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Technology Use and Performance: A Field Study of Broker Workstations*

Henry C. Lucas, Jr. and V.K. Spitler
Stern School of Business, New York University, 44 West Fourth Street, New York, NY 10012, hlucas@stern.nyu.edu, vspitler@stern.nyu.edu

ABSTRACT

Organizations invest in technology with the expectation that it will contribute to performance, and members of the organization must use technology for it to make a contribution. For this reason, it is important for managers and designers to understand and predict system use. This paper develops a model of workstation use in a field setting where the use of the system is an integral part of the user's job. The model is based on the Technology Acceptance Model (TAM), which we extended to include social norms, user performance, and two control variables. Brokers and sales assistants in the private-client group of a major investment bank provided data to test our extended model. The core perception variables in TAM do not predict use in this study. Social norms and one's job requirements are more important in predicting use than workers' perceptions about ease of use and usefulness. The paper discusses the implications of these findings and suggests directions for future research.

Subject Areas: Field Study, IS Implementation, Performance, Survey Research, and Technology Acceptance Model.

INTRODUCTION

The Commerce Department estimates that 45% of capital investment in the U.S. is for information technology (U.S. Department of Commerce, 1998); *BusinessWeek* estimates that there are 63 PCs per 100 workers in the U.S. (including machines at home), and others have calculated that one in three U.S. workers uses a computer on the job. One brokerage firm is investing over $700 million in new technology for its brokers. The recent mergers of Bank of America and Nations Bank, and Citibank and Travelers will produce two new companies, each of which has a combined annual information technology budget of some $4 billion before any savings from a merger.

There will be little return from investments in information technology (IT) if workers fail to accept it or to fully utilize its capabilities. How can managers and

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developers of advanced technology predict its use and likely success when making investment decisions? The purpose of this research study is to model knowledge workers' use of a new, multifunctional, windowed workstation, including the relationship between use and job performance, in a field setting where use of the system is an integral part of the worker's job.

This paper develops a model to predict the use of a workstation designed for private-client brokers at a major investment bank. These brokers work with sales assistants to provide investment services for high net worth customers of the bank. The model also includes performance in this complex work setting. In comparison with many past studies of the use of technology and job performance, the present study includes all of the following characteristics:

- A field setting in a real organization,
- Users for whom the technology is an integral part of their work,
- A multifunctional workstation with a windowed interface and network technology,
- Complex tasks, some of which are better supported by the workstation than others,
- Two different groups of workers performing different tasks using the same technology,
- The opportunity to measure performance at the level of the individual.

The combination of these features in a single study is unique. For example, DeLone and McLean (1992) reviewed 27 studies of the use of information systems. Of these studies, eight were conducted in a laboratory and 19 in the field. For the field studies, 11 examined workers' use of their firms' systems in general, whereas eight examined specific applications including DSS, planning systems, and PERT. None of the studies appears to include windowed, multifunctional workstations. In a review of studies of the Technology Acceptance Model in the next section, we found 5 out of 11 studies involved a field setting. Of these, two were of mail systems and none involved a workstation. We were unable to locate any study that encompasses all of the characteristics of the research design reported here.

PRIOR RESEARCH

There have been a number of studies of implementation and the use of new technology; reviews and summaries of some of these studies may be found in Swanson (1988), DeLone and McLean (1992), and Lucas, Schultz, and Ginzberg (1990). Davis' (1989) Technology Acceptance Model (TAM), based on the Theory of Reasoned Action developed by Fishbein and Ajzen (1975), has been widely applied. Because of TAM's strong base in theory and the relatively large number of studies that support it, this model provides the starting point for building our research model relating technology use and performance.

In the original test of TAM (Davis, 1989), high levels of perceived usefulness and perceived ease of use predicted intentions to use information technology. Davis found that perceived ease of use acts primarily through perceived usefulness to influence intentions to use. (Davis' results supported his model. Several other studies also provide evidence for TAM). See Table A1 in Appendix A for a summary of this research. Davis, Bagozzi, and Warshaw (1989) compared a model based on the Theory of Reasoned Action with TAM and found mixed results for both models, though there was support for the key variables of perceived usefulness and perceived ease of use, and their positive relationship with behavioral intentions to use a system. Mathieson (1991) also compared TAM with the Theory of Planned Behavior (TPB) and found that both models predicted intention to use well, but that TAM was slightly better from an empirical view.

Taylor and Todd (1995b) looked at TAM and the Theory of Planned Behavior in a longitudinal study of a resource center. They concluded that the Theory of Planned Behavior with a decomposed belief structure provided more insights than TAM, though TAM received support from their data. In another study drawn from their data (Taylor & Todd, 1995a), these same authors found that TAM, modified to include subjective norms (as included in the original TRA) and perceived behavioral control, performed adequately in predicting use for both experienced and inexperienced users. Straub, Limayem, and Karahanna-Evaristo (1995) used TAM to compare self-report and computer monitored voice mail use in a field setting; their focus was on finding appropriate measures of usage rather than a test of TAM. Szajna (1996) found that a revised TAM, dropping attitudes from the model and making a slight change for pre- versus post-implementation, predicted use, but that adding a variable to account for experience with the technology would be a worthwhile extension of the model. Szajna also recommended that measures of actual use may work better than self-report measures, at least when studying the use of email.

Venkatesh and Davis (1996) extended TAM to include external variables that might predict perceived usefulness and perceived ease of use. They found that an objective measure of system usability had an impact on perceptions only after direct experience with the system. Jackson, Chow, and Leitch (1997) focused on behavioral intention to use a system in a field study of a number of systems across different organizations, extending the model to include constructs such as user involvement. Their results suggest that involvement needs to be broken into psychological and participative components to understand its impact on systems development.

Igbaria, Zinatelli, Cragg, and Cavaye (1997) used an extended version of TAM to study personal computer use in small businesses in New Zealand. They added external factors related to support and training from within and outside the organization. Their results supported TAM and the extensions. Subramanian (1994) also found support for the measurement of the perception variables, ease of use and usefulness, in TAM.

Although there are many studies of TAM, most of the research has been conducted in the laboratory with student subjects using single-function technology such as word processors. Researchers have conducted a small number of studies in a field setting, and only two of the studies featured computer systems as opposed to technology such as voice mail. These two studies sample from multiple organizations and include a variety of technologies, making it difficult to draw conclusions about any particular type of technology such as a managerial workstation

(Jackson et al., 1997; Igbaria et al., 1997). The objective of our research is to examine the use of technology and staff members' job performance in a field study with users who have multifunctional workstations designed to support relatively well-defined tasks, and where the technology is an integral part of work life. Users must use information technology in order for an organization to receive a return from its investments in IT. Managers who can predict and influence use should obtain more benefits from IT than those who ignore the issue of technology use.

THE RESEARCH MODEL

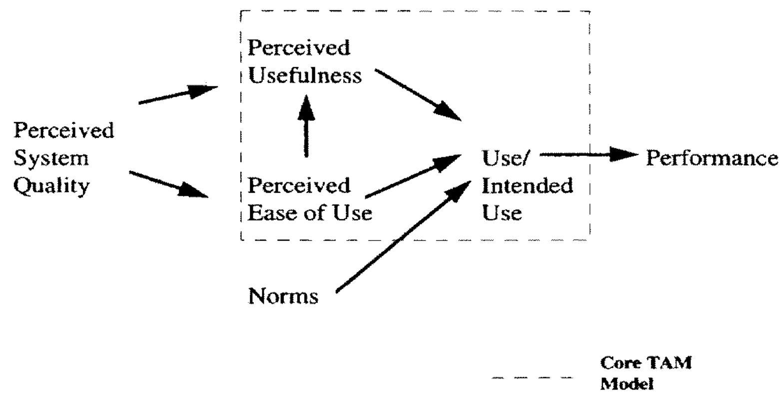
The research model is found in Figure 1. The core of the model, delineated by dashed lines, is from TAM. Perceived ease of use and perceived usefulness predict use or intended use. Based on past research (Davis, 1989), we also include a link between perceived ease of use and perceived usefulness. We have added three variables to TAM to adapt it for a field study of broker workstations: perceptions of system quality, subjective norms, and user performance. These variables are based on our analysis of the field setting and the system in the bank, and on past research that has extended TAM. In particular, we draw upon Davis' extension of TAM to include external variables, the DeLone and McLean (1992) model which includes perceived quality, the importance of social norms in the original TRA, and past implementation and IT value studies that are concerned with user and organizational performance.

Davis (1989) described a set of external or antecedent variables that influence perceived ease of use and perceived usefulness. In a recent study, Venkatesh and Davis (1996) included two antecedent variables, self-efficacy and objective usability, in a test of TAM. These researchers argued that understanding the antecedents of perceived ease of use is important for theory and for the design of training programs, assuming one accepts the causal implications of the model.

Venkatesh and Davis (1996), working in a laboratory setting, were able to create an objective measure of usability by comparing users' times on a series of tasks to the times of experts. Where users' times are closer to those of experts, the system has higher usability. In a field setting, tasks are quite varied, and the identification of experts would be difficult. As discussed in the next section, this study used a subjective measure of usability—perceptions of system quality—as an antecedent variable for perceived ease of use and perceived usefulness. Modeling perceived quality as a predictor of the two TAM perception variables is also consistent with the model of use proposed by DeLone and McLean (1992) and Seddon (1997).

TAM is based on Ajzen and Fishbein's (1980) Theory of Reasoned Action, which recognizes the importance of social norms in influencing individual behavior. According to our theory, the more a person perceives that others who are important to him think he should perform a behavior, the more he will intend to do so (Ajzen & Fishbein, p. 57). Early studies by Davis failed to show significant relationships between social norms and use, so this variable is not generally included in TAM. However, Thompson, Higgins, and Howell (1991) found a relationship between social norms and PC utilization in a large manufacturing company, and Hartwick and Barki (1994) found weak associations between social norms and

Figure 1: The research model.



other variables in an empirical study of participation. Our study takes place in the field rather than a laboratory, where management and colleagues are likely to influence users. Thus, social norms are included in the research model. Both theory and Thompson et al.'s study suggest a direct relationship between norms and use as shown in Figure 1.

An addition to the present research compared to past studies is the inclusion of variables that predict performance. Organizations such as investment banks invest in technology for a number of reasons. For systems like the one studied here, there are a variety of justifications for an investment:

- To reduce costs by making sales assistants more productive, reduce market data fees, and/or consolidate various systems.
- To improve the performance of brokers and sales assistants.
- To impress customers, provide better service, and encourage them to do more business with their broker.

The data in this study make it possible to look at the second reason above for investing in the system, improved performance for individuals. The model posits a direct link between system use and future performance.

The research model also includes two control variables (not shown in Figure 1), which come from our analysis of broker and sales assistant tasks, and from past research on factors that influence performance. The first objective is to predict use without the influence of differing levels of workload. In a laboratory setting one might expect that all students will be confronted with about the same workload. In the case of broker workstations, there is high variance in the workload for each user. For example, it takes the same effort (number of keystrokes, number of screens) to enter a trade for a hundred dollars as it does for a million dollars. The broker with 10 very large accounts confronts a different kind of workload than a broker with 100 average accounts, so that usage can be expected to vary according to workload.

The second control variable is prior performance. The study includes prior performance in predicting contemporary or future performance, since much performance is influenced by historical performance (Weill, 1992). Past performance can also influence system use directly. Lucas (1975) found that low performing members of a sales staff were more likely to use a sales information system to solve problems related to their performance than were high performance sales representatives.

THE STUDY

The data to test the research model came from a sample of brokers and sales assistants at a major investment bank. Groups of brokers and assistants work with private clients, customers with a high net worth. The brokers' objective is to help clients manage their assets, whereas sales assistants support the brokers. This business is valued by the bank because it tends to be stable compared to the volatility the bank experiences in other activities. Both brokers and sales assistants are highly compensated for their efforts.

The Tasks

Brokers provide advice and order execution for a group of clients. Brokers are also constantly seeking new clients to replace those lost to attrition or to the competition. Brokers tend to work in groups of two to four, supported by one or more sales assistants per broker. The job of sales assistants is varied; they maintain account information and serve clients in a number of ways. Some have frequent phone contact with clients and may take on some of the broker's normal duties when the broker is not available.

Prior to the fall of 1994, brokers and assistants had access to relatively limited information technology. They used a variety of quotation systems, and a number worked with their own analytic, word processing, and spreadsheet programs on personal notebook and/or home computers. Some of these workers felt that the bank had underinvested in technology for their division. In late 1994, the bank implemented a major new system for the private-client brokerage unit in order to provide better support and client service, and to reduce administrative overhead. This system includes a Sun workstation for each broker and each sales assistant. The workstation runs a windowed interface with the Unix operating system. The workstations are networked to servers and to the corporate mainframe computer, which maintains transaction processing and accounting data.

The workstation has three main applications: market data, office software, and mainframe access. Market data include snap stock quotes in real time from the various exchanges, and monitoring functions that signal when an event happens, such as a stock hitting a certain price on the NYSE. Market data are a fundamental requirement for brokers and sales assistants who must use them to answer customer queries and execute orders. The investment bank purchases market data; the market data package includes a series of analytic routines for research; for example, functions to graph stock prices and volumes.

Office applications include three common functions: word processing, spreadsheets, and presentation graphics. The bank purchased these applications for Unix, which are similar to Microsoft Office for a PC.

The last major application is access to mainframe data. All information on a client's portfolio is on the mainframe. To access client records and to perform maintenance on them, users must work with existing mainframe applications. Once within the mainframe window, the graphical user interface is no longer active and all work must be done in character mode.

At the time we collected data, there were 71 brokers and 81 sales assistants in the personal-client group. Of these, 54 brokers and all sales assistants completed questionnaires about the variables in the model of Figure 1, except for performance data, which came from bank records. The majority of respondents completed the survey in a conference room on one of two days. About 20% of the respondents could not complete the survey on one of these days and replied later by mail. All respondents completed the survey before the end of 1994. Our understanding is that nonparticipants felt they could not afford to spend time completing the survey. The bank was unable to provide performance data on five brokers who were new to the job or firm. Based on the calculations for sales assistants' performance described in the next section, the final sample includes 49 brokers and 58 sales assistants for whom we have mostly complete data (some respondents did not fill out enough of the survey to be included).

Variables and Data

We developed an instrument to measure variables in our model based on the studies reviewed earlier and by constructing new scales where necessary. Correlation and factor analysis were used to construct scaled variables from individual items. Table 1 presents a summary of the items making up each scale and the reliability coefficient for scales. In a longitudinal study over two years at another firm, "social norms" and all the TAM variables except one had test-retest correlations of .6 or above, indicating reasonable test-retest reliability. The actual items are contained in the Appendix.

It was necessary to alter the wording of some questions to refer to the bank's systems because questions for perceived ease of use and usefulness refer to a specific system (Davis, 1989). Three studies have indicated satisfactory reliability for these two key variables in TAM (Hendrickson, Massey, & Cronan, 1993; Segars & Grover, 1993; and Adams, Nelson, & Todd, 1992).

We developed a scale for social norms based on Fishbein and Ajzen (1975), and pretested it on several groups of MBAs and on brokers using a workstation in a different firm. Questions for use variables were similar to those included in past studies of implementation (Lucas et al., 1990).

Past studies of implementation provided the basis for a scale of perceived system quality (Lucas et al., 1990). The scale measures perceptions of reliability (system does not go down) and the ease of accessing market data in the new system. Data access has been suggested as one measure of data quality (Strong, Lee, & Wang, 1997), and firms often use reliability as a measure of system quality. Our measure of quality relates to usability as defined by Venkatesh and Davis (1996) in their experiments. However, the measure in this study is perceptual whereas Venkatesh and Davis' usability was an objective measure—the ratio of an expert user's time to complete a set of tasks compared to the time required by users to complete the tasks.

This study uses self-report measures of current use and intended use for the next six months for each of the major functions provided by the workstation.

Table 1: Variables in the study.

Variable	Scaled Variable	Description	Number of Items	Alpha
Perceived usefulness	USEFUL	Workstation improves performance, productivity, effectiveness; is useful	4	.91
Perceived ease of use	PEOU	Easy to use, easy to get workstation to do what is wanted	2	.82
Norms	NORMS	Perceived support by management and peers to use workstation, desire to please management and peers by using workstation	4	.77
Perceived quality	QUALITY	Ratings of reliability and ability to access market data	2	.67
Use	USE	Use of market, office, and mainframe subsystems	15	.87
Intended use	IUSE	Intended use of market, office and mainframe subsystems	15	.83
Control: Workload	NOCLIENTS	Number of active, revenue-generating clients	1	NA
Prior performance	LNPERF94	Natural log of 1994 average monthly commission revenue (12 months)	1	NA
Performance	LNPERF95	Natural log of 1995 average monthly commission revenue (5 months)	1	NA
Job	JOB	Dummy, Broker = 0, Sales Assistant = 1	1	NA

Straub et al. (1995) cautioned that under certain conditions, self-report measures may not be valid indicators of use, though their study involved voice mail and may not apply to workstations. Szajna (1996), in a test of a modified version of TAM, also argued in favor of actual use with TAM in a study of students using email. In the case of a modern workstation, indirect measures of use, for example, through a monitor that counts how often a function is invoked, may not provide a more accurate measure than a self-report.

Brokers may leave a stock ticker running across their screen all day; there is no way for a software monitor to know if the broker is looking at the ticker. One broker may graph a stock and study it for some time, whereas another graphs five stocks in 10 minutes. Who has used the system more? For a complex system with many possible functions, self-report measures may be the best alternative available. The survey includes 15 items on use in order to study detailed usage patterns and relate them to performance.

The bank was able to provide performance data for individual brokers based on their commissions for all of 1994 and the first five months of 1995. Given the timing of implementation, 1994 is defined as implementation and 1995 as post-implementation. We computed a monthly average commission for each year and then took the natural log of that average to create a less skewed distribution. There was no comparable measure of sales assistants' performance. The analysis computed an implied performance for each sales assistant by averaging the commissions of the brokers with whom the sales assistant works. There are variations in the relationship between sales assistants and brokers, but the basic objective of brokers is managing assets for clients, and for sales assistants the objective is supporting the broker.

The number of clients, NOCLIENTS, describes the number of active, revenue-generating clients, and is a measure of transactions and administrative workload.

The investment bank provided brokers and sales assistants with the same technology. Initial interviews indicated that there were differences between the two groups; for example, sales assistants appear to be involved in more record keeping activities than brokers, whereas this latter group has more contact with customers. The Job variable identifies whether or not a respondent is a broker or sales assistant. Individuals surveyed indicated their position, which was confirmed with management before undertaking data analysis.

In general, the reliabilities are sufficiently high to use each scale. The means and variances for the variables show (1) differing levels of use for brokers and sales assistants, and (2) variance in all of the variables.

RESULTS

Multiple regression analysis tests the model in Figure 1, consistent with the majority of past studies of use. The Job variable was significant in most of the equations, so the analysis includes subsample regressions to better understand how our model predicts use for brokers and sales assistants. At the suggestion of a referee, we also ran a structural equation model using the AMOS system, and its results are consistent with the regression analysis. The regression results are presented because the majority of past research used this kind of analysis. In addition, the sample size for the full sample is marginal, and for the subsamples well below the recommended size for structural equation modeling.

The results present beta weights that represent the change in the dependent variable in standard deviation units caused by a single standard deviation change in an independent variable. Beta weights provide an indication of the relative importance of each independent variable in influencing the dependent variable. Note, however, that this research is cross-sectional. The research model implies causality, but the research design can only indicate support for the associations in the model.

Predicting Perceived Ease of Use and Usefulness

The research model predicts that favorable perceptions of system quality will be associated with favorable perceptions of ease of use and usefulness.

$$\text{PEOU} = f(\text{QUALITY}). \tag{1}$$

$$\text{USEFUL} = f(\text{QUALITY, PEOU}). \tag{2}$$

The results of the regressions are shown in Table 2. In general, perceived quality is a significant predictor of high levels of perceived ease of use and perceived usefulness in the full sample and the two subsamples. These results are comparable to Venkatesh and Davis (1996), who reported that objective usability is related to perceived ease of use after users have experience working with a system. Perceived quality is an important predictor of perceived usefulness in the full sample and for sales assistants, but not for brokers. Similar to Davis' findings, PEOU is a significant predictor of perceived usefulness for the full sample, brokers, and sales assistants.

Predicting Use

Overall use is a scale consisting of items asking about the respondent's use of the three main subsystems, whereas intended use asks about intentions to use these subsystems during the next six months. The general form of the equation predicting reported or intended use is:

$$\text{USE} = f(\text{PEOU, USEFUL, NORMS, NOCLIENTS, LNPERF94}), \tag{3}$$

where USE indicates both use and intended use.

The model predicts that social norms established by managers and peers will be important predictors of use along with perceived ease of use and usefulness. Brokers with more accounts can use the workstation to service their clients, so we expect a positive relationship between number of clients and use.

If one exists, there are two possible relationships between performance and use: positive or negative. The causal direction could be in one of two directions for each of these relationships. For example, a positive correlation between use and performance could be interpreted as high levels of use leading to high performance, or high performance leading to greater use of the system (or even some third variable responsible for both high performance and use). Likewise, a negative relationship between use and performance might mean that use leads to lower performance, say, by distracting the user from what is important in his or her task, or the relationship might mean that low performing workers use a system to try and improve their performance.

It is expected that in this setting a lower performing broker will use the workstation to help solve problems and improve performance. Therefore, poorer 1994 performance should be associated with high levels of use of the workstation.

The results of estimating (3) may be found in Table 3. There are no significant relationships between perceived usefulness and perceived ease of use and use for the full sample or for the two subsamples (brokers and sales assistants). In this field setting of broker workstations, the individual perception variables in TAM do not approach significance in predicting use.

The diagnostics for multicollinearity indicated that there was no need to correct for this problem. However, PEOU and USEFUL are correlated at .62, whereas all of the other independent variables in the equation are correlated at .32 or less. By combining PEOU and USEFUL to form a single variable, it was possible to re-estimate (3). The combined perception variable is a significant predictor of use for

Table 2: Predicting perceptions.

Dependent Variable	Full Sample	Brokers	Sales Assistants
PEOU			
QUALITY	.44 (4.90)***	.54 (4.39)***	.30 (2.33)**
JOB	.08 (.92)	NA	NA
Adjusted $R^2(n)$	.21 (107)	.28 (49)	.07 (58)
F	14.75***	19.24***	5.44**
USEFUL			
QUALITY	.27 (3.20)***	.18 (1.49)	.32 (2.61)***
PEOU	.46 (5.70)***	.62 (5.25)***	.33 (2.74)***
JOB	.14 (1.89)*	NA	NA
Adjusted $R^2(n)$	.45 (107)	.52 (49)	.24 (58)
F	30.10***	26.93***	10.20***

$*p \leq .10$; $**p \leq .05$; $***p \leq .01$
Numbers in the table are the beta weight and (t statistic)

Table 3: Predicting use and intended use.

	Full Sample		Brokers		Sales Assistants	
Dependent Variable	Use	Intended Use	Use	Intended Use	Use	Intended Use
PEOU	.13 (1.13)	.15 (.88)	.10 (.51)	-.14 (-.69)	.18 (1.12)	.16 (1.04)
USEFUL	.10 (.83)	.14 (1.17)	.13 (.63)	.25 (1.19)	.09 (.54)	.07 (.44)
NORMS	.23 (2.38)**	.31 (3.17)***	.17 (1.03)	.29 (1.77)*	.32 (2.40)**	.41 (2.99)***
NOCLIENTS	.16 (1.71)*	.11 (1.20)	.28 (1.93)*	.16 (1.08)	.14 (.96)	.13 (.93)
LNPERF94	−.11 (−1.23)	−.21 (−2.30)**	−.28 (−2.02)**	−.29 (−2.04)**	.06 (.48)	−.12 (−.93)
JOB	.35 (3.62)***	.36 (3.86)***	NA	NA	NA	NA
Adjusted R^2 (n)	.30 (94)	.33 (94)	.20 (48)	.17 (48)	.14 (46)	.20 (46)
F	7.56***	8.52***	3.34**	2.99**	8.33***	3.26**

$*p \leq .10$; $**p \leq .05$; $***p \leq .01$
Numbers in the table are the beta weight and (t statistic)

the full sample at the .05 level, and for sales assistant use at the .10 level. Combining PEOU and USEFUL provided limited support for the original TAM model.

Norms are significant predictors of use and intended use for all groups except brokers' reported use. The number of clients is weakly associated with use in the full sample and for brokers. Lower 1994 performance is associated with higher levels of use and intended use for brokers, and for intended use for the full sample. Even though this research is cross-sectional, the timing of data collection provides some information for causal analysis. Performance for 1994 is an average for each month of the year. Because the bank implemented the workstation late in the year, it is unlikely that use of the workstation could lead to lower 1994 performance. The negative correlation suggests that low 1994 performance stimulated use, or that some third variable is influencing both performance and use.

This finding that poor 1994 performance is related to use is similar to that of Lucas (1975), in which low performing sales representatives used an information system to try to improve their performance. An examination of individual items in the use scale helps us to understand this finding better. The strongest negative relationship between 1994 performance and individual use items is for office software, and for the word processing component of this package. When discussing this finding with bank management, an executive commented that brokers should be on the phone selling and meeting with clients, not using a workstation to send letters to existing and potential clients. At least this manager felt that the path to higher performance was not through technology! Management felt that poor performance stimulated inappropriate use.

Using the Job variable to compare brokers and sales assistants, different patterns of use appear. High levels of broker use and intended use are strongly predicted by lower 1994 (prior) job performance. For sales assistants, use and intended use are most strongly correlated with social norms.

In general, the R^2 values (shown in Table 5) are lower than those found in laboratory experiments on the use of technology. However, they are slightly higher in the full sample than the field study results of Igbaria et al. (1997). Part of the reason for the poorer fit is the relatively uncontrolled environment of the field setting. It also may be that the complexity of the workstation and/or work environment require more complex models of IT use.

Predicting Performance

We expect performance in 1995 to be influenced by prior performance and workstation use. The regression equation is:

$$\text{PERF95} = f(\text{LNPERF94, USE, JOB}), \tag{4}$$

where use is either reported or intended. By 1995, both the high performing and low performing brokers should have learned how to use the workstation to improve performance. Therefore, we expect to see a positive relationship between reported use near the end of 1994 and 1995 performance. The results of testing (4) for use are found in Table 4.

Performance in 1994 is the best predictor of performance in 1995; use is not significant in the full sample nor for brokers or sales assistants alone. If use is replaced by intended use in Table 5, the pattern is the same, with one exception. In the full sample, intended use is not significant in predicting LNPERF95, nor is the Job dummy variable. However, by dropping the Job variable, intended use in the full sample is significant at the .10 level in predicting LNPERF95, while LNPERF94 is significant at less than .01. This finding provides weak evidence that intentions to use the workstation more at the end of 1994 are associated with higher performance in the first part of 1995.

Table 4: Predicting LNPERF95 with use.

Dependent Variable	Full Sample	Brokers	Sales Assistants
LNPERF95			
LNPERF94	.82 (14.74)***	.81 (9.04)***	.85 (12.38)***
USE	.03 (.45)	.03 (.29)	.05 (.73)
JOB	.07 (1.07)	NA	NA
Adjusted R^2 (n)	.70 (109)	.64 (49)	.72 (60)
F	85.37***	42.91***	77.37***

*$p \leq .10$; **$p \leq .05$; ***$p \leq .01$
Numbers in the table are the beta weight and (t statistic).

Table 5: Predicting LNPERF95 with intended use.

Dependent Variable	Full Sample	Full Sample	Brokers	Sales Assistants
LNPERF95				
LNPERF94	.83 (14.88)***	.84 (16.12)***	.82 (9.11)***	.87 (12.69)***
IUSE	.07 (1.17)	.09 (1.72)*	.05 (.56)	.10 (1.51)
JOB	.04 (.49)	Dropped	NA	NA
Adjusted R^2 (n)	.71 (109)	.71 (109)	.65 (49)	.74 (60)
F	86.71***	130.45***	43.24***	80.59***

* $p \leq .10$; ** $p \leq .05$; ***$p \leq .01$
Numbers in the table are the beta weight and (t statistic).

Weill (1992) used a similar model lagging performance one year for firms in the valve industry. He found that type of information system was significant after removing the influence of past performance. Weill studied performance at the firm level, rather than for individuals, so the results may not be comparable.

Our analysis looked for a relationship between the various components of use and performance, including scales representing market, office, and mainframe use, and even individual items within these scales, and none was significantly related to 1995 performance, whether controlling for 1994 performance or not. It is possible that the workstation had not been in use long enough to have an impact on 1995 performance. It may also be that the relationship between use and performance in this environment and with this type of knowledge work is more complex than suggested in the research model.

DISCUSSION

Our key findings are:

- This field study of a windowed, multifunctional workstation supporting knowledge workers does not provide support for TAM. The variables that researchers most frequently study in this model are not significant in our research.

- Variables not in the original TAM such as social norms and prior performance are very important in this field setting.
- Job differences between brokers and sales assistants are associated with different patterns of use, suggesting that the task may be an important predictor of use.
- One interpretation of the data is that poor performers perceive that using a system can improve their performance.

A major conclusion of this research is that in this field setting, organizational variables such as social norms and the nature of the job are more important in predicting use of the technology than are users' perceptions of the technology. Past field testing using this model either deal with voice and email (Straub et al., 1995) or with a variety of systems across a number of different companies (Jackson et al., 1997; Igbaria et al., 1997). The Jackson et al. study, despite problems with response rate, only found a significant relationship between perceived ease of use and intention to use. The links between perceived ease of use and perceived usefulness, and perceived usefulness and intention to use were insignificant. The study of personal computer use of generic packages in small businesses in New Zealand by Igbaria et al. (1997) did support the core TAM variables. Thus, the study provides mixed evidence about the strength of the relationship between the TAM perception variables and use.

Why do the data in the present study fail to support TAM? There are several possible explanations:

1. Poor data and/or responses.
2. The nature of the system.
3. Not enough voluntary use of the system.
4. A field versus laboratory setting.
5. A poor or incomplete model.

It is possible that respondents did not cooperate or that the data are suspect. Our interviews and observations during the survey suggest that respondents thought about the questions and answered responsibly. The study also features data from multiple sources, not just the brokers and sales assistants. Although a defect in the study is always possible, we believe the explanation for TAM's weak support lies elsewhere.

It is possible that TAM does not work well for a multifunctional workstation where there are components of captive and voluntary use (Adams et al., 1992). In the case of the workstation, observations of brokers and sales assistants suggest that mandatory use is very natural. For years, brokers and sales assistants used Quotron (dumb) terminals to obtain stock quotes. They worked with the mainframe system to enter trade data. By the time the workstation appeared, its mandatory functions were an integral part of the job. For many multifunctional workstations, there will be a base level of use that is required to perform one's job. However, beyond the base, it is likely that a complex system will be used in a number of ways, with users having considerable discretion in exercising different functions and features (Jackson et al., 1997; Igbaria et al., 1997). As a result, this kind of workstation will exhibit both voluntary and mandatory usage that will be very difficult to separate in conducting research on use.

In an ongoing organization, other variables such as the nature of the task, reward structure, and social norms appear to be important variables in predicting use of a system that is designed for a relatively well-defined series of tasks. Although Igbaria et al. (1997) found support for the relationship between TAM perception variables and use, their study focused on generic software packages across over 200 small businesses and not on knowledge workers with similar tasks using the same technology.

We believe that the combination of explanations 2, 3, and 4, above—the system, its use, and the field environment—are responsible for the weak support for TAM from this study. Under these conditions, researchers need to apply TAM and other models, such as those from the task-technology fit literature (Goodhue, 1995), to predict use.

Consistent with their jobs, brokers and sales assistants have different patterns of use and intended use. Barley (1986) has demonstrated that medical technology can influence roles in radiology departments in hospitals. Likewise, workstation technology in the bank may serve to blur the roles of the broker and sales assistant. The workstation lets a broker perform certain routine tasks more easily than in the past, possibly taking over some functions from the sales assistant. (Who among us has not increased the amount of secretarial work he or she does since the development of office technologies?) Likewise, sales assistants have access to all of the information and technology available to the broker. They can expand their role to encompass some tasks normally completed by brokers.

This study has implications for understanding the use of a workstation designed for professionals and individual performance. Although the technology is exciting and required a significant investment, the impact of the system has not been revolutionary. One can speculate that a system with a large number of functions and access to huge databases will take considerable time for the user to integrate with his or her daily activities. It also may take considerable time for the user to realize that the workstation makes it possible to perform one's job differently than in the past.

If our reasoning is correct, then the type of training and support needed for sophisticated and complex workstations will be much different than for clerical workers using transaction processing systems. First, it is clear from the results that different groups given the same workstation and functionality in a system will have quite different use patterns depending on their tasks. Designers who include users in developing a system need to involve a cross section of representatives from different work groups. Managers should pay attention to social norms that encourage the use of new technology.

The results also have implications for training and education. It is interesting to note that on the survey 23% of brokers and 28% of sales assistants thought they had not received sufficient training in the use of the workstation. On one level, education about the system has to address the mechanics—what clicks and keystrokes accomplish what functions. It is very tempting to stop training once users understand the mechanics of how to use the workstation. However, to obtain the full benefits from complex technology, organizations should consider training that demonstrates how the user might do his or her job differently, and how the technology enables different strategies and different approaches to one's job. In the investment bank, the sales assistants and brokers knew how to use the mainframe transaction-oriented functions. They can easily learn the mechanics of using analytic routines that come with the market data system, but do they understand how to use the analytics to improve their performance? Have they seen how the most successful brokers use spreadsheets and word processing to contribute to their success?

FURTHER RESEARCH

This study suggests a number of topics for future research:

- The development of models of use for a field setting with modern, complex technology.
- Studies to explore the nature of actual use and how to measure it in a workstation environment where multiple windows may be active all day.
- Research to examine the relationship among intentions, self-reports, and actual use.
- Further studies of the relationship between use and performance.
- Studies to understand where TAM is applicable, and the nature of its limitations.

The research model is intended to predict the use of technology and performance. Following use, the next question is what kind of impact the technology has on users and the organization. Can models like this be extended to show how technology enables users to take new approaches to their jobs? Can research estimate the organization's return from investing in information technology? We are struck with the complexity of the work setting and the technology in an ongoing firm. Can we develop testable models to show the relationships among technology use and performance under these conditions?

More field studies of the use of technology are needed. Organizations continue to invest very large sums in information technology expecting that its use will improve outcomes. An understanding of the use of new technology and its impact on performance are prerequisites for obtaining a return from these investments. [Received: September 29, 1997. Accepted: July 1, 1998.]

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Henry C. Lucas, Jr. is professor of information systems at the Leonard N. Stern School of Business, New York University. He received his BS from Yale University, and his MS and PhD from the Sloan School of Management at MIT. Professor Lucas has also been on the faculty of the Graduate School of Business at Stanford and has spent leaves at the IBM European Systems Research Institute in La Hulpe, Belgium; on the faculty of INSEAD in Fountainebleau, France; and at Bell Communications Research in Morristown, NJ. His research interests include the management of information technology, implementation, systems analysis, expert systems, and the impact of technology. He has published articles in information systems and management journals including *Management Science*, *Information Systems Research*, *Decision Sciences*, *Communications of the ACM*, *MIS Quarterly*, and *JMIS*. Professor Lucas is the author of numerous books including *Information Technology for Management* (6th ed.) and *The T-Form Organization*, among others.

Valerie Spitler is a doctoral candidate in the Information Systems Department at the Stern School of Business, New York University. She holds an MBA from INSEAD in Fontainebleau, France, and a BS from the Wharton School. After several years of corporate work experience in the U.S. and abroad, Ms. Spitler is pursuing an academic career. Her research interests include IS implementation, end-user computing, and organizational impacts of technology.

APPENDIX A: A Review of Studies of the Technology Acceptance Model

Table A1: Summary of TAM studies.

Author	Model/ Subjects	Relation to Workstation Study	Results
Davis (1989)	TAM 1. IBM developers using PROFS, XEDIT 2. MBA students	Half of study involves workers in the field using mainframe technology	1. Developed Perceived Ease of Use, Usefulness scales in study 1. 2. Regression showed Usefulness and Perceived Ease of Use associated with self-reported use. Perceived Ease of Use acts primarily through Usefulness. 3. Study 2 showed similar results for students in an experiment based on self-reports predicting their own future use of software packages.
Davis, Bagozzi, and Warshaw (1989)	TRA, TAM MBA students		1. Perceived Usefulness predicts intentions to use whereas Perceived Ease of Use is secondary and acts through Perceived Usefulness. 2. Attitudes have little impact mediating between perceptions and intentions to use. 3. Relatively simple models can predict acceptance.
Mathiesson (1991)	TAM, TPB Students		1. Both models predict intentions to use well. 2. TAM is easier to apply, but provides only general information. 3. TPB provides more specific information for developers
Adams, Nelson, and Todd (1992)	TAM 1. Email and voice mail in organizations 2. Office packages by students	Field study, but of mail systems	1. Perceived Ease of Use and Usefulness are reliable and valid. 2. LISREL models exhibit poor fit.
Taylor and Todd (1995b)	TAM, TPB Students		1. All models performed well based on fit and explanation of behavior. 2. TPB provides a fuller understanding of intentions to use. 3. In TAM attitudes are not significant predictors of intention to use.

Table A1: (continued) Summary of TAM studies.

Author	Model/ Subjects	Relation to Workstation Study	Results
Taylor and Todd (1995a)	Modified TAM including social influences Students		1. Modified TAM explains usage for both experienced and inexperienced users. 2. Stronger link between behavioral intention and behavior for experienced users. 3. Antecedent variables predict inexperienced users' intentions better.
Straub et al., (1995)	TAM as a framework for comparing self-reported and actual usage measures	Field study, but of mail systems	1. Focus on agreement between self-report and computer recorded usage measurements. 2. Field study of voice mail system. 3. For voice mail, self-report and computer recorded usage do not have high agreement.
Szajna (1996)	Revised TAM Students		1. Looked at pre- and post-implementation. 2. Questions self-report measures versus actual measurement of usage for e-mail system. 3. Experience component may be important in TAM.
Venkatesh and Davis (1996)	TAM with external variables Students		1. Included self-efficacy and objective usability. 2. Objective usability has an influence on PEOU and PU only after experience using system.
Jackson et al. (1997)	Extended TAM with involvement variables and others Field study of users	Field study of TAM, but not of workstation	1. Found user involvement associated with variables in their model in different ways. 2. Intrinsic involvement shapes perceptions.
Igbaria et al. (1997)	Field Study of extended TAM featuring external training and support	Field study of small New Zealand firms; not focused on any particular technology such as workstations	1. Found support for TAM perceptions in predicting system use. 2. Selected external variables predicted Perceived Ease of Use and Perceived Usefulness.

APPENDIX B: Items in the Survey

(Response choices—5-point scale from *strongly disagree* to *strongly agree*)

Social Norms NORMS

Others in my group strongly support my using the new workstation.

I would like very much to use the new workstation because others in my group think I should use it.

Senior management strongly supports my using the new workstation.

I would like very much to use the new workstation because senior management thinks I should use it.

Perceived System Quality QUALITY

Compared to my prior system:

The new workstation is very reliable (i.e., does not go down).

Using the new workstation is much better for accessing market data.

Perceived Usefulness USEFUL

Compared to my prior system:

Using the new workstation improves my performance.

Using the new workstation improves my productivity.

Using the new workstation enhances my effectiveness.

Overall, using the new workstation is very useful in my job.

Perceived Ease of Use PEOU

Compared to my prior system:

I find the new workstation easy to use.

I find it easy to get the new workstation to do what I want it to do.

Use	USE (Current use)
Intended Use	IUSE (Next 6 months)

(Response choices—1 to 5, *Extremely light* to *extremely heavy*)

Market data system: snap-quotes, monitor, analytics, fundamental data, options, research.

Mainframe system: Trade data functions, customer service functions, DOT (a proprietary system), syndicate functions, electronic mail, EBS (a proprietary system)

Office applications: Spreadsheets, word processing, graphics

Workload	NOCLIENTS	How many active client relationships do you currently manage?
Job	JOB	0 = Broker, 1 = Sales Assistant