

# Understanding Relationships Among Teleworkers' E-Mail Usage, E-Mail Richness Perceptions, and E-Mail Productivity Perceptions Under a Software Engineering Environment

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**Abstract**—This study was undertaken to investigate the use of e-mail and its implications under a telework environment for distributed software engineering. For this, the relative strength between a social influence and individual attributes in affecting teleworkers' e-mail use was studied. Management support was used as the representative social influence, and age, status, and ease of use represented individual attributes. An examination was also made on how e-mail use, individual attributes, and management support affected the perceptions of e-mail's information richness and e-mail productivity. Two different types of surveys, log sheets and perception-based self-reports, as well as interviews and e-mail correspondences composed the data sources. Three hierarchical regression models were defined and tested for the hypothesis validation. Data analysis indicated that management support was a much more powerful indicator for teleworkers' media use than individual characteristics. Furthermore, although labeled as a relatively lean medium from the media richness theory perspective, e-mail could become an effective and richer communication tool through an active social construction process of management support. Finally, the management support and perception of e-mail as a rich medium were both highly influential in creating teleworkers' positive perception on e-mail productivity. This study rendered a strong indication that effective adoption of e-mail by teleworkers as an information-rich medium could benefit distributed work and distributed organizations through enhanced work productivity.

**Index Terms**—Media choice, media productivity, media richness, software engineering, telework.

## I. INTRODUCTION

**I**N TODAY'S competitive and demanding business environment, more organizations are adding flexible, dynamic, and virtual components to their organizational design in order to enhance the effectiveness of organizational processes [9], [31], [33], [38]. Telework is such an adaptation to the environment. It

embraces, in a broader sense, both traditional and nontraditional types of distributed work arrangement by an organization, including mobile work, home-based telecommuting and satellite offices [19]. Telework (both home- and satellite office-based) is attracting special attention because of its multifaceted strategic and nonstrategic implications for individuals, organizations, and society [24], [35], [41], [44]. The enhancement of organizational flexibility, reduction of business overhead costs, increase in employee productivity, delivery of better customer services, and reduction of commuting time were frequently mentioned as reasons for its introduction.

The rapid development of information technology (IT), especially in the fields of communication and remote processing, is also facilitating telework as a viable option for organizational design. Especially, electronic mail (hereafter called e-mail) in improving the quality of organizational communication and the effectiveness of organizational processing has been emphasized. E-mail has a functional richness that can effectively supplement the telephone as a general-purpose medium. From the media richness perspective, the telephone is regarded as a richer medium than e-mail, mostly because it enables synchronicity through natural voices. Synchronicity enables a high degree of interactivity, and natural voice delivers a variety of communication-related cues between communicators [11]. These two characteristics may be important to deal with complex and equivocal communication. Nonetheless, e-mail has its own strength unmatched by the traditional medium, which can increase personal productivity and organizational effectiveness in communication, information processing, and decision making. Among the most distinct are broadcasting capability, management of communications, access to information resources, low communication cost, file transfers, and temporal and spatial flexibility [1]. Such capabilities of e-mail can be especially crucial for distributed telework, and for virtual corporations whose people depend upon remote communications to coordinate and control their team efforts [5], [34].

The motivation of this research was to empirically investigate e-mail use by teleworkers who were involved in the development of large-scale communication software and its corresponding effects. Most of the teleworkers were software engineers. This study is accordingly an effort to partially address issues of a broader research stream on technology-mediated com-

Manuscript received February 23, 1998; revised June 1999. Review of this manuscript was arranged by Department Editor G. F. Farris.

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Publisher Item Identifier S 0018-9391(00)03359-6.

munication and their implications. For this, the relative strength between a social influence and individual attributes in affecting the media choice of teleworkers was studied. Management support was used as the representative social influence. Individual attributes contained age, status, and ease of use. Then, how the media usage, individual attributes, and management support affected the perception of e-mail's information richness and e-mail productivity was examined.

## II. E-MAIL: EXISTING STUDIES

The potential of e-mail as a facilitator for personal productivity and organizational effectiveness in communication, information processing, and decision making has been frequently cited [9], [21], [58]. E-mail differs from traditional media in the ways it communicates, stores, and retrieves information, and controls communication [1], [9]. Such functional diversity could profoundly affect organizations through productivity gains and new ways of working [56]. For instance, it enables bypass of a formal hierarchy, improved communication linkages among individuals, increased span of control, and the addition of virtual and dynamic components in organizational design [9], [33], [38]. It can enhance the ease and speed of communication inside the organization [61], it can save hours a week through the elimination of unreturned phone calls and the acceleration of internal correspondence, it can change patterns of information distribution in organizations [55], and it promotes information dissemination within weakly associated units, and facilitates socialization as well as problem solving [18]. The medium may reduce the functional complexity of managerial coordination [21]. Rice *et al.* [48] characterized the diverse impacts of e-mail communication as substitution effects, communication effects, and augmentation effects.

Despite the promise, effective use of e-mail may be conditioned by a number of forces. When the constraints such as norms and cultures become a substantial roadblock, an organization may underutilize the potential of e-mail. Other factors, such as the proliferation of junk mail, which creates information overload, the emergence of security hazards, especially in the form of executable file attachment and viruses, and prohibitive organizational policy on legal and privacy issues, can undermine its productive use as well [4], [8], [28]. On the other hand, if a communication network is structured such that e-mail is regarded as a rich and dependable medium, organizations and workers may substantially benefit from its use. This may especially be true for distributed workers who rely upon remote communication to carry out their tasks.

## III. THEORETICAL BASIS

Theories of media choice are relevant in explaining teleworkers' media use behavior. Media richness and social influence are the most influential components of the media choice theory.<sup>1</sup> The classical media richness theory suggests that each communication medium has a different information-carrying capacity because of the difference in the feedback capability, types of language used, and the number of cues being used. The richest medium provides face-to-face contact, immediate feedback, visual and audio channels, and natural

language communication [11], [63]. According to these criteria, a synchronous face-to-face talk is considered richer than telephone, and telephone is regarded as richer than e-mail, which uses asynchronous and textual correspondence. The effectiveness of communication is achieved when a person matches the complexity of a communication task with an appropriate medium, and therefore, when an insufficiently rich medium is chosen for a communication task, performance may suffer. The media richness theory is flawed by the lack of consistency in empirical findings [39], [43], [46].

Social influence theory emphasizes media choice behavior defined through social construction processes [39]. It suggests that social characteristics such as influences from coworkers, attitudes of superiors, group norms, existing characteristics of a communication network, and the existence of a critical mass play a critical role in shaping peoples' media choice behavior and their perception of medium effectiveness. Because of the social nature of media use, the theory assumes that members of a social network or a defined group will show similar patterns of media use. From this perspective, the media richness is not a rational, but a subjective concept, defined during social interactions and varying across groups or individuals. Fulk and Boyd [21] identified four major influences on media perceptions and use: statements from coworkers, vicarious learning, group or organizational norms, and social definition of rationality. Organizational policies and managerial pressures were also pointed out as important social influences [21]. These social influences may occur concurrently rather than sequentially in nature. For instance, organizational norms or cultures of communication may be highly associated with the social meaning and organizational policies of media usage. Management support for a technology may also be closely associated with coworkers' attitudes toward the technology or the social definition of its capability. Accordingly, separating their respective influence on the media use, the behavior of people may be difficult. In reality, studies rarely have been conducted from this perspective.

## IV. VARIABLES IN CONSIDERATION

In this study, three endogenous variables pertaining to teleworkers' media use and outcome categories were chosen. We set "*e-mail use*" as a binary variable, with e-mail and telephone as its two values. In fact, other communication media, including fax, video-, and audioconferencing, were available for teleworkers. However, e-mail and telephone are more general-purpose communication media, whereas the utility of fax, audioconferencing, and videoconferencing, is more narrowly defined. In our empirical study, about 92% of electronic communication was conducted via either e-mail or telephone, and the remaining 8% was based on fax, audioconferencing, and videoconferencing [54]. This indicates that, in most cases, e-mail and telephone were alternative options for communication among teleworkers.

The second endogenous variable was the "*perceived media richness of e-mail*" (hereafter called *e-mail richness*)." According to the theory of social influences, media richness is a constructive concept that is redefined by the users or by the communication network to which they belong. By adopting this variable, we investigated what types of variables

<sup>1</sup>Refer to Markus [39], Fulk and Boyd [21], and Rice [46] for details.

significantly altered teleworkers' perception of e-mail in its information-carrying capacity. "*Perceived productivity gains resulting from e-mail use* (hereafter called *e-mail productivity*)" was the third one. When e-mail, although generally perceived as a lean medium, is effectively adopted as an alternative for information-rich media, its distinct functionality and other technology features may substantially contribute to the increase in teleworkers' productivity.

Four exogenous variables were adopted from the categories of social and individual structures. Management support for a technology was a representative form of the former. In this study, our attention was placed on how management support for e-mail use affected media choice, e-mail richness, and e-mail productivity among teleworkers. The operationalization of management support variable is described in Section VI-A. Age, status, and e-mail's ease of use were chosen as exogenous variables that might significantly affect media choice behavior as well as media perception of teleworkers. In fact, the implications of the individual attributes on media use and media perception can be understood from two different perspectives of IT adoption for an innovation and symbolic considerations in communication. More discussions will be presented when relevant hypotheses are proposed in the next section. In this study, attention was paid to examining associations among endogenous variables, as well as those between exogenous and endogenous variables.

## V. HYPOTHESES PROPOSED

For convenience, hypotheses are organized under three categories: personal characteristics related, management support related, and e-mail use and outcomes related.

### A. Personal Characteristics Related

Personal attributes are important indicators of technology adoption [10], [13], [23], [27], [36], [57], [60]. For instance, senior people may find it harder to adopt new technologies than younger people because of the substantial learning effort required [20], [57]. Due to the learning curve, people who have more IT experience and knowledge may adopt them more easily. From that perspective, age may be a significant factor in determining media usage. The age effect on e-mail use may be understood from the perspective of symbolic meanings of media as well. Senior people may perceive that e-mail communication is more informal, less authoritative, and less serious than telephone conversation, and therefore, that the former is less salient and less effective than the latter for business communication. Furthermore, senior people who are used to traditional interpersonal and telephone communication that offers synchronous and vocal messages may feel that e-mail's asynchronous and text-based message is not rich and effective enough to satisfy their communication needs [39]. Therefore, the following was proposed.

*H1*: The age of a teleworker is a negative indicator of e-mail use (*H1a*), e-mail richness (*H1b*), and e-mail productivity (*H1c*).

From the perspective of innovation adoption, people of higher status may be more likely to resist changing their

communication behavior to adopt a new technology. Their attitude toward new technologies might reflect several reasons, such as organizational tenure, inherent inertia, lack of relevant knowledge, and a negative perception toward a technology [22], [48], [57]. Besides, people in higher status in general deal with unstructured or highly interactive tasks, which may entail more complex communication [15], [45], [62]. Naturally, they may prefer richer communication media such as face to face or phone to reduce the equivocality or ambiguity of communication, and to increase shared meaning [11], [50], [48]. People in higher status may also prefer to use personal contacts or phone over e-mail because of their differences in the symbolic meaning in terms of authority, formality, legitimacy, seriousness, and care. Therefore, the following was proposed.

*H2*: Teleworkers use the telephone relatively more than e-mail as their status gets higher (*H2a*). Also, the status of a teleworker is a negative indicator of e-mail richness (*H2b*) and e-mail productivity (*H2c*) perceptions.

An individual's perception of the technological characteristics of a communication medium may also contribute to a willingness to adopt it, and to recognition of its information richness and productivity. Ease of use, defined as "the degree to which a person believes that using a system would be free of effort" [14] has been a major variable used in technology-acceptance modeling, based on such theories as that of innovation. Accordingly, a teleworker's perception of an e-mail system's ease of use may influence his/her use of the technology. Also, Fulk *et al.* [23] indicated that the perception toward e-mail capability (e.g., richness and productivity) was largely affected by their e-mail experience and knowledge, their prior use behavior, and their current e-mail use behavior. Naturally, teleworkers who are more comfortable with e-mail technology may have higher confidence in its ability to carry rich information and to increase work productivity [59]. Therefore, the following hypothesis was proposed.

*H3*: Teleworkers' recognition of e-mail's ease of use is a positive indicator of e-mail use (*H3a*), e-mail richness (*H3b*), and e-mail productivity (*H3c*).

### B. Management Support Related

The effect of management support for e-mail use on teleworkers' media choice and on media perception was investigated. Management support has been frequently discussed as an effective vehicle for the adoption and diffusion of organizational and technological innovations [10], [13], [37], [52], [60]. Management is an effective initiating sponsor of and active change agent for an innovation [32], [52]. From the perspective of media choice, management support can be a social influence that redefines the nature of a communication network at an organization [51], [53]. The impression of management support for a communication technology, therefore, may effectively change workers' perceptions of the media characteristics and their impact [23], [59]. Furthermore, when the project members are remotely distributed, a manager becomes a key or focal communicator, whose attitude may have a stronger influence on the communication culture of the group [20]. The following hypothesis was therefore suggested.

*H4*: Management support for e-mail communication is a positive indicator of increased e-mail use (*H4a*), e-mail richness (*H4b*), and e-mail productivity (*H4c*) among teleworkers.

The impact of management support for e-mail correspondence on teleworkers' media use may be moderated by their individual attributes. In general, people who are disposed to be responsive for changes may be more accommodating of social influences. In that context, junior people may be more affected by management support than senior people, as the former may be more receptive to technological changes. The same line of thought can be applied to the social status, in which people in a lower status may be more compliant to changes than those in higher status. Also, social support for a technology may become more effective when prospective users feel comfortable and at ease with the technology. Based on the conjecture, the following was proposed.

*H5*: Management support for e-mail usage becomes more effective when teleworkers are younger (*H5a*), are in lower status (*H5b*), and perceive e-mail as easy to use (*H5c*).

### C. E-Mail Use and Outcomes Related

Several studies investigated the association among media characteristics, media use (or interaction) behavior, and the perception of media usefulness or effectiveness. Fulk [20] and Schmit and Fulk [53] showed that the perceived richness of a technology could affect its usefulness and usage. Trevino and Webster [59] revealed that the mode of technology interaction (flow) was positively associated with perceived technology effectiveness. Rice and Shook [49] postulated the positive association between the usage of electronic messaging system (EMS) and quality of work, and between the usage of EMS and information processing efficiency. Professionals such as software engineers adopting e-mail to support their work may recognize e-mail as more productive than nonprofessionals do [27]. Therefore, we revisited the relationships by suggesting the following.

*H6*: Increased use of e-mail is a positive indicator of teleworkers' e-mail productivity.

*H7*: Richness perception of e-mail communication is a positive indicator of teleworkers' e-mail productivity.

## VI. RESEARCH METHODOLOGY

### A. Samples and Data Collection

Research data were collected from the formal telework program operated by Fujitsu Kyushu Communication Systems Limited (QCS), which develops and markets communication software in Japan. It is a subsidiary of Fujitsu Limited, one of the largest providers of information technology products and solutions. QCS had established remotely separated local offices to provide a better working environment (i.e., reduce workers' commuting, provide more spacious offices, and cheaper housing), to enhance productivity, to reduce operating cost, and to recruit and retain local talents. Forty-four software engineering workers and managers from two project groups (23 and 21 members, respectively, in

each group) initially participated in the study (see Shin *et al.* [54] for the status of teleworkers). Each group was responsible for developing large-scale communication software. Group members were scattered to several local offices throughout Japan, some of which were separated by 1000 km (refer to Nakamura *et al.* [42] and Shin *et al.* [54] for the geographical distribution). This spatial setup demanded extensive communications for the project coordination and control among teleworkers.

This study employed multiple methods of data collection to compensate for any weaknesses each approach entails, and to increase the overall reliability of the study [50]. First, log-sheet surveys were used to gather diary data on teleworkers' media use in natural settings. The log sheets were designed to record situational details whenever teleworkers initiated or received a work-related communication. Gathering data from natural settings was expected to substantially reduce the perception bias resulting from a self-report survey [48]. Recording of communications was continued for five working days, from Monday through Friday of a week. As the log-sheet data provided limited information, additional data were collected with a follow-up survey. The survey items were mostly based on seven-point Likert scale, and were designed to provide information regarding teleworkers' media perceptions, including the information richness of e-mail and e-mail's contribution to work productivity.

In evaluating the richness perception of e-mail, we took the position that, to a certain degree, media richness is a socially predisposed subjective concept. In designing survey items, we considered two main information richness dimensions of a medium: its "feedback capability" [11], and its ability to handle communication tasks of "different complexity." The complexity of a communication is a general concept that can be represented by such measures as determinability [6], ambiguity or equivocality [11], analyzability [46], and variety [12]. Five survey items were used to represent the two dimensions of perceived e-mail characteristics. Three items that measured quick response, (*Q18*), timely response (*Q11*), read on time (*Q14*), were related to teleworkers' confidence in being able to receive timely feedback on e-mail correspondence. Two items (*Q9* and *Q19*) were considered to indicate the teleworkers' perception of e-mail capability to handle communication tasks of different complexity.

Thirty-six workers completed both surveys, which were used for the data analysis. Besides, through unstructured interviews and a number of e-mail correspondences with a junior and a senior engineer from the company, additional information was gathered on the level of management support on e-mail correspondence, the experimental environment, and other background information of the engineering groups.

Two teams shared a high degree of similarity in terms of demographics, group composition, and the nature of working project [54]. Nevertheless, interviews indicated that there was a fundamental difference between two groups in the level of managerial support for e-mail communication. In one telework group, the manager and group leaders (regarded by the company as a management class) supported e-mail use in two different ways. First, they encouraged team members to use the available e-mail program for the project coordination and collaboration.

Second, as a change agent and key communicator, the manager and group leaders actively adopted e-mail communication. They not only used e-mail for information delivery such as general announcements, but also made themselves available via e-mail by initiating e-mail communication with subordinates and responding e-mails from them [54]. On the other hand, there was no type of management influence on the media use of teleworkers in the other group.

The empirical comparison of managers' communication patterns based on log-sheet data also confirmed that there was a substantial difference between two project groups in management support for e-mail communication. Four managers (including supervisors) in the *no-management support* group predominantly used the telephone (88.1%) for communication; on the other hand, three supervisors from the *management support* group heavily adopted e-mail (70.6%) over telephone (29.4%) (see Appendix I). In that managers become key figures in shaping the communication culture of a defined group [53], such extreme difference in the communication preference becomes a concrete indicator for the discrepancy of managerial support for e-mail communication. Therefore, the variable, management support, was coded in a binary value of either exist (1) or nonexist (0).

### B. Reliability Test and Aggregation of Observations

Two endogenous variables, e-mail richness and e-mail productivity, and one exogenous variable, e-mail's ease of use, had multiple indicators. They were therefore tested in their discriminant (between endogenous variables) and convergent validities based on the exploratory and confirmatory factor analysis, respectively. The test showed that most items were reliable indicators of related constructs. Two indicators (*Q7* for ease of use and *Q9* for e-mail richness) were dropped from further consideration due to their lack of convergence. Consequent Cronbach alphas (0.85 for ease of use, 0.88 for e-mail richness and e-mail productivity) confirmed the high reliability of the factor structures (see Appendix II). The convergence showed that the perceived media richness of e-mail was a high-order concept that covered teleworkers' confidence in feedback capability and the capacity to handle complex communication tasks.

Because the media use data were gathered in real settings, each teleworker had multiple observation points. 316 e-mail or telephone correspondences were initiated by teleworkers during five days of field experiment. These observations were aggregated for each teleworker to make the unit of analysis an individual. To measure the rate of e-mail use by a teleworker, observations (e-mail = 1, telephone = 0) were summed, and then divided by the total frequency of media use. A higher metric value thus indicated higher use of e-mail for communication. For the variables with multiple indicators (ease of use, e-mail richness, and e-mail productivity), the aggregation needed a two-stage process to ensure equal contribution of weights from each indicator. For this, the raw data from each indicator were standardized (assuming normal distribution) with *Z* scores, and then the standardized values of indicators were averaged to get the unit-weight scores for each variable.

### C. Statistical Procedures

Hierarchical regression models were used so that the sequential order among constructs was counted in the model estimation. First, proposed hypotheses were evaluated through saturated models that counted all defined relationships among the exogenous and endogenous variables. Three hierarchical regressions based on Type I sum of squares (conditional sum of squares) were implemented to test the proposed hypotheses. Then, more parsimonious models were tested for the parameter estimation of statistically significant variables.

Model 1 studied the effect of management support (MS) and individual characteristics (IC) on teleworkers' e-mail use (EU). Also, the interaction effect between them was examined. Model 2 investigated the impact of management support and individual characteristics on the perceived e-mail richness (ER). Model 3 examined the association relationship between e-mail productivity (EP) and the remaining variables (management support, individual characteristics, e-mail use, and e-mail richness). With the hierarchical regressions, the order in which the predictors are listed reflects the order in which they were entered into regression models. For individual characteristics, three variables were entered in the order of *age*, *status*, and *ease of use*.

$$\text{Model 1: } EU = MS, IC, MS * IC$$

$$\text{Model 2: } ER = MS, IC$$

$$\text{Model 3: } EP = MS, IC, ER, EU$$

where

- MS management support for e-mail use;
- IC individual characteristics of teleworkers (age, status, and e-mail's ease of use);
- ER e-mail richness;
- EU e-mail use;
- EP e-mail productivity.

It needs to be pointed out that e-mail use is a first-order dependent variable, and also an independent variable for Model 3. E-mail richness, as an outcome variable, is a first-order dependent variable, and at the same time an independent variable for the second-order regression, Model 3. Although the three models are simultaneous equations, they fall into the case in which each of them can be estimated based on the ordinary least squares [26, pp. 370–372]. Therefore, the estimation of parameters was conducted with regular regression analysis.

## VII. RESULTS

### A. Correlation Matrix

The correlation matrix was reviewed prior to the estimation of regression models to avoid potential bias due to multicollinearity among independent variables (Table I). It revealed several significant correlation relationships, indicating that the use of independent variables should be cautious. An especially high correlation was recognized between e-mail use and management support (0.67) and between age and status (0.65). It rendered a strong indication that management support played an important role in promoting e-mail use among teleworkers.

TABLE I  
PEARSON CORRELATION COEFFICIENTS  
AND DESCRIPTIVE STATISTICS (\* AND \*\* INDICATE A STATISTICAL  
SIGNIFICANCE AT 0.99 AND 0.95 CONFIDENCE, RESPECTIVELY; SD: STANDARD  
DEVIATION, MS: OVERALL MEANS FOR THE SCALES)

	EU	MS	AGE	STAT	EASE	PER	PEP
EU	1.00						
MS	<b>0.67*</b>	1.00					
AGE	<b>-0.48*</b>	<b>-0.35**</b>	1.00				
STAT	<b>-0.36**</b>	-0.18	<b>0.65*</b>	1.00			
EASE	0.09	-0.10	<b>-0.33**</b>	-0.25	1.00		
PER	0.21	<b>0.39*</b>	-0.26	-0.26	-0.23	1.00	
PEP	0.11	<b>0.53*</b>	-0.16	-0.03	0.05	<b>0.45*</b>	1.00

EU: Email usage, MS: Management support, AGE: Teleworkers' age, STAT: Organizational status, EASE: Email's ease of use, PER: Perceived email richness, PEP: Perceived email productivity

Variable	N	Item	Min	Max	Mean	SD
Email usage (EU)	36		0.00	1.00	0.53	0.38
Status (STAT)	36		1.00	4.00	1.88	1.25
Age	36		23.0	35.0	29.0	3.40
Management support	36		0.00	1.00	0.47	0.50
Ease of use (EASE)	36	Q12	1.00	5.00	2.13	1.26
		Q15	1.00	4.00	2.11	0.88
		Q21	2.00	7.00	5.50	1.15
		Average	1.33	5.33	5.75	1.10
(Comment: 8-Q12 and 8-Q15 were used for the mean computation.)						
Email richness (PER)	36	Q11	1.00	6.00	2.75	1.66
		Q14	1.00	7.00	2.88	1.68
		Q18	1.00	6.00	2.80	1.68
		Q19	1.00	7.00	2.86	1.69
		Average	1.00	6.50	2.82	1.68
Email productivity (PEP)	36	Q8	3.00	6.00	4.72	1.05
		Q10	3.00	7.00	5.13	1.07
		Q13	2.00	7.00	5.13	1.26
		Q17	2.00	7.00	5.08	1.20
		Average	2.50	6.75	5.01	1.15

The high correlation between age and status may be natural in a Japanese organization where the status of a person in general is highly associated with his seniority. Table I also contains descriptive statistics of the studied variables.

*Test of Model 1:* It was indicated that management support and age were statistically significant in explaining the variation of the e-mail use by teleworkers [Table II(a)]. Estimates showed that management support substantially increased the use of e-mail among teleworkers, whereas age was negatively associated with the dependent variable. The social status of teleworkers, despite its high correlation with age variable, was not significant because age explained most of its variations. When the order of input was changed between age and status, status achieved  $p = 0.06$ , and age was not significant ( $p = 0.24$ ). Both age and social status affected the use of e-mail substantially ( $p = 0.06$  can be considered close to significant considering the small sample size), but age was the better indicator. E-mail's ease of use was not a significant indicator of e-mail choice. It appeared that, because teleworkers were mostly software engineers who were supposedly knowledgeable in information technology, an e-mail system's user friendliness did not constitute a substantial barrier to its e-mail utilization. The survey data confirmed this conjecture. For instance, the mean value was 5.50 out of 7 (strongly agree), and the standard deviation was a mere 1.15 for the question item, "It was easy to use e-mail system." Thirty-three teleworkers selected five or higher values for the

TABLE II  
(a) HYPOTHESIS TESTS FOR THE PREDICTORS OF E-MAIL USE—MODEL 1  
(\* AND \*\* INDICATE STATISTICAL SIGNIFICANCE OF SS AT 0.99 AND 0.95  
CONFIDENCE, RESPECTIVELY; "+" INDICATES SUPPORTED HYPOTHESIS). (b)  
ANALYSIS OF VARIANCE AND PARAMETER ESTIMATES

Predictors	df	SS	MS	F-Ratio	P	Hyp.
Mgn't support	1	2.35	2.35	28.7	0.00*	H4a+
Age	1	0.37	0.37	4.58	0.04**	H1a+
Status	1	0.04	0.04	0.51	0.48	H2a-
Ease of use	1	0.01	0.01	0.16	0.69	H3a-
Support * Age	1	0.05	0.05	0.71	0.41	H5a-
Support * Status	1	0.01	0.01	0.08	0.78	H5b-
Support * Ease of use	1	0.11	0.11	1.39	0.25	H5c-

Support = Management Support, SS= Conditional sum of squares (Type I SS)  
MS = Mean square

(a)

Source	df	SS	MS	F	P	R <sup>2</sup> (adj. R <sup>2</sup> )
Model	2	2.72	1.36	17.4	0.00*	0.51 (0.48)
Error	33	2.58	0.07			
Total	35	5.31				

Variable	df	Parameter Estimate	Standard Error	R <sup>2</sup>
Intercept	1	1.27	0.45	
Mgt support	1	0.43	0.09	0.44
Age	1	-0.03	0.01	0.07

(b)

question. None of the interaction terms showed statistical significance, indicating that the influence of management support on teleworkers' e-mail adoption was consistent regardless of their age, status, and the perception of e-mail's ease of use.

As a next step, statistically significant indicators, management support and age, were used for parameter estimation in a more parsimonious environment. Standardized regression coefficients were evaluated to compare the relative contribution of the independent variables to the model significance. Estimation of the parsimonious model showed that 51% of variation in teleworkers' media choice was explained by two variables. Management support was a predominant positive indicator, explaining about 44%, and age accounted for 7% of the variation in e-mail use. The statistics rendered a strong indication that social influences were much more influential than individual attributes in determining teleworkers' media choice behavior. The parsimonious model was statistically significant ( $p = 0.00$ ).

*Test of Model 2:* Model 2: ER = MS, IC was tested. Four independent variables (management support, age, status, and ease of use) were included in the initial model. Management support again significantly affected the teleworker's perception on e-mail richness ( $p = 0.02$ ). Perceived ease of use appears to have a marginal negative effect on e-mail richness ( $p = 0.09$ ). The insignificance of age and status appeared to imply that the personal demographics of teleworkers did not necessarily result in different perceptions of the information richness of e-mail. The statistics are summarized in Table III(a).

The test of the parsimonious model, which included management support and ease of use, explained about 19% of variations in the dependent variable. The former again had a much stronger impact than the latter in shaping individual perception

TABLE III

(a) HYPOTHESIS TESTS FOR THE PREDICTORS OF PERCEIVED E-MAIL RICHNESS (\*\* \* INDICATES STATISTICAL SIGNIFICANCE OF SS AT 0.90 CONFIDENCE). (b) ANALYSIS OF VARIANCE AND PARAMETER ESTIMATES

Predictors	df	SS	MS	F-Ratio	P	Hyp.
Mgn't support	1	4.19	4.19	6.32	0.02**	H4b+
Age	1	0.46	0.46	0.69	0.41	H1b-
Status	1	0.55	0.55	0.83	0.37	H2b-
Ease of use	1	2.05	2.05	3.09	0.09***	H3b-

SS = Conditional sum of squares, MS = Mean square

(a)

Source	df	SS	MS	F	P	R <sup>2</sup> (adj. R <sup>2</sup> )
Model	2	5.25	2.62	3.85	0.03**	0.19 (0.14)
Error	33	22.5	0.68			
Total	35	27.8				

Variable	df	Parameter Estimate	Standard Error	R <sup>2</sup>
Intercept	1	-0.29	0.19	
Mgt support	1	0.65	0.28	0.15
Ease of use	1	-0.19	0.16	0.04

(b)

of e-mail richness. Two variables explained about 15 and 4% of variation in e-mail richness. It confirmed that the perceived information richness of a communication medium was partially a subjective notion that could be socially constructed. The parsimonious model was statistically significant ( $p = 0.03$ ).

*Test of Model 3:* Model3:EP=MS,IC,ER,EU wastested. The initial estimation showed that management support ( $p = 0.00$ ), e-mail richness (0.01), and e-mail use (0.04) were significant indicators of e-mail productivity. The estimation result is summarized in Table IV(a). Management support and e-mail richness positively explained the perceived e-mail productivity of teleworkers. However, the coefficient estimate (-0.89) indicated a negative relationship between e-mail use and e-mail productivity. It seemed that controlling for management support and e-mail richness had a negative effect on e-mail productivity by wasting time on unproductive communications. Teleworkers' demographic variables did not substantially affect their perception of e-mail productivity.

Table IV(b) summarizes the estimation of the parsimonious model that included management support for e-mail richness and e-mail use. Three variables explained about 44% of variation in the dependent variable, respectively adding 27, 7, and 8% of explanatory power to e-mail productivity perception. The test result appeared to suggest that technical characteristics of e-mail such as *ease of use* were less influential than social and attitudinal factors in deciding the sense of e-mail productivity. The parsimonious model achieved a statistical significance ( $p = 0.00$ ).

### VIII. DISCUSSION

#### A. Summary of Results and Implications

The empirical study confirmed that teleworkers' media choice behavior was affected by several complementary factors. This study considered two categories of variables

TABLE IV

(a) HYPOTHESIS TESTS FOR THE PREDICTORS OF PERCEIVED E-MAIL PRODUCTIVITY. (b) ANALYSIS OF VARIANCE AND PARAMETER ESTIMATES

Predictors	df	SS	MS	F-Ratio	P	Hyp
Mgn't support	1	7.34	7.34	16.16	0.00*	H4c+
Age	1	0.02	0.02	0.05	0.83	H1c-
Status	1	0.13	0.13	0.29	0.59	H2c-
Ease of use	1	0.44	0.44	0.96	0.33	H3c-
Email richness	1	3.18	3.18	7.02	0.01*	H7+
Email use	1	2.15	2.15	4.74	0.04**	H6-

SS= Conditional sum of squares, MS = Mean square

(a)

Source	df	SS	MS	F	P	R <sup>2</sup> (adj. R <sup>2</sup> )
Model	3	11.62	3.87	8.36	0.00*	0.44 (0.39)
Error	32	14.82	0.46			
Total	35	26.45				

Variable	df.	Parameter Estimate	Standard Error	R <sup>2</sup>
Intercept	1	-0.09	0.20	
Mgt support	1	1.18	0.32	0.28
Email richness	1	0.26	0.14	0.07
Email use	1	-0.89	0.40	0.09

(b)

(individual and social). Overall, management support, selected as a representative social influence, was much more influential than individual characteristics in explaining teleworkers' media use behavior. From the standpoint of an *R*-square analysis, management support (0.44) was more than six times stronger than age (0.07) in affecting media choice. Complete generalization of the study result may be difficult due to the probable compounding of management support with other group differences. For instance, although two telework groups shared many similarities in terms of working projects, group size, technology support, group composition, and teleworker demographics, circumstantial differences, mainly in the number of local offices being used and the duration of the software project [54], were also recognized. Nonetheless, the analysis results still send a strong message that social influences are substantially more powerful than individual attributes in constructing teleworkers' media use behavior.

That the two variables accounted for approximately half of the variation in media choice implies that other contextual variables substantially contributed to the media choice of teleworkers as well. This study confirmed that theories of media choice are complementary rather than exclusive [16], [60]. In addition, the study affirmed the importance of social influences in redefining the characteristics of a communication network for telework, and maintaining them without their being moderated by differences in worker age and status or perception of e-mail's ease of use.

It has to be pointed out that the two software engineering groups employed in our study were relatively small project teams, each consisting of fewer than 25 teleworkers. Because of the clearly defined scope of the groups' boundaries and the nature of their projects, the two groups were expected to have had a highly coherent and focused communication culture. The empirical study showed that, when individuals are strongly

attached to their work groups, as they were in this case, social influences on technology use behavior could be stronger because members become more receptive to internal influences [20]. In this study, therefore, management support might more effectively have been transformed into a vehicle for increased e-mail adoption among teleworkers.

Management support for e-mail and e-mail's ease of use were significant predictors of the perceived information richness of e-mail. Although the influence of the ease of use variable was somewhat marginal, it was considered substantial because of the relatively small sample size. Comparison of the  $R$ -square values indicated that the social construction process of an e-mail system was much more powerful than technical impressions in creating an information richness perception. Furthermore, e-mail's ease of use was shown to be a negative indicator of information richness. A relatively low  $R$ -square value (0.19) appeared to confirm that teleworkers had a rational opinion on e-mail's information richness, although it was partially subject to alteration associated with the social structure of the communication network [7], [21], [39]. In sum, this study refutes some existing work that examined the media choice of workers from a one-dimensional perspective only, and advocates that a multi-dimensional- and multitheory-based approach (e.g., [39], [48], [60]) is more appropriate for relevant research.

Management support and perception of e-mail richness were positive contributors to e-mail productivity among teleworkers. They felt that e-mail increased productivity when it could carry rich information, and when there was support from management and supervisors for its use, supporting the results of previous work [59]. Technical features of user friendliness and individual attributes of age and social status were noninfluential. The results reconfirmed that, when teleworkers recognized e-mail as an information-rich medium, e-mail's functional diversity and richness could considerably improve their productivity by curtailing process bottlenecks in traditional media. This study, therefore, offered a strong possibility of e-mail's *augmentation effect* [48] of enhancing individual information-processing capabilities. An overall summary of the hypothesis testing is displayed in Fig. 1.

### B. Limitations and Future Research Directions

Limitations of the empirical study need to be pointed out. Making management support operational is important as this could entail both strengths and weaknesses. In fact, a common fallacy in measuring social influences (such as management support) has been to rely on self-reports by respondents, which is a social projection on management by the supposed target of influence. It having been shown that such projections of others' attitudes are highly associated with one's own attitudes [3], the challenge is to have independent measures of managers' attitudes, and to see how these correlate with the respondents' own attitudes. This has rarely been done. By interviewing two engineers from Fujitsu Company, we identified the existence of different forms of management support in one telework team, and expected that this approach would minimize the response bias on the social influence. A comparison of managers' communication patterns also supported the substantial

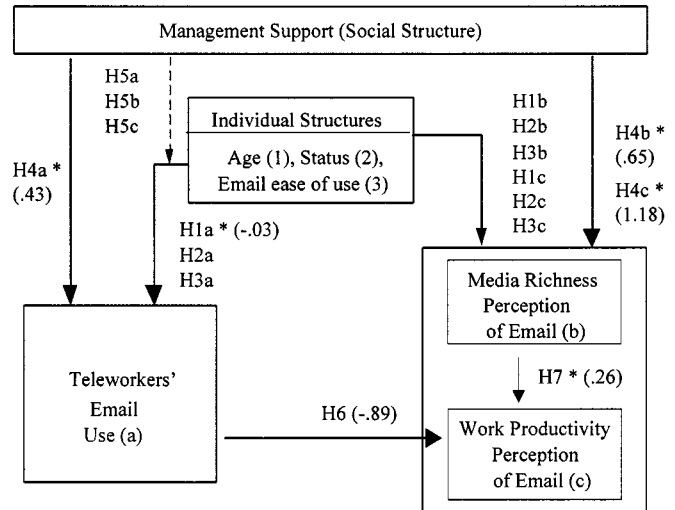


Fig. 1. Summary of hypothesis testing ("\*" indicates the supported hypothesis; values in parentheses are significant regression coefficients).

difference in the level of management support for e-mail communication (Appendix I). Nevertheless, our approach had a potential weakness. From the interviews, we were able to learn of the existence or nonexistence of management support at a telework group as a binary response, but could not determine its intensity. Certainly, it is very natural to conjecture that the strength of management support creates different effects on the media choice of teleworkers.

The relationship among different types of social influences also needs review. Fulk and Boyd [21] indicated four main forms of social influences on both media perceptions and media use: direct statement by coworkers in the workplace, vicarious learning, norms for how media should be evaluated and used, and social definitions of rationality. The role of critical mass in media choice was also theorized by Markus [39], [40]. It might have been that media use of teleworkers was the composite result of several social influences such as peer pressure and cultural norms, rather than attributable to management support alone [51]. Separating the contribution of each social force is a difficult task that future study will have to address.

The study contained several situational factors that could degrade the generalizability of analysis results. It is an intensive rather than an extensive study, based on distributed telework groups in a single company. Accordingly, the generalizability (or replicability) of empirical results may be limited, a rather common weakness for this type of study. A possible lack of replicability can also be viewed from the cultural perspective, where Oriental values and traditions differ from those of Western society [30], [58]. For instance, there might be the difference in media richness perception between collectivist and individualistic countries [47]. Also, because Japanese companies may emphasize homogeneity [29], the effect of social influences over media use may be more apparent than in Western organizations.

Since the subjects were mostly developers of large-scope communication software, they were expected to have employed new technologies more easily than non-IT workers. In that sense, generalizing study results to non-IT workers may have

to be cautious. On the other hand, in that e-mail is quickly becoming a popular medium for general-purpose communication, the difference in the e-mail adoption between IT and non-IT workers may not be as substantial as it at first appears. Future efforts should incorporate more teleworkers employed in non-IT fields.

Although the central limit theorem is applicable to a small sample size of 30 or more [2], the relatively small sample (36) might have reduced the statistical power of our analysis. On the other hand, the aggregation of observations pertaining to each individual and the use of real data captured from natural settings might have positively contributed to the enhanced power of statistical analysis. Future investigation will be better served by larger samples, which will not only augment the statistical power of tests, but also permit additional investigation of bidirectional relationships among constructs.

We relied on a perception-based survey to measure the changes of work productivity resulting from e-mail adoption. The perception of productivity is bias prone, and therefore can jeopardize the findings. In future studies of e-mail productivity, methods that avoid perception-based responses will have to be introduced to make the analysis more reliable. In fact, productivity from the traditional definition of the ratio between quantity of input and that of output may be difficult to measure when it comes to knowledge work. As a remedy, measurement based on multidimensional aspects of work in quantity, quality, timeliness (e.g., ability to meet deadline), and multiple priorities (e.g., how many things can be done simultaneously?) have been suggested [17], [25].

Finally, in this study, the perceived media richness of e-mail was focused on its feedback capability and viability for communication tasks of different complexity. Recognizing that information richness has a multidimensional structure [11], we nevertheless defined and used the theoretical concept rather narrowly. This might have limited the reliability of relationships between media richness in a broader sense and other constructs.

IX. CONCLUDING REMARKS

Many organizations are adopting distributed work arrangements as part of their business strategies. The rapid proliferation of networks (i.e., Internet, LAN, WAN) and advanced communication technologies (both guided and unguided) are creating a world where people can be in touch beyond their temporal and spatial limits. Powerful technologies are facilitating the growth of virtual components such as telework in organizational design. The software industry is among the most aggressive in adopting telework to reduce operating costs and to achieve competitive advantages. In this case, effective logical and physical communication networks established among distributed entities will constitute a critical success factor in achieving organizational goals. Our study offered a strong suggestion that a telework program could benefit substantially from having a communication network where e-mail is recognized as a reliable, information-rich, and productive medium. The study opened up areas of future improvement as well. Above all, future studies will have to test research integrity with larger samples based on integral approaches such as structural modeling to further

improve the understanding of media use and implications. It will be necessary to validate the presumed bidirectional relationships between media use and outcomes, and between the dynamics of social influences and outcomes. Finally, it is our suggestion that future studies be conducted at three different levels (observational, individual, and defined group level) in aggregation to obtain balanced and more complete insights into media usage and corresponding implications.

APPENDIX I  
FREQUENCY TABLE FOR MEDIA USAGE BY MANAGERS

Management Support	Manager or Supervisor	Communication media		Sub-total for each manager
		Email	Telephone	
No	#1	2 (25%)	8 (75%)	10
	#2	0 (0%)	9 (100%)	9
	#3	1 (13%)	8 (87%)	9
	#4	2 (14%)	12 (86%)	14
	Group total	5 (11.9%)	37 (88.1%)	42
	Group average	1.25	9.25	10.5
Yes	#1	8 (50%)	8 (50%)	16
	#2	26 (90%)	3 (10%)	29
	#3	14 (61%)	9 (39%)	23
	Group total	48 (70.6%)	20 (29.4%)	68
	Group average	16	6.67	22.67

Values in the parenthesis indicate relative percentage of media use by each manager or supervisor.

APPENDIX II  
TEST OF CONVERGENT AND DISCRIMINANT VALIDITY

1. Confirmatory factor analysis for *ease of use* (Re-coding: Q12A = 8 - Q12, Q15A = 8 - Q15)

Items	Loading	Loading w/o Q7	Descriptions
Q7	0.45		I was knowledgeable with the E-mail program.
Q12A	0.75	0.78	I was NOT good at keyboard typing.
Q15A	0.75	0.77	Our E-mail program was NOT easy to use.
Q21	0.93	0.90	It was easy to use E-mail system.
Cronbach alpha = 0.85			

2. Convergent and discriminant validity test for media richness and media productivity constructs

	Initial loading.		Loading w/o Q9		Description
	Fac.1	Fac.2	Fac.1	Fac.2	
Q18	0.88	0.19	<b>0.88</b>	0.19	I used E-mail when the communication needed a quick response.
Q11	0.87	0.15	<b>0.87</b>	0.17	I was confident that I would get timely responses for the E-mails I sent.
Q19	0.83	0.09	<b>0.83</b>	0.10	I used E-mail regardless of the type of communication task.
Q14	0.82	0.29	<b>0.82</b>	0.28	I was confident that E-mail would be read on time.
Q10	0.10	0.87	0.09	<b>0.87</b>	Using E-mail increased my productivity.
Q17	0.34	0.84	0.33	<b>0.86</b>	Using E-mail improved my job performance.
Q13	0.10	0.84	0.10	<b>0.84</b>	Using E-mail made it easier to do my job.
Q8	0.24	0.77	0.23	<b>0.78</b>	Using E-mail enabled me to accomplish tasks more quickly.
Q9	-0.06	-0.40			I didn't use E-mail when the communication task was complex.
Cronbach alphas: Q8, Q10, Q13, Q17 = 0.89, Q11, Q14, Q18, Q19 = 0.89					
Inter-factor correlation : 0.45					

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