the portfolio task tends to increase.

Staff Characteristics	2	3	4	5	6	7	8	9
1. Staff size					-.70 s=.00	.48 s=.02		
2. Staff growth rate		-.58 s=.01	-.51 s=.02		.52 s=.02			
3. Mean service length			.84 s=.00	.44 s=.04	-.68 s=.00			
4. Variance service length					-.57 s=.01			
5. Experience proportion							-.69 s=.00	-.60 s=.00
6. Mean education level								
7. Variance education level								
8. Mean training level								
9. Variance training level								.61 s=.00

Table 3. Associations Among Staff Characteristics.

Staff Characteristics	Port Size	Port Grow	Mean Age	Var Age	Prop Maint	Medn Size	Range Size	Intern Devel.
	System Characteristics							
1. Staff size								.42 s=.04
2. Staff growth rate	-.50 s=.02							
3. Mean service length					.50 s=.02			.43 s=.04
4. Var service length	.60 s=.00				.40 s=.05			.42 s=.04
5. Exper proportion								
6. Mean educ level	-.48 s=.02							
7. Var education level				-.47 s=.03				
8. Mean training level								
9. Var training level								

Table 4. Associations Between System and Staff Characteristics.

Associations among distributions of staff member characteristics

In Table 3, the negative association between staff growth rate and staff member service length reflects, perhaps, the slowing of growth which typically accompanies staff maturation. More mature staffs, furthermore, appear to be composed of those hired more on the basis of prior job experience than on the basis of level of education. It is the faster growing staffs (probably in newer, less mature IS organizations) that appear to be composed of those who are more highly educated. An historical effect may be involved to the extent that more recent hires are in general better educated.

Variance in the staff member service length is negatively associated with the mean staff member education level. A plausible explanation is that less educated staff are more likely to invest their futures in the organization, with the consequence that the turnover rate is differentiated by level of education.

The mean level of staff member training is negatively associated with the proportion of IS staff with immediate prior job experience. Thus, those hired on the basis of prior job experience may not receive the same investment in training as do those hired out of school.

Associations between distributions of staff member and system characteristics

The size of the application system portfolio can be seen in Table 4 to be associated with a number of staff characteristics. Larger portfolios in this sample appear to be maintained by slower growing, less highly educated staffs of longer but more internally differentiated tenures.

As might be expected, longer tenure staffs tend to be more involved in maintenance than in new system development, and tend also to work with systems which were originally developed internally.

Associations between maintenance problems and distributions of system and staff member characteristics

In Table 5 it appears that problems of user knowledge tend to be perceived by the smaller, faster growing IS organizations, and in organiz-

System Characteristics	Maintenance Problems User Knowledge	Programmer Effectiveness	Product Quality
1. Portfolio size	-.50 s=.02		
2. Portfolio growth rate			
3. Mean age		.42 s=.04	
4. Var age		.42 s=.04	
5. Proportion maintenance			
6. Median system size		.55 s=.03	
7. Range system size			
8. Internal development			
Staff Characteristics			
1. Staff size	-.53 s=.01		
2. Staff growth rate	.43 s=.05		
3. Mean service length			
4. Variance service length			
5. Experience proportion			
6. Mean education level	.71 s=.00		
7. Variance education level			
8. Mean training level			
9. Variance training level			

Table 5. Associations Between Problems/System/Staff Characteristics.

ations where the education level of the staff is comparatively high.

Consistent with past findings (Lientz and Swanson, 1981), problems of programmer effectiveness are more frequently perceived where the systems maintained are the oldest and largest.

In summary, the first-order correlational results suggest a rich pattern of relationships. In particular, the correlations suggest interesting evolutionary patterns in portfolio and staff development. It appears that there are significant differences in staff education, prior job experience, and the maintenance proportion of the portfolio task which are related to overall IS size and maturity. To further examine the correlates of perceived problems of user knowledge, programmer effectiveness, and product quality, exploratory regression analyses were conducted, the results of which are described next.

Regression Analyses

Each of the three maintenance problem indices was regressed against a set of fifteen independent variables, which were themselves organized hierarchically into three subsets. The first of these subsets consisted of four measures of overall scale of operation: the size and growth rate of the installed application system portfolio, and the corresponding size and growth rate of the application staff. The second subset consisted of the means associated with application system age, and staff service length and levels of education and training, and included too the maintenance proportion of the total extended portfolio, the proportion of systems developed internally, and the proportion of staff with immediate prior job experience, a total of seven measures. The third subset included the variances associated with application system age, staff service length and levels of education and training, a total of four measures.

Two independent variables, the median and range in size of systems in the portfolio, were not included in the regression analyses in that they were insufficiently represented among the cases.

Each level of the regression hierarchy thus served as a control for the subsequent level(s) of analysis. The first level offered the simplest potential explanation of variance in maintenance problems, scale of operation, as captured by both the application system portfolio and associated staff. The second and third levels employed more sophisticated explanations in terms of means and variances associated with distributions of specific individual system and staff characteristics.

Within each level of the analysis, stepwise entry of the independent variables was further employed, based on strict entry criteria. Specifically, at each step a minimum F-level of 1.0 and a tolerance of 0.5 were required for entry. The total number of entered variables was also restricted to ten. Together, these criteria thus encouraged parsimonious explanation and mitigated against problems of multicollinearity.

Results of the regression analyses are described in Table 6a, b and c. Each table documents the regression equation produced to explain variance in one of the three maintenance problem assessments.

In Table 6a, it is seen that only scale of operation variables explain variance in the problem of user knowledge. Specifically, smaller IS organizations, measured in terms of both systems and staff, indicate relatively greater problems with user knowledge. This finding differs from that reported in Lientz and Swanson (1980), where scale of operation failed to explain variance in the problem of user knowledge. However, in this earlier study the problem was associated with a single selected system rather than with the full portfolio.

In contrast, in Table 6b, it is seen that scale of operation variables do not enter into the regression equation in which variance in the problem of programmer effectiveness is explained. Rather, in this case, the mean level of staff member training and the mean age of systems in the portfolio are positively associated with the problem, independent of scale of operation. That older systems pose problems for programmer effectiveness is known from previous research (Lientz and Swanson, 1981). That greater levels of staff member training are associated with the same problem is, however, new. The likely interpretation is that such training is symptomatic of the problem it is designed to address (not that it causes it).

In Table 6C, it is seen that variables at all three levels of the hierarchy enter into the explanation of variance in the problem of product quality. At the first level, portfolio size and growth rate, and staff size and growth rate are significantly and negatively associated. At the second level, the mean level of staff member training and the mean age of systems in the portfolio are significantly and positively associated. At the third level, variance in staff member education level is significantly and positively associated. In all, these variables account for a considerable portion of the variance in problems of product quality across sites (90%).

Problems of product quality are thus more prominent for smaller organizations, and for those that are slower growing. Where growth is lacking, it may be noted, slack in organizational resources may be taken up, posing problems for performance standards in general (Galbraith, 1973) Problems of product quality are further explainable in terms of the same factors which explain problems of programmer effectiveness with the same interpretation.

6A. Regression of Demographic Variables on Problem of User Knowledge

Variables in Equation	Coefficient	Standard Error	F-Ratio
Portfolio size	-0.00496	0.00219	5.104*
Staff size	-0.00209	0.00124	2.866
Portfolio growth rate	-1.038	0.921	1.269
Constant	0.845		
Adjusted R-square	0.344		
F-ratio	3.620*		

6B. Regression of Demographic Variables on Problem of Programmer Effectiveness

Variables in Equation	Coefficient	Standard Error	F-Ratio
Mean training level	0.0639	0.0303	4.450*
Mean system age	0.1003	0.0539	3.468
Constant	-0.796		
Adjusted R-square	0.267		
F-ratio	3.729*		

6C. Regression of Demographic Variables on Problem of Product Quality

Variables in Equation	Coefficient	Standard Error	F-Ratio
Portfolio size	-0.0089	0.0010	75.185***
Staff growth rate	-1.1174	0.2833	15.554**
Portfolio growth rate	-2.2624	0.3644	38.542***
Mean training level	0.0340	0.0083	16.735**
Variance in education level	0.2532	0.0401	39.890***
Staff size	-0.0016	0.0006	8.678*
Mean system age	0.0912	0.0183	24.895***
Constant	-0.337		
Adjusted R-square	0.899		
F-ratio	20.079***		

*p≤.10 **p≤.01 ***p≤.001

In summary, the results of the correlation analysis and the exploratory regression analyses are consistent with the working hypothesis. In the present sample, problems associated with the maintenance and management of the application system portfolio are explainable in significant part by demographic variables associated with both the application systems staff and the systems themselves.

CONCLUSION

Organizational demographics is thus confirmed to be a promising means of study of IS organizations, as originally suggested above. The particular suitability of IS organizations for this form of analysis is based on the nature of the IS task, it is argued. As depicted in Figure 1b, this task focuses on the development and maintenance of an application system portfolio which itself possesses attributes amenable to demographic analysis. Together, the demographics of the IS staff and the application system portfolio offer substantial potential for explaining fundamental problems in IS management.

In the case of IS organizations, therefore, demographic analysis may be extended to a form of task analysis. Might other organization types also lend themselves to such study? We suggest two such possibilities. First, certain organizations based fundamentally on projects (e.g. architectural firms and development engineering organizations) might be suitable candidates where the projects are knowledge-based and possess extended life cycles in addition to portfolio properties (as with information systems). Secondly, certain organizations involved in case work (e.g. legal firms and governmental agencies) might also be good candidates, given the same conditions. Thus, the analysis suggested here would appear to have application to organization theory in general.

Finally, the present study has implications for IS management practice as well. In a sense, the manager of any medium to large scale IS organization already attends to the demographics of his or her unit in concern about the costs (or benefits) of staff turnover, the wisdom of new technology implementations, or the right assignment for each staff member. IS managers are faced each day with the heterogeneity inherent in their staffs and portfolios. Not all systems are in structured code or employ the data dictionary. Not all the staff has a college education. This variety is frequently regarded as something to be overcome by diligent allocation of resources. Principles of portfolio management, on the other hand, regard variety, if properly managed, as insurance in a world of rapid change. The argument we put forth here is that variety in the portfolio maintenance task is best managed by matching it with variety in the IS staff.

In order to be more aware of the relevant dimensions of variation, the IS manager should begin to attend more closely to the demographics of his or her unit, and in particular to attend to measures of dispersion in addition to measures of central tendency. In our study we observed that many IS organizations are less than well informed on their basic demographics. Not only was aggregate data on systems sometimes difficult to obtain, comparable data on staff was even harder to come by, and virtually no reports of aggregate staff characteristics existed to serve IS management. Given the findings of the present study, this is a deficiency deserving of remedy.

REFERENCES

Boehm, B. W. "The Economics of Software Maintenance," Software Maintenance Workshop, Naval Postgraduate School, Monterey, California, December 6-8, 1983.

Brooks, F. P., Jr. *The Mythical Man-Month.* Addisson-Wesley, Reading, Massachusetts, 1975.

Couger, J. D. and Colter, M. A. *Motivation of the Maintenance Programmer.* Cysys, Colorado Springs, Colorado, 1983.

Galbraith, J. *Designing Complex Organizations.* Addison-Wesley, Reading, Massachusetts, 1973.

Ives, B. and Olson, M. H. "User Involvement and MIS Success: A Review of Research," *Management Science,* Volume 30, Number 5, 1984, pp. 586-603.

Katz, R. "Project Communication and Performance: An Investigation into the Effects of Group Longevity," *Administrative Science Quarterly,* Volume 27, Number 1, March 1982, pp. 81-104.

Lientz, B. P. and Swanson, E. B. *Software Maintenance Management,* Addison- Wesley, Reading, Massachusetts, 1980.

Lientz, B. P. and Swanson, E. B. "Problems in Application Software Maintenance," *Communications of the ACM,* Volume 24, Number 11, November 1981, pp. 763-769.

McFarlan, W.F. "Portfolio Approach to Information Systems," *Harvard Business Review,* Volume 59, Number 4, July-August 1981, pp. 142-150.

McLean, E. R. "End-Users as Application Developers," *MIS Quarterly,* Volume 3, Number 4, December 1979, pp. 37-46.

Mitchell, T. R. "An Evaluation of the Validity of Correlational Research Conducted in Organizations," *Academy of Management Review,* Volume 10, Number 2, April 1985, pp. 192-205.

Nolan, R. L. "Managing the Crisis in Data Processing," *Harvard Business Review,* March-April, 1979.

Nolan, R. L. "Managing the Advanced Stages of Computer Technology: Key Research Issues," in *The Information Systems Research Challenge.* F. W. McFarlan (ed.), Harvard Business School Press, Boston, Massachusetts, 1984.

Pfeffer, J. "Organizational Demography," in *Research in Organizational Behavior, Volume 5,* L. L. Cummings and G. M. Staw (eds.), JAI Press, Greenwich, Connecticut, 1983, pp. 299-357.

Pfeffer, J. "Organizational Demography: Implications for Management," *California Management Review,* Volume 28, Number 1, Fall 1985, pp. 67-81.
Swanson, E. B. "Organizational Designs for Software Maintenance," *Proceedings of the Fifth International Conference on Information Systems,* Tucson, Arizona, November 28-30, 1984, pp. 73-81.
Swanson, E. B. and Beath, C. M. *The Division of Labor in Software Development and Maintenance,* Information Systems Working Paper #3-86, Graduate School of Management, University of California, Los Angeles, October, 1985.
Terborg, J. R. and Lee, T. W. "A Predictive Study of Organizational Turnover Rates," *Academy of Management Journal,* Volume 27, Number 4, 1984, pp. 793-810.
Wagner, W. G., Pfeffer, J. and O'Reilly, C. A. "Organizational Demography and Turnover in Top-Management Groups," *Administrative Science Quarterly,* Volume 29, Number 1, March 1984, pp. 74-92.