An Examination of the Software Development Backlog Problem

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ABSTRACT

The software development backlog problem has been suspected of being widespread in the United States, threatening the competitiveness of some organizations. This paper reports the results of a national survey of DP/MIS managers in the United States regarding their software development situation. The findings substantiate the pervasiveness of the problem and identify some of its correlates. Several untested beliefs related to the backlog problem are verified empirically. Implications of the findings are discussed.

INTRODUCTION

The terms backlog, application backlog, and systems backlog relate to the backlog of applications or requests for software development that have to be met. This backlog can be measured in terms of the time it would take to meet these requests with existing resources. Such requests may take the form of upgrading existing systems, adding new systems that interface with the existing systems, or developing autonomous new systems. In many organizations this backlog has grown to be a threat to the productivity of the entire organization (10). Even the defense industry, which is critical to national security, is no exception to the backlog malaise. It is believed that the backlog problem in the defense industry contributed to the delayed debut of the controversial B-2 Stealth bomber, prompting the federal government to charter a think tank to help mitigate the problem (13). The magnitude of the problem is so enormous that the word "logjam" is used to describe the backlog problem.

In addition to the backlog problem, there is the phenomenon of the "hidden" backlog. This represents application requests that users don't even bother to submit because the visible backlog is so substantial (1, 6). Although the hidden backlog problem is indeed real, albeit difficult to measure, our research study focuses on the documented backlog problem.

A perusal of the literature on the backlog issue raises a number of questions such as: How pervasive is the backlog problem? Is it related to company size and the size of a company's data processing (DP) department? Is there a relationship between the number of personal computers (PCs) in an organization and its backlog? Is there a relationship between an organization's experience with PCs and its backlog situation? Does the homogeneity or diversity of PCs used in an organization affect its backlog situation? And, finally, what can an organization do to mitigate, if not solve, its backlog problem?

Although the literature on applications backlog suggests answers to some of the above questions, many of these answers lack empirical validation. For example, while the presence of the backlog problem has been documented, is the problem related to company size? Little is known in this regard. Concerning the size of DP departments and the backlog problem, some have suggested that increasing DP personnel will reduce the backlog (2, 4). Contrary to this idea, members of the New York Council point out that it does not seem to matter whether their staffs consist of 200 programmers, 75 programmers, or only four programmers; all these staffs seem to be coping with four-year backlogs (12).

Does the use of PCs affect the magnitude of the problem? In an article titled, "Micros Ease Backlog Blues," the author, Robbin Juris (9), suggests that the introduction of micros will mitigate the backlog problem. In this regard, Charles S. Parker (11) notes, "Theoretically, as end users become capable of meeting their own computing needs, both the visible and invisible applications backlog will be reduced in size." In some contrast to this view, Vaughn G. Johnson (8) believes that turning to PCs and end user computing is only a partial solution to the application backlog problem because a significant amount of the data that is needed for decision making is not readily accessible to free standing PCs.

Regarding the relationship between the number of brands of PCs in use in a company and its backlog situation, it would appear that as the number of brands of PCs proliferates, the problems of micro interfacing, or the transferability of application software, increase. Furthermore, an increased need for training, customized to the various PC brands, would seem to place additional demands on a DP department. Consequently, standardizing PCs across the organization would reduce the workload of a DP department, allowing more time to deal with and reduce the backlog. While this seems reasonable, there is no empirical evidence to confirm or deny this notion.

Answers to these questions could provide a better understanding of the backlog problem and serve to shed some light on remedies for the backlog problem. Given this, an empirical study was undertaken. The specific objectives and methodology of this research study are described next.

RESEARCH OBJECTIVES AND METHODOLOGY

The research objectives of this study were to determining:

- How pervasive is the backlog problem?
- Is the magnitude of the problem related to company size?
- Is the magnitude of the problem related to the size of the DP department?
- What effect, if any, does the use of PCs in the organization have on the backlog problem?
- If an organization has more experience (in terms of time) with the use of PCs, does it affect the magnitude of the backlog problem?
- Does the homogeneity of diversity of PCs used in an organization impact on the problem?
- In the context of the findings related to the above questions, what measures can be implemented by organizations having a backlog problem?

With the above research objectives in mind, a survey of data processing managers of 2,000 companies was undertaken. After the initial cutoff time of four weeks for the mailed survey, a second mailing was completed to the non-respondents. A total of 456 completed questionnaires was returned for a response rate of 23 percent.

SAMPLE DESCRIPTION

The distribution of respondents by their titles in the organization in shown in Table 1. As can be seen, the participants hold positions of responsibility and authority. They represent systems managers, directors of the MIS function, vice presidents and a few presidents. The responses came from a good cross section of companies in terms of company size.

The responding companies were classified into three groups. Companies with revenues up to $25 million were classified as small, those with revenues between $26-$250 million were classified as medium, and companies with revenues in excess of $250 million were classified as large. This classification scheme is consistent with the Federal government's definition of a small business and with classification norms commonly used in research. Of the total responses received, 106 (23.2 percent) were from small companies, 166 (36.4 percent) were from medium-size companies, and 120 (26.3 percent) were from large companies. Figure 1 shows the response rate by company size. As can be seen, the largest percentage of responses came from companies with annual revenue of $26 million to $250 million. A total of 64 of the respondents (14.0 percent) did not indicate annual company revenue.

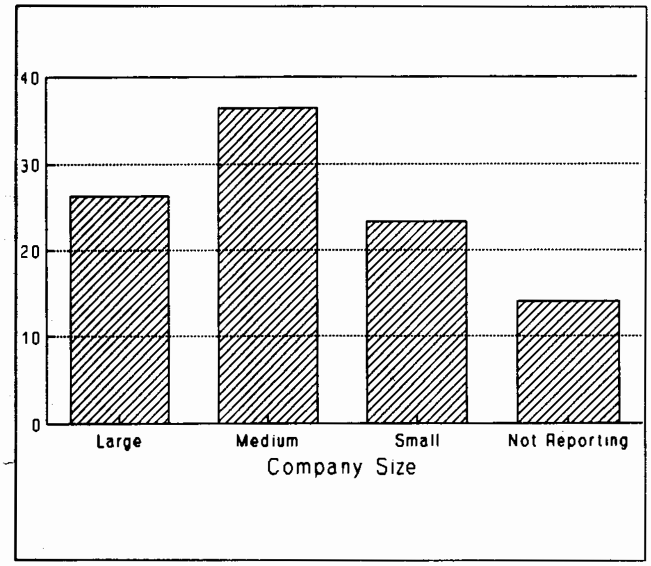
Table 1. Distribution of Respondents according to their Titles

Title	Percentage of Respondents
President / Executive VP / Vice President	6.8
Director / Partner / Manager of Information Center / Manager Technical Services / Consultant	37.3
Functional Manager / Manager Computer Operations / Office Manager / Office Automation	32.1
New and Unique title	13.6
Systems / Technical Manager / Systems Analyst / Programmer or Engineer	10.2

SURVEY QUESTIONNAIRE AND DATA ANALYSIS

An initial questionnaire was constructed on the basis of personal interviews with local managers and directors of data processing/MIS departments. This questionnaire was then pretested nationally on a sample of 40 DP managers, and appropriate changes were made as a result of this pretest.

Figure 1. Response Rate According to Company Size (Reported as Percentages)



The questionnaire used in the survey, among other things, collected information on company size, the number and use of PCs and mainframes in the organization, the length of time PCs were in use, the number of brands of PCs being used, the size of the DP department in terms of number of employees, the extent of the backlog in terms of months, and what measures were being tried to reduce the backlog.

The data was analyzed using bivariate analysis and the chi-square test, as well as discriminant analysis. The bivariate analysis examined the relationship between the magnitude of an organization's backlog in terms of time and the following independent variables: (1) size of the DP department, (2) the number of PCs in use in an organization, (3) the number of years the organization had been using PCs, and (4) the number of brands of PCs in use in the organization.

Discriminant analysis was used to obtain the linear combination of variables included in the bivariate analysis that best discriminated between the companies having a backlog of over two years and those that had a backlog of under one year. This linear discriminant function can be expressed as:

$$Z = w_1x_1 + w_2x_2 + \ldots + w_nx_n$$

where

Z = the organization's discriminant score

w = the computed discriminant weights

x = the selected independent variables

The discriminant function was derived from approximately 75 percent of the sample of 88 organizations and then tested on the 25 percent "hold out" sample for predictive validity. There is no definitive rule about the relative sizes of these two sample groups. Some researchers prefer a 50-50 split, others a 60-40 or 75-25 split between analysis and the "hold out" sample groups (7). We chose a 75-25 split. The larger sample was used to develop the discriminant function. This function was then tested on the smaller sample for predictive validity. The justification for dividing the total sample into two groups is to eliminate the upward bias that would occur if the organizations used in developing the discriminant function are the same as those used in testing the function for predictive accuracy (5). The use of the significantly larger sample to develop the discriminant function obtained better reliability of the function itself.

SURVEY FINDINGS

The extent of the backlog problem can be seen from the data in Table 2. Surprisingly, 8.8 percent of the responding companies indicated no backlog. The data in Table 2 show that 62.8 percent of the companies had a backlog of less than one year and 37.2 percent had a backlog of over two years.

Table 2. Extent of Backlog (Reported in Percentages)

Period of Backlog	Percent of Companies
None	8.8
Up to 6 months	33.0
6–12 months	21.0
12–24 months	16.2
Over 24 months	21.0

Is the backlog situation more acute in smaller, midsize or larger companies? This question has not been addressed in the research literature. The data in Table 3 indicate that large companies are much more likely to have longer backlog periods. For example, 34.8 percent of the large companies have a backlog of over two years, whereas only 9.1 percent of the small companies and 16.4 percent of the medium-size companies have a backlog of over two years. Conversely, 82.8 percent of the small companies reported having a backlog of one year or less, as compared to 68.9 percent of the medium-size companies and 39.8 percent of the large companies. The relationship between company size and backlog is significant at the 0.001 level. Clearly, the backlog situation is more acute in the larger companies.

Table 3. Company Size and Backlog
(Reported in Percentages)

Company Size	Backlog of One Year or Less	Backlog of 1–2 Years	Backlog of Over 2 Years
Small	82.8	8.1	9.1
Medium	68.9	14.7	16.4
Large	39.8	25.4	34.8

$X^2 = 46.94 \quad \alpha = 0.001$

Because the backlog problem is greater in large companies, the analysis that follows focuses exclusively on the large companies. There were a total of 120 large companies. Of these companies those with a backlog of one year or less and those with backlogs of over two years were analyzed further. The exclusion of large companies reporting a backlog between one and two years was motivated by the desire to obtain a clearer picture and understanding of the differences between companies having a significantly greater backlog of two years or more. This elimination resulted in a sample size of 88 large companies.

Is the size of the DP department in a large company related to the extent of the backlog? There is a belief that one way of reducing backlog is by employing more systems development personnel (2, 4). The data in Table 4 is interesting because it shows that companies with larger DP departments are more likely and not less likely to have a backlog. (The size of the DP department was defined in terms of the ration of DP personnel to company sales. Companies with a ratio above the median ratio were classified as having large DP departments and vice versa.) For example, 57.6 percent of companies with the larger DP departments had a backlog of over two years, whereas only 24.1 percent of the companies with the smaller DP departments had a backlog of over two years. The relationship between the size of DP departments and backlog is significant at the 0.003 level. It therefore appears that increasing the size of a DP department will not necessarily reduce the backlog. The situation here may be that of demand increasing as the supply is augmented, a case of supply creating its own demand.

There has been some speculation and discussion on the impact of PCs on the backlog problem (3, 9, 14). Will the backlog be reduced as more micros are introduced in a company as a result of an increase in end user computing? The ratio of the number of PCs to sales was used as a measure of the use of PCs in a company. The companies were then classified into two groups, those above the median ratio and those below. The data in Table 5 does not support the notion that having more PCs will reduce the backlog. The chi-square value of 0.366 is not significant (α = 0.54). For example, 50.0 percent of the companies over the median ratio of PCs to sales have a backlog of one year or less. For companies below this median ratio, this number is 56.5 percent. A possible explanation for this is that the number of PCs in an organization is not as relevant to the backlog problem as the number of PCs in a *networked* environment. Furthermore, it is quite conceivable that the proliferation of PCs in an organization, at least initially, increases the workload of the DP department by way of requests for assistance, and workshops and programs aimed at educating

Table 4. Size of DP Department and Backlog for Large Companies
(Reported in Percentages)

Size of DP Department*	Backlog of One Year or Less	Backlog of Over 2 Years
Ratio Below the Median	75.9	24.1
Ratio Above the Median	42.4	57.6

* Ratio of Number of Persons in the DP department to total sales

$X^2 = 8.76 \quad \alpha = 0.003$

Table 5. Number of PCs and Backlog in Use for Large Companies
(Reported in Percentages)

Number of PCs in Use*	Backlog of One Year or Less	Backlog of Over 2 Years
Ratio Below the Median	56.5	43.5
Ratio Above the Median	50.0	50.0

* Ratio of Number of PCs to total sales

$X^2 = 0.366 \quad \alpha = 0.540$

the neophyte PC user, which in turn exacerbates the backlog. However, as new PC users gain more experience and expertise in using PCs, the situation may indeed reverse itself and lead to a reduction of the backlog.

The data in Table 6 look at the relationship between the number of years of experience with PCs and the magnitude of the backlog. This relationship is not statistically significant. However, a closer investigation of the numbers in the cells suggests that, as companies gain more experience with the use of PCs, the backlog may decrease. For example, 39.4 percent of the companies with less than three years of experience have a backlog of over two years.

Table 6. Backlog and Experience with PCs for Large Companies
(Reported in Percentages)

Number of Years PCs in Use	Backlog of One Year or Less	Backlog of Over 2 Years
Ratio Below the Median	50.0	50.0
Ratio Above the Median	60.6	39.4

$X^2 = 0.928 \quad \alpha = 0.330$

The data in Tables 5 and 6, when viewed in concert, suggest that the mere introduction of micros in an organization by itself will not reduce the backlog, at least initially. As the organization introduces more PCs, incorporates them into the information network and gains more experience with PCs, the backlog could be reduced over a period of time.

The data in Table 7 look at the relationship between the number of brands of PCs in an organization and the magnitude of the backlog in the organization. The chi-square test shows no significant relationship between these two variables. We can conclude, therefore, that the number of brands of PCs used by an organization has no impact on the magnitude of its backlog.

RESULTS OF DISCRIMINANT ANALYSIS

The four independent variables in the bivariate analysis (size of DP department, number of PCs in use, number of years of experience with PCs and the number of brands of PCs in use) were taken collectively and analyzed using the stepwise discriminant analysis procedure. The stepwise procedure sequentially selects the "next best" discriminating variable at each step until all variables meeting a specific F-ratio that is consistent with the desired level of significance are utilized. This method was preferred to the direct method (in which all the independent variables are entered into the analysis concurrently) because it utilizes variables on the basis of their discriminating power and ignores the variables that have a non-significant impact on the discrimination.

Table 7. Backlog and Number of Brands of PCs in Use for Large Companies
(Reported in Percentages)

Number of Brands of PCs in Use	Backlog of One Year or Less	Backlog of Over 2 Years
One	59.4	40.6
Two	48.0	52.0
Over two	51.8	48.4

$X^2 = 0.78 \quad \alpha = 0.670$

The results of the stepwise discriminant analysis are presented in Table 8. Of the four independent variables in the analysis, two were found to be significant in discriminating between organizations having a backlog over one year or less and organizations having a backlog of over two years. These two variables are the size of the DP department and the number of years the organization had been using PCs. As can be seen in the top half of the table, the size of the DP department is positively related to backlog and has a standardized discriminant coefficient of 0.92 and a loading of 0.81. The second variable is negatively related to backlog and as a standardized discriminant coefficient of 0.59 and a loading o -0.42. Both of these variables are significant at the 0.01 level.

The lower portion of Table 8 shows the classification results when the obtained discriminant function is tested on the "hold out" sample. As can be seen, 71.4 percent of the organizations in the "hold out" sample were classified correctly. This proportion of correct classification is significantly greater than the 54.5 percent correct classification that would have occurred on the basis of chance. The results of this discriminant analysis are consistent with the findings of the bivariate analysis using chi-square.

CONCLUSIONS

The survey data reinforce the view that the majority of DP departments of companies in the United States no have a backlog of work requests that relate to application software, systems and/or information development. The magnitude of the backlog seems to be directly related to company size. Typically, larger companies have longer backlogs. The difference in the reported backlog between small, medium and

Table 8. Results of Stepwise Discriminant Analysis

Significant Variables	Standardized Discriminant Coefficient	Loadings	Level of Significance
Size of DP department	0.92	0.81	0.01
Number of years PCs in use	-0.59	-0.42	0.01

Classification Results on Hold-Out Sample

		Predicted Group	
Actual Group	Number of cases	Up to 1 year of backlog	Over 2 Years of backlog
Up to 1 year of Backlog	5	60.0%	40.0%
Over 2 Years of Backlog	16	25.0%	75.0%

Correct classification = 71.4%

Chance criteria = 54.5%

large companies is quire significant.

When the large companies are analyzed separately, some interesting findings emerge. These are summarized below.

1. Companies with larger DP departments generally have a longer backlog of work requests.
2. There is no relationship between the number of PCs in a company and the magnitude of its backlog.
3. There is some evidence to suggest that if a company uses PCs for a longer time, its backlog may be reduced.
4. The diversity or homogeneity of PCs (in terms of brands in a company) does not have any significant relationship with a company's backlog situation.

A word of caution in extrapolating too much from the presented data and analysis is useful. The "associative" nature of the survey research method employed in this study dictates that causal extrapolations must be made with care and with the benefit of additional insights. For example, companies having an acute backlog problem may indeed be the very companies who expand their DP departments. Thus, the larger DP department is a result of a backlog problem and not its cause!

Perhaps the most likely response by an organization to the backlog problem is to increase the number of DP/Systems personnel. This in itself, however, is unlikely to resolve the problem. It appears that an increase in supply seems to create additional demand. Given this, the need for a multidimensional approach that targets both the demand and the supply side of the equation might be necessary. Measures that appear promising in controlling the demand side include the use of chargebacks to users/departments requesting software development assistance from the DP department. Such charges would discourage frivolous requests for software development or modification. A possible risk here is that very meaningful software development requests may be neglected. An alternative to using chargebacks is screening and prioritizing criteria. These criteria must reflect the strategic objectives of the organization.

Although the results of the chi-square test on the relationship between backlog and the number of years that PCs have been used in an organization is not significant, a closer examination of this data does suggest that, as an organization gains more experience with the use of PCs, its backlog situation may improve. It is interesting to note that the discriminant analysis does support this view. The number of years that an organization has been using PCs has a negative standardized discriminant coefficient that is significant at the 0.001 level. This suggests that as an organization gains more experience with PCs, its backlog situation improves. The implications of this is that organizations should introduce PCs and, more important, support the use of PCs. This can be accomplished by providing training, workshops, and by continuing education opportunities for its employees. Supporting and encouraging end user computing is likely to pay off in the long run in terms of a reduced backlog. Integrating PCs into the information network would further improve the backlog.

REFERENCES

(1) Alloway, R.M. and Quillard, J.A., "User Managers' Information Needs," *MIS Quarterly,* Vol. 7, No. 2, June 1983, pp. 27-41.

(2) Brancheau, J.C. and Wetherbe, J.C., "Key Issues in Information Systems Management," *MIS Quarterly,* Vol. 11, 1987, pp. 23-45.

(3) Brown, Gary D., and Sefton, Donald H., "The Micro versus the Application Logjam," *Datamation,* January 1984, pp. 96-104.

(4) Buss, M.D., "Penny-wise Approach to Data Processing," *Harvard Business Review,* July-August 1981, pp. 111-117.

(5) Frank, R.E., Massey, W.F. and Morrison, D.G., "Bias in Multiple Discriminant Analysis," *Journal of Marketing Research,* Vol. 2, No. 3, August 1965, pp. 250-58.

(6) Frenzel, Carroll W., *Management of Information Technology,* Boyd and Fraser Publishing Co., 1992, pp. 195-96.

(7) Hair, Jr., J.F., Anderson, R.E. and Tatham, R.L., *Multivariate Data Analysis,* Second Edition, Macmillan Publishing Company, 1987, p. 82.

(8) Johnson, Vaughn G., *Information Systems: A Strategic Approach,* Mountain Top Publishing, 1990, p. 198.

(9) Juris, Robbin, "Micros Ease Backlog Blues," *Computer Decisions,* May 6, 1986, pp. 68-73.

(10) McFadden, Fred and Discenza, Richard, "Confronting the Software Crisis," *Business Horizons,* November-December 1987, pp. 68-73.

(11) Parker, Charles, *Management Systems Strategy and Action,* McGraw-Hill Publishing Company, 1989, p. 712.

(12) Rhodes, Jr., Wayne, "The Applications Backlog," *Computer Decisions,* May 6, 1986, p. 73.

(13) Schlender, Brenton R., "How to Break the Software Logjam," *Fortune,* September 25, 1989, pp. 101-112.

(14) Wolfe, Curtis and Vondle, David, "How to Solve the Information Backlog," *Management Review,* March 1983, pp. 46-50.

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