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Technology-push and communication-pull forces driving message-based coordination performance

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Abstract

This study adopts 'push–pull' concepts to address the effects of technology, communication and tasks on e-mail coordination, and to explore appropriate e-mail contexts in cooperative work. The perceived benefits of communication technology form a 'push' force. Two 'pull' forces include the desire to solve a cognitive gap caused by the communication context, and the desire to bridge the performance gap in allocating resources to tasks. The empirical findings confirm that 'technology-push' and 'communication-pull' forces are positively associated with e-mail coordination performance, showing the coexistence of rational and social influences, while the association between task and communication contexts indicates that the development of perceived information-sharing norms is context-dependent. Accordingly, this study concludes that appropriate information-sharing norms enable actors to create an active communication context for using e-mail in cooperative work.

Keywords: Technology-push; Need-pull; E-mail coordination; Active communication context; Appropriate information-sharing norms

1. Introduction

Early communication theory, such as Daft and Lengel's (1984, 1986) famous information-richness theory (IRT), focused on theories of *why* and *how* managers use media in organizations. According to IRT, the match between information processing requirements

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(reducing information uncertainty and equivocality) and communication channels (face-to-face and e-mail) may influence individual and organizational effectiveness. Accordingly, the information provided by face-to-face communication is richer than that provided by e-mail. Hence, managers are likely to use face-to-face communication when the equivocality of information is high. Many researchers have addressed the relative merits of communication media richness and leanness in IRT over the past two decades. Several theories, including 'social influence model' (Fulk et al., 1990), 'social definition theory' (Markus, 1994b), 'channel expansion theory' (Carlson and Zmud, 1994) and 'critical social theory' (Ngwenyama and Lee, 1997), all argue that communication richness is not an inherent or objective property of the communication medium itself, but is instead an emergent or subjective property of human–media interactions influenced by social contexts. For instance, Markus (1994b) found that managers' use of e-mail is inconsistent with IRT, and that effective senior managers tend to use e-mail heavily even to communicate about equivocal tasks. Most importantly, Markus' empirical results indicated that social, rather than rational processes are responsible for the use of e-mail for communication. Likewise, Lee (1994) argued that perceptions of information richness or leanness depend on the interaction between the medium and the communicative context, but not on the medium itself. Thus, the communication context is very important for human actors when engaged in e-mail coordination. However, exactly what communication context is required in e-mail coordination remains unclear.

E-mail is an asynchronous, fast, text-based medium that supports multiple addressability (Finholt and Sproull, 1990), making it suitable for communication, and for coordinating cooperative work. Mackay (1988) explored e-mail coordination processes by surveying experienced e-mail users, and found that professional office workers use e-mail to delegate tasks, prioritize their activities in response to incoming messages, and gather and transfer information. The use of e-mail in communication is a context-dependent process (Rudy, 1996), so the norms of social networks govern the interaction between human actors and e-mail. However, e-mail coordination becomes complex for human actors when engaged in cooperative work in different social contexts. Thus, the extended study of communication theory heavily emphasizes how to enhance e-mail coordination. To address this question by surveying experienced e-mail users, this study not only explores appropriate contexts for using e-mail in cooperative work, but also examines how technology, communication and task influence e-mail coordination. Results of this study provide a valuable reference for e-mail users concerned with how to improve the coordination performance of cooperative work.

2. 'Technology-push and need-pull' theory

The early literature discusses technical innovation driven by market demand or technology shift (Langrish et al., 1972; Utterback and Abernathy, 1975). 'Technology-push' and 'demand-pull' are two motivating and driving forces behind an innovation. The 'push' concept regards innovation as being driven by science, which in turn drives technology and its applications. By contrast, the 'pull' concept considers personal demand as the primary force guiding innovation. 'Push' and 'pull' forces are located at opposite ends of an innovation process spectrum. The 'technology-push, need-pull' theory explains Lyytinen and King's (2004) cyclical model of science, technology and society, and accurately reflects the technical innovation life cycle in human society.

Zmud (1984) argued that successful innovation or new technology stems from 'technology-push' and 'need-pull' forces. According to the 'push–pull' theory, a technical innovation is likely to occur when a need and the means to meet it are simultaneously recognized. A successful innovation often depends on reducing performance gaps between technological means and organizational requirements. Chidamber and Kon (1994) reviewed eight studies on successful innovation and concluded that 'technology-push' and 'demand-pull' are complementary, rather than contradictory, factors determining the success of innovation. Similarly, King et al. (1994) argued that 'supply-push' and 'demand-pull' are both required forces for product/process innovation. Moreover, Munro and Noori (1988) found that adoption of new manufacturing technology is more strongly stimulated by integrated 'technology-push' and 'market-pull' forces than by either force alone. Chau and Tam (2000) found that 'technology-push' and 'need-pull' are two motivating and driving forces determining the adoption of organizational technology. Overall, the 'supply-push, user-pull' concepts have been used to predict successfully the diffusion and adoption of communication technology (Newell et al., 2000).

The shift in technology and need may cause an 'interactive innovation' governed by 'technology-push' and 'need-pull' forces (Rothwell, 1994). Firms are willing to adopt a new technology which can enhance their competitive advantage. By contrast, individuals may use a new technological means if it benefits them directly. Recognizing the benefits from using a new technological means can be considered a 'push' force stemming from technology (Munro and Noori, 1988). The perceived benefits (e.g. time saving and cost reduction) of a new technology tend to 'push' individuals to use it at work (Munro and Noori, 1988; Chau and Tam, 2000). Market performance gap often occurs when suppliers cannot satisfy buyers' needs. The desire to solve a particular market performance gap can be considered as a 'pull' force derived from need (Munro and Noori, 1988). Thus, the performance gap between expected and perceived performance is likely to 'pull' individuals' need to use new information systems (IS) to improve work outcomes (Rai and Patnayakuni, 1996; Chau and Tam, 2000). This study integrates the 'push–pull' concepts to predict the e-mail coordination performance from the perspectives of technology and need.

3. Research model and hypotheses

Kling (1991) defined computer-supported cooperative work (CSCW) as the combination of technologies, users (in self-directed professional teams) and a worldview emphasizing convivial work relations. Moreover, as Heath and Luff (2000) pointed out, much of the work on CSCW has focused on the development of social meaning around work, technology and interactions among organizational environments. Taking both perspectives of CSCW, the use of e-mail in cooperative work depends on three contexts, *technology*, *communication* and *task*. The influence of the perceived benefits obtained from adopting a communication technology is considered as a 'push' force. From the perspective of technological determinism (Markus, 1994a), this study adopts perceived usefulness and perceived ease of use, stemming from Davis's (1989) technology acceptance model (TAM), to measure the 'technology-push' forces, which are posited to influence the e-mail coordination performance. The cognitive gap often occurs among actors when they communicate or coordinate with each other without using a shared communication context, for instance by using different languages or obeying conflicting laws or beliefs. The desire to solve such a cognitive gap is considered as a 'pull' force derived from the communica-

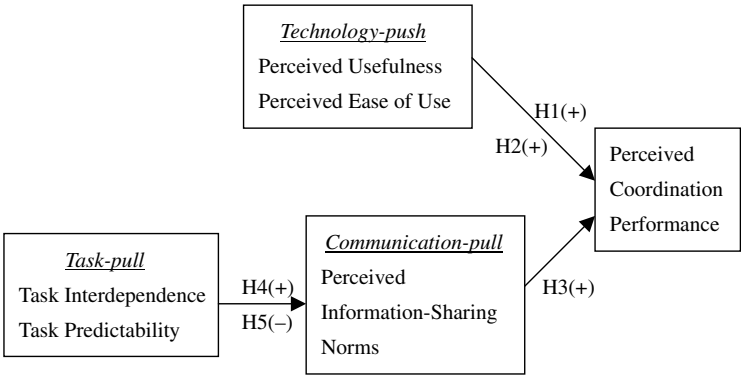

Fig. 1. The research model.

tion context. This study adopts perceived information-sharing norms to describe communication context, which is regarded as a 'pull' force influencing e-mail use in cooperative work. Based on the information-processing model (Tushman and Nadler, 1978), the performance gap often occurs when the information processing capabilities cannot match the information processing requirements. An alternative solution to bridge the performance gap is to seek more resources (i.e. opportunities) to perform a task. The desire to solve the performance gap in allocating resources to tasks is considered as a 'pull' force. This study considers task interdependence and task predictability as two 'pull' forces, which are posited to guide information sharing in coordinating collaborative activities. Fig. 1 depicts the research model associated with the five hypotheses underlying the 'push–pull' concepts.

This study makes three assumptions regarding the dual views of e-mail use. First, this study assumes that individuals would evaluate the benefits and costs of e-mail use from a rational viewpoint. Second, this study assumes that individuals would perceive the cognitive and performance gaps of e-mail use from a social viewpoint. Third, both rational and social perceptions simultaneously emerge in e-mail use.

3.1. Technology-push factors

3.1.1. Perceived usefulness and perceived ease of use

Davis (1989) adopted perceived usefulness and perceived ease of use to measure individual perceptions toward a new IS. According to TAM (Davis, 1989), perceived usefulness (PU) represents an individual's perceptions of job performance when using a particular system, while perceived ease of use (PEOU) refers to individual perceptions that using the system would be free of effort. Many empirical results of prior studies (Davis et al., 1989; Mathieson, 1991; Adams et al., 1992; Davis, 1993; Venkatesh and Davis, 2000; Chau and Hu, 2002) show that the perceived benefits of using an effective, efficient, and easy-to-use information technology to support work would encourage many people to adopt the technology. Thus, the two key beliefs (PU and PEOU) can be used to 'push' an individual's intentions to use new IS, and to predict its usage. The successful diffusion of e-mail shows that its use is an organizational learning process that improves users' communication capabilities (Romm et al., 1996). Such communication capabilities are the conditions for individuals to understand the perceived benefits of e-mail use.

Despite personal habits and preferences in face-to-face meetings, most office information workers use e-mail in cooperative work because it is less time-consuming and costly than face-to-face meetings. The 'absent availability' of e-mail allows people to communicate effectively and easily from different locations and working at different times (Sarbaugh-Thompson and Feldman, 1998). Continuous improvements in e-mail use, including its integration with the Internet, collaborative technology and personal digital adaptors, enable actors to use existing e-mail to effectively and easily communicate and coordinate cooperative work with each other. Consequently, the use of e-mail improves the productivity of cooperative work, including both individual and interrelated tasks (McManus et al., 2002). From a rational viewpoint, this study hypothesizes that:

H1. Perceived usefulness of e-mail is positively associated with perceived coordination performance in cooperative work.

H2. Perceived ease of use of e-mail is positively associated with perceived coordination performance in cooperative work.

3.2. Communication-pull factor

3.2.1. Perceived information-sharing norms

Social networks help establish communication contexts that support information sharing across departments. That is, establishing social networks allows members of organizations to reduce communicative barriers, and quickly establish strong relationships facilitating information exchange in cooperative work. Hence, strong ties among organizational members typically create strong norms guiding actions in communication contexts. Although previous literature has claimed that the use of e-mail in organizations represents only a weak tie in interpersonal relationships, the lean e-mail medium can still produce rich communication (Huang et al., 1998). That is, social networks supporting human–media interactions may produce strong norms. This phenomenon can be explained by separating the e-mail use context into *active* and *passive* communication contexts. Active communication contexts connect informal social networks where actors develop cohesive work and interpersonal relationships. Such informal social networks can be conducted in terms of relationship ties, including advice, trust, and communication networks (Krackhardt and Hanson, 1993). This study defines an active communication context as an open social network where actors have complete autonomy in connecting with each other and establishing strong norms to support cooperative work. For example, an international IS journal can offer an active communication context to scholars interested in contacting potential coworkers for research collaboration. Such an academic community enables IS-related scholars from Taiwan, Hong Kong, and United States to exchange ideas and opinions on current issues, and thereby create strong norms for future research directions. Thus, actors located in a common community are likely to create an active communication context for seeking effective resources to support cooperative work. By contrast, the passive communication context not only establishes work relationships among actors with power or authority, but also governs their actions with predefined rules and procedures. This study defines the passive communication context as a closed environment where actors have limited autonomy and weak norms in social interactions. For example, an executive committee of a state-run corporation is likely to establish a so-called passive communication context, leading members to respond passively to events in group decisions.

This study borrows Dewhirst's (1971) perceived information-sharing norms to exert a communication-pull force guiding actors to share information with coworkers. Unlike the subjective norms in the theory of reasoned action (Fishbein and Ajzen, 1975) underlying the passive communication context, perceived information-sharing norms denote cooperative actors' self-awareness of information needs emerged in an active communication context. Thus, weak ties among e-mail users in active communication contexts may create strong norms of information sharing if they have perceived the need for information in cooperation processes. This argument is central in examining the relationship between communication context and e-mail usage. Two examples from the literature demonstrate active communication contexts in cooperative work. First, Zack (1994) argued that e-mail is an effective and efficient tool for exchanging messages within a shared interpretive context and expected communication mode. Second, a software team with a common view enables members to build the project, share information and mesh collective activities in software development (Kraut and Streeter, 1995). In summary, both shared interpretive contexts and common views characterize the active communication context.

'Boundary-spanning individuals' denote a particular social network where members need to transfer information internally and externally (Tushman and Scanlan, 1981a,b). Moreover, such 'boundary-spanning individuals' represent a cohesive social network that is conducive to information sharing across boundaries (Ebadi and Utterback, 1984). March and Simon (1958) noted that organizational boundaries depend on organizational norms. Hence, the norms of exchanging social and substantive information enable people to conduct cohesive relationships crossing organizational boundaries (Hinds and Kiesler, 1995). Active communication contexts offer actors opportunities to seek information resources over social networks or enhance the information processing ability, preventing information overload by 'adjustment processes' across organizational boundaries (Brown, 1966), while passive communication contexts may involve 'sticky' social networks to impede information sharing across organizational boundaries (Tushman, 1979). Sproull and Kiesler (1986) pointed out that geographic, organizational and situational variables constitute the social context of information exchange in e-mail usage. Moreover, such a social context influences information exchange through perception, cognitive interpretation and communication behavior. Thus, social networks underlying an active communication context can help a group achieve an 'organizing vision' of collective actions (Swanson and Ramiller, 1997), and create shared meaning (e.g. sharing the content and interpretation of information) inside the group. The shared meaning of information helps actors cope with barriers to communication. Ngwenyama and Lee (1997) noted that norms of interaction can be used to define organizational context. Thus, this study adopts perceived information-sharing norms to shape the active communication context of cooperative work via the social construction of meaning (Miranda and Saunders, 2003).

Information sharing theory (Constant et al., 1994) states that individual perceptions of information sharing depend on pro-social attitudes and organizational ownership norms. Jarvenpaa and Staples (2000) empirically identified a positive relationship between propensity to share information and the use of collaborative electronic media. However, the relationship between information-sharing norms and performance in e-mail coordination remains unresolved in the literature. Regardless of ownership constraints, information sharing (including task content and task results) in active communication context reduces conflicts and redundancies in coordination, and increases mutual feedback in

communication, thereby improving performance in cooperative work. From a social viewpoint, this study examines the following hypothesis.

H3. Perceived information-sharing norms of e-mail use are positively associated with perceived coordination performance in cooperative work.

3.3. Task-pull factors

Tasks critically shape social contexts, especially in cooperative work (Zack and McKenney, 1995). Some researchers have addressed the association between tasks and communication contexts in the past decade. For instance, Zack and McKenney (1995, p. 394) argued that social contexts influence organizational communication patterns. With respect to the link between work and communication, Hinds and Kiesler (1995) found that different work involves different communication patterns. Coordination theory (Crowston, 1997) addressed the role of tasks in designing coordination processes to support collaborative activities. The link between task and active communication context can be induced from the literature. Overall, a task is a 'pull' force driving the change of communication contexts to suit cooperative activities. For simplicity in developing the theoretical model, this study primarily assesses the associations between task characteristics and perceived information-sharing norms in e-mail coordination.

3.3.1. Task interdependence

The concept of task interdependence stems from Thompson's (1967) work flow categories. As noted by Van de Ven et al. (1976), task interdependence increases with the degree of task-related collaboration. Tushman and Nadler (1978, p. 676) stated that task interdependence refers to the degree to which a subunit depends on other subunits to perform a task effectively, and argued that the degree of task interdependence between subunits is associated with the need for effective coordination and joint problem-solving. Accordingly, task interdependence strongly determines technical communication (Tushman, 1978). Strong coordination is necessary when task interdependence increases to reciprocal and team level (Kim, 1988). The interdependency of tasks is managed by appropriate coordination processes, such as sharing resources, synchronization between producers and consumers and the decomposition of task and subtasks (Malone and Crowston, 1994). Crowston (1997) indicated that task processes can be decomposed, documented and redesigned to create new processes to reduce the need for coordination. Fritz et al. (1998) indicated that highly interdependent tasks require relevant activities to be extensively integrated, to facilitate task sharing among cooperative actors. Along the logics, information must be shared among cooperative actors to coordinate mutual actions involved in interdependent tasks. Jarvenpaa and Staples (2000) identified a strong positive relationship between task interdependence and the use of collaborative electronic media. Karsten (2003) noted that constructing interdependencies is a social process enabling information sharing using appropriate communication technology. In summary, this study hypothesizes that:

H4. Task interdependence is positively associated with the development of perceived information-sharing norms of e-mail use.

3.3.2. Task predictability

The concept of task predictability stems from Perrow's (1967) task variability, defined as '[T]he number of exceptional cases encountered in the work, that is, the degree to which stimuli are perceived as familiar or unfamiliar' (Perrow, 1967, p. 195–196). By contrast, Comstock and Scott (1977, p. 180) defined task predictability as '[T]he extent to which raw materials and task activities associated with the performance of a particular job were well understood and nonproblematic for individuals in that position.' This definition implies that the degree of task predictability depends on actors' knowledge of work processes and materials. Individuals can develop clear decision rules and operating procedures when engaged in predictable tasks (Comstock and Scott, 1977). According to Kim and Umanath (1992), nonroutine activities have low task predictability, while routine activities have high task predictability. Thus, this study defines *task predictability* as the extent of routinization of work processes or procedures, as required by actors in coordinating cooperative work. Low task predictability often leads to high equivocality (ambiguity) of information requirements. Such equivocality can be reduced by exchanging existing views among actors for defining problems and developing a shared interpretation of future activities (Daft and Lengel, 1986). This information-sharing process can be managed in the predefined active communication context. The association between the task and communication contexts is less studied in the literature. However, the negative relationship between task predictability and perceived information-sharing norms can be induced from Fritz et al.'s work (1998). Thus, this study hypothesizes that:

H5. Task predictability is negatively associated with the development of perceived information-sharing norms of e-mail use.

4. Methodology

4.1. Sample and procedure

Office information workers with experience of using e-mail at work participated in this questionnaire survey. The questionnaire was distributed to 15 companies, including traditional industry and service sectors in Taiwan. Each questionnaire was sent with a cover letter describing the objectives of the survey, and the subjects were asked to indicate the degree to which they agreed with a series of statements. A total of 500 questionnaires were distributed to the selected companies in 2003, with 20–50 copies sent to each company, and 295 usable responses were collected.

Table 1 shows that the respondents came from a wide range of functional units across 15 organizations. The respondents were on average 32.1 years old; had been working at their current companies for an average of approximately 74.7 months, and had an average of 48.6 months (i.e. over 4 years) of experience of using e-mail. Overall, the participants had used e-mail to coordinate different levels of cooperative work. Thus, the participants of this study could be considered as experienced e-mail users.

4.2. Measures

Perceived usefulness and perceived ease of use of e-mail in task coordination were measured using Davis's (1989) instruments with necessary word changes to suit the survey.

Table 1
Profile of the respondents

Characteristic	Statistic
Age	Mean = 32.1; Standard deviation = 7.3 (missing = 7)
Gender	(missing = 10, 3.3%)
Male	129 (42.3%)
Female	166 (54.4%)
Education	(missing = 3, 1.0%)
High school	18 (5.9%)
Junior college	108 (35.4%)
University	158 (51.8%)
Graduate school	18 (5.9%)
Job description	(missing = 5, 1.6%)
Managers	46 (15.1%)
Marketing	64 (21.0%)
Production	12 (3.9%)
Finance	50 (16.4%)
Human resource planning	11 (3.6%)
R & D	6 (2.0%)
Administration	55 (18.0%)
System/network management	18 (5.9%)
Others	38 (12.5%)
Job experience at current company	Mean = 74.7 (months); Standard deviation = 70.4 (missing = 3)
E-mail experience	Mean = 48.6 (months); Standard deviation = 29.1

Task interdependence was measured by modifying the measurement items from Jarvenpaa and Staples (2000) to assess cooperative work. Task predictability was measured in terms of three scales modified from Fritz et al. (1998) to meet the cooperative work context. Perceived information-sharing norms were measured in terms of perceived need of information sharing in cooperative work, including the inherent need for information to meet existing usage patterns at work (Howells, 1997, p. 1211), message transfer in communication processes (reducing the interaction gap between information owners and information seekers) and information exchange (influencing others with information) in coordination processes (Finholt and Sproull, 1990, p. 44).

Malone and Smith (1988) adopted production cost (the amount of time taken to perform a task) and coordination cost (the effort required to achieve a goal), as proposed by Malone et al. (1987), to evaluate the coordination performance of different organizational structures. Crowston (1997) used both costs to evaluate the performance of coordinating software bug fixing. This study adopts an approach similar to that of Crowston to measure perceived coordination performance in terms of individual perceptions of task success (achieving the goal), time saving (minimizing production cost), workload reduction (minimizing coordination cost) and improved outcomes (approaching seamless coordination) in the use of e-mail systems. Appendix A outlines the measurement items and their associated underlying constructs, measured on a five-point Likert-type scale, ranging from (1) strongly disagree to (5) strongly agree.

4.3. Data analysis

The research model was tested using a second-generation multivariate technique, called Partial Least Squares (PLS) (Wold, 1982). PLS is appropriate for examining an

exploratory model that involves multiple constructs with multiple indicators, without requiring multivariate normality of data distribution. PLS too is tolerant (more so than LISREL) of small samples (Chin, 1998; Chin and Newsted, 1999). PLS holistically tests both the measurement model and the structural model (Fornell, 1982; Lohmoller, 1989).

The measurement model was used to estimate the relationships (factor loadings) between observed indicators and their posited underlying latent constructs. The factor loadings should exceed 0.7 to ensure that each measure accounts for 50% or more of the variance of the underlying latent construct (Chin, 1998). The structural model was used to estimate the hypothesized associations among constructs, including the path coefficients and the proportion of variance in the endogenous constructs that can be accounted for by the exogenous constructs.

The measurement model was examined by estimating the composite reliability (internal consistency reliability), convergent validity and discriminant validity of the research constructs. The composite reliability of a construct was assessed using the 0.7 threshold (Nunnally, 1978). The convergent validity was accepted if the average variance extracted (AVE) from each construct exceeded the recommended threshold of 0.5 (Fornell and Larcker, 1981). The discriminant validity was acceptable whenever the constructs were correlated more strongly with their indicators than with any other construct (Fornell et al., 1982). Accordingly, the shared variance among constructs should be lower than the corresponding AVEs of the constructs.

5. Results

Following the PLS procedure (Chin, 2001), the Bootstrapping approach was used to generate 300 random samples of observations from the original data set. The Bootstrapping approach can be used to simultaneously examine the validity of the measurement model, and to estimate the path coefficients and the explained variance, according to the structural model.

5.1. Measurement model

Table 2 shows that all observed indicators intended to measure the same latent construct exhibited higher factor loadings on the posited correspondent construct than on other constructs (Fornell et al., 1982; Chin, 1998), evidencing the unidimensionality of each construct. Table 3 shows higher correlation among indicators intended for the same construct than with those measuring other constructs. Table 4 shows that the composite reliability of the six constructs ranged between 0.838 and 0.966, exceeding the threshold of 0.7 recommended by Nunnally (1978). Table 4 also shows that the AVEs of all constructs exceeded the 0.5 threshold (Fornell and Larcker, 1981), indicating that the measurement model exhibited satisfactory convergent validity. Table 5 shows that the shared variance between any two constructs was smaller than the corresponding AVEs of either construct, ensuring adequate discriminant validity (Fornell et al., 1982). Consequently, the measurement model used herein exhibited acceptable construct validity.

5.2. Structural model

Table 6 shows that all path coefficients of the hypothesized links were statistically significant, indicating that the collected data support the five hypotheses in the

Table 2
Analysis of measurement model

Constructs/indicators	Loadings	Standard error	T-statistic
Perceived usefulness			
PU1	0.870	0.022	39.862
PU2	0.916	0.015	60.446
PU3	0.945	0.009	107.747
PU4	0.953	0.008	115.185
PU5	0.924	0.015	60.306
Perceived ease of use			
PEOU1	0.865	0.025	34.975
PEOU2	0.866	0.027	31.847
PEOU3	0.910	0.019	47.836
PEOU4	0.935	0.011	86.329
PEOU5	0.893	0.018	49.276
Task interdependence			
TI1	0.737	0.123	5.986
TI2	0.803	0.100	7.986
TI3	0.775	0.109	7.079
TI4	0.836	0.065	12.820
TI5	0.755	0.098	7.703
Task predictability			
TP1	0.752	0.219	3.434
TP2	0.913	0.180	5.074
TP3	0.712	0.245	2.908
Perceived information-sharing norms			
PISN1	0.866	0.020	42.205
PISN2	0.915	0.014	67.299
PISN3	0.846	0.023	37.256
Perceived coordination performance			
PCP1	0.895	0.020	44.625
PCP2	0.890	0.028	31.689
PCP3	0.920	0.017	55.155
PCP4	0.906	0.023	38.743

research model. The PLS results from the structural model show that perceived usefulness is strongly and positively associated with perceived coordination performance in cooperative work (direct effect = 0.457), supporting hypothesis H1. Also, perceived ease of use is positively and significantly associated with cooperative work performance (direct effect = 0.197), supporting hypothesis H2. As asserted by hypothesis H3, perceived information-sharing norms are positively and significantly associated with perceived coordination performance (direct effect = 0.241). Consistent with hypothesis H4, task interdependence is positively and significantly associated with the development of perceived information-sharing norms inside an organization (direct effect = 0.235). By contrast, task predictability is negatively associated with perceived information-sharing norms (direct effect = −0.197), supporting hypothesis H5. Consequently, the 'technology-push and task/communication-pull' factors jointly accounted for 49.6% of the variance of perceived coordination performance. Overall, the survey identified the effects of the 'push–pull' forces stem from technology, communication and task contexts.

Table 3
Correlation matrix of measurement items

	PU1	PU2	PU3	PU4	PU5	PEOU1	PEOU2	PEOU3	PEOU4	PEOU5	TI1	TI2	TI3	TI4	TI5	TP1	TP2	TP3	PISN1	PISN2	PISN3	PCP1	PCP2	PCP3	PCP4
PU1	1.00																								
PU2	**0.80**	1.00																							
PU3	**0.75**	**0.83**	1.00																						
PU4	**0.76**	**0.84**	**0.89**	1.00																					
PU5	**0.72**	**0.77**	**0.87**	**0.90**	1.00																				
PEOU1	0.47	0.37	0.45	0.45	0.50	1.00																			
PEOU2	0.42	0.40	0.46	0.43	0.50	**0.74**	1.00																		
PEOU3	0.35	0.36	0.39	0.34	0.37	**0.70**	**0.75**	1.00																	
PEOU4	0.39	0.34	0.38	0.35	0.39	**0.72**	**0.74**	**0.88**	1.00																
PEOU5	0.39	0.32	0.34	0.36	0.35	**0.70**	**0.66**	**0.75**	**0.84**	1.00															
TI1	−.03	−.01	−.06	−.02	0.01	0.05	0.02	−.02	0.02	0.04	1.00														
TI2	0.06	0.04	−.01	0.04	0.06	0.07	0.02	0.01	0.08	0.08	**0.67**	1.00													
TI3	0.03	−.01	0.02	−.01	0.02	0.10	0.04	0.05	0.07	0.10	**0.53**	**0.60**	1.00												
TI4	0.05	0.03	0.02	0.02	0.05	0.08	0.01	−.02	0.05	0.03	**0.46**	**0.61**	**0.56**	1.00											
TI5	0.06	0.09	0.10	0.05	0.06	0.13	0.02	0.05	0.05	0.06	**0.45**	**0.41**	**0.41**	**0.51**	1.00										
TP1	−.05	−.03	−.00	−.04	−.02	0.08	0.07	0.04	0.08	0.08	0.15	0.21	0.23	0.25	0.21	1.00									
TP2	0.01	−.01	0.05	0.07	0.08	0.14	0.04	0.03	0.05	0.08	0.23	0.27	0.31	0.29	0.23	**0.45**	1.00								
TP3	−.09	−.05	−.00	−.02	−.06	0.10	0.04	0.06	0.06	0.07	0.14	0.11	0.18	0.17	0.14	**0.51**	**0.45**	1.00							
PISN1	0.30	0.21	0.24	0.23	0.26	0.29	0.26	0.23	0.27	0.28	0.20	0.18	0.20	0.22	0.21	−.07	0.02	−.13	1.00						
PISN2	0.33	0.25	0.26	0.29	0.29	0.25	0.22	0.18	0.25	0.28	0.07	0.15	0.07	0.14	0.09	−.11	0.01	−.14	**0.75**	1.00					
PISN3	0.26	0.24	0.31	0.26	0.29	0.24	0.22	0.22	0.25	0.25	−.02	−.02	0.07	0.11	0.16	−.06	0.00	−.12	**0.54**	**0.67**	1.00				
PCP1	0.52	0.54	0.60	0.55	0.54	0.42	0.38	0.42	0.46	0.51	0.06	0.06	0.07	0.08	0.12	0.08	0.04	−.01	0.31	0.37	0.44	1.00			
PCP2	0.51	0.44	0.49	0.47	0.49	0.42	0.37	0.36	0.38	0.46	0.02	0.05	0.05	0.12	0.04	0.10	−.01	−.02	0.35	0.39	0.38	**0.77**	1.00		
PCP3	0.48	0.52	0.62	0.56	0.56	0.37	0.38	0.38	0.35	0.42	−.01	−.05	−.01	0.01	0.08	0.09	0.04	0.02	0.28	0.32	0.41	**0.74**	**0.74**	1.00	
PCP4	0.46	0.49	0.58	0.53	0.52	0.36	0.34	0.37	0.34	0.41	0.00	−.06	−.01	−.00	0.06	0.09	0.02	0.02	0.29	0.33	0.45	**0.72**	**0.72**	**0.85**	1.00

Table 4
Descriptive statistics, reliability and convergent validity

	Mean	SD	Composite reliability[a]	Average variance extracted (AVE)[b]
PU	4.07	0.58	0.966	0.850
PEOU	4.05	0.58	0.952	0.799
TI	4.04	0.50	0.887	0.611
TP	3.75	0.57	0.838	0.635
PISN	3.91	0.67	0.908	0.767
PCP	3.94	0.59	0.946	0.815

[a] Composite reliability is estimated using $(\sum \lambda_i)^2/((\sum \lambda_i)^2 + \sum \mathrm{var}(\varepsilon_i))$; where λ_i, the factor loadings of the observed indicators on the respective latent constructs.
[b] Average variance extracted is estimated using $(\sum \lambda i^2)/(\sum \lambda i^2 + \sum var(\varepsilon i))$ (Fornell and Larcker (1981)).

Table 5
Analysis of discriminant validity

Construct	PU	PEOU	TI	TP	PISN	PCP
PU	**0.850**					
PEOU	0.228	**0.799**				
TI	0.002	0.005	**0.611**			
TP	0.001	0.009	0.061	**0.635**		
PISN	0.111	0.099	0.035	0.019	**0.767**	
PCP	0.398	0.241	0.003	0.002	0.207	**0.815**

Diagonal elements represent the AVE of the constructs, while the other matrix elements represent the shared variance (the squared correlations).

Table 6
Results of PLS analysis

Causal link	Path coefficient	Standard error	T-statistic	Hypothesis testing
PU → PCP	0.457**	0.065	7.001	H1 is supported
PEOU → PCP	0.197*	0.068	2.917	H2 is supported
PISN → PCP	0.241**	0.064	3.794	H3 is supported
TI → PISN	0.235**	0.061	3.850	H4 is supported
TP → PISN	−0.197*	0.077	2.553	H5 is supported

R^2 (PISN) = 7.1%; R^2 (PCP) = 49.6%. *: 0.01 significance level; **: 0.001 significance level.

6. Discussion

6.1. Technology context

This empirical study has identified the association between two 'technology-push' factors (perceived usefulness and perceived ease of use) and e-mail coordination performance. That is, e-mail functionality helps experienced users to coordinate task, save time, reduce workload and improve work outcomes. From the perspective of rationality, this study argued that the perceived benefits of e-mail motivate actors to use it to coordinate cooperative work. This survey confirms that the two 'technology-push' factors significantly govern individual use of e-mail in task coordination. Moreover, the perceived usefulness is more strongly associated with the perceived performance of e-mail coordination than is the perceived ease of use. The empirical findings indicate that work-oriented e-mail users, especially professional office workers, are more concerned with effectiveness and efficiency than with ease of use of a

communication medium in cooperative work. More than 70% (207 of 295) participants in this study are the so-called professional office workers who must spend most of their time in technical rather than administrative communication, as shown in Table 1. In summary, the 'technology-push' factors confirm Sproull and Kiesler's (1992) 'first-level effects' and show that these rational influences still significantly govern e-mail use in social groups.

6.2. Communication context

Perceived information-sharing norms are positively associated with e-mail coordination performance, indicating that establishing an active communication context helps seamless coordination. This study considers an active communication context as a particular social network where people can influence each other via messages. The social process as occurred behind cooperative work motivates the need of cohesive relationships among cooperative actors, enabling them to perceive the importance of developing common norms for information sharing in e-mail coordination. Information sharing allows cooperative actors to cope with ambiguity and ensure convergence in understanding coordination processes, reducing conflicts among their communicative actions. Such an active communication context associated with common information-sharing norms enables e-mail groups to create shared meaning and reduce cognitive gaps via cohesive social networks. In the survey of experienced e-mail users, the identified effect that emerges from the 'communication-pull' factor shows that the need of information sharing governs the use of e-mail in cooperative work. As argued in the research model, the social influence of e-mail use is likely to create common norms of information sharing for improving the performance in cooperative work. Accordingly, the 'communication-pull' factor tends to exert a 'second-level effect' on e-mail groups (Sproull and Kiesler, 1992). Hence, social networks, rather than information networks, govern the development of active communication contexts for reducing the communication boundaries among cooperative actors.

6.3. Task context

The empirical finding that interdependence among tasks is positively associated with perceived information-sharing norms shows that high interdependency among tasks pushes actors to develop strong information-sharing norms. Thus, cooperative actors develop an active communication context associated with strong information-sharing norms to resolve possible conflicts emerging from interdependent task coordination. By contrast, the high predictability of tasks allows actors to achieve cooperative work by following existing procedures. As expected from the model, a task with a clear procedure is likely to reduce individuals' need to share information through a social network. Additionally, the association between task context and communication context found in this study indicates that the development of information-sharing norms is a context-dependent process governed by tasks. The empirical findings show that the 'task-pull' forces can shape perceived information-sharing norms, suggesting that the cooperative work coordination processes should be designed to fit the information flows. Thus, high task interdependence intensifies information flows among cooperative actors. By contrast, high task predictability leads to loose control of information flows by cooperative actors. For instance, 'standardization' and 'participatory design' were used to control information sharing in coordinating collaborative activities (Malone and Crowston, 1994). 'Standardization'

can be considered as an information procedure design for highly predictable tasks, while 'participatory design' is an information procedure design for highly interdependent tasks. Both 'standardization' and 'participatory design' are viewed as opposite coordination strategies behind the 'task-pull' forces, which can be employed to meet certain active communication contexts via information flow control.

7. Implications

Markus' (1994b) 'social definition theory' regards e-mail as an appropriate medium for work-related communication not involving private social and interpersonal relationships or personal matters. This study extends Markus' theory to consider links between task and communication contexts, to seek appropriate active communication contexts to 'fit' e-mail coordination. High task interdependence or low task predictability increase cooperative actors' load and need to acquire and process information. By contrast, low task interdependence or high task predictability reduce the difficulty and need of information processing among cooperative actors. A lack of information makes problems too ambiguous, while excessive information causes information overload, in which the amount of available information exceeds an individual's capacity to process it (Schultze and Vandenbosch, 1998). The paradox of information needs implies that cooperative actors should seek appropriate rather than excessive information to reduce the cognitive gap underlies bounded rationality (Simon, 1991). Thus, appropriate information-sharing norms facilitate cooperative actors to reduce information overload in e-mail coordination.

In practice, the empirical findings offer strategic directions for avoiding information overload in e-mail coordination. Regarding the use of e-mail for sharing information required in cooperative work, an appropriative active communication context enables cooperative actors to choose each other autonomously via cohesive social networks, so that they know whom to contact and what topics to address without losing control of information flows inside a self-selected group. Two information processing strategies with respect to information flow control, *filtering* and *prioritizing*, are available to reduce information overload. An individual can filter irrelevant e-mail by its author or title (Hiltz and Turoff, 1985), and can prioritize the processing of incoming e-mail according to its importance or urgency. People could apply the two information processing strategies to capture socially-defined information searching and sharing rules for the e-mail coordination context.

8. Limitations

Four limitations of this study should be discussed before the research model can be applied to predict perceived coordination performance in e-mail use. First, this study surveyed only the cooperative work performed by experienced e-mail users. The results must be extended carefully to explain the performance of inexperienced e-mail users. Second, this study did not examine collaborative activities in relation to various coordination modes or mechanisms, nor did it separate cooperative work into technical and administrative communications. This limitation may explain the low explained variance in perceived information-sharing norms. Third, this study used the perceived information-sharing norms to define the active communication context, which may overly simplify the multi-dimensional characteristics of e-mail use context. Other dimensions outside the scope of this study, such as cooperative values, culture and communication grammar, need to be

included to define the active communication context of e-mail use. However, this study is a basis for refining an active communication context in further research by exploring additional dimensions. Future research can use the active communication context to explore information overload and organizational boundaries, as both issues are related to the control of information over social networks. Fourth, the instrument of this study was administered by translating previous items from English to Mandarin Chinese, possibly causing a slight loss of meaning in the translation.

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Appendix A. Summary of measures and the underlying constructs

A.1. Perceived Usefulness (PU)

PU1 Using e-mail enables me to coordinate tasks more quickly
PU2 Using e-mail improves my performance when coordinating my tasks
PU3 Using e-mail in my coordinated tasks can increase my productivity
PU4 Using e-mail can enhance my effectiveness on the coordinated tasks
PU5 I find e-mail useful in coordinating my tasks

A.2. Perceived Ease of Use (PEOU)

PEOU1 Learning to use e-mail is easy for me
PEOU2 I find it easy to get e-mail to do what I want it to do
PEOU3 My interaction with e-mail is clear and understandable
PEOU4 It is easy for me to become skillful at using e-mail
PEOU5 I find e-mail easy to use

A.3. Task Interdependence (TI)

TI1 My work is often completed with the support of people from other departments
TI2 My work is related to other people in my department
TI3 My work often requires the cooperation of other departments
TI4 The results of my work depend on team coordination
TI5 The results of my work depend on communication with other team members

A.4. Task Predictability (TP)

TP1 A clearly known way is available to do the major type of work that I normally encounter
TP2 An understandable sequence of steps can be followed in doing my work
TP3 A clearly defined body of knowledge of subject matter guides my work

A.5. Perceived Information-Sharing Norms (PISN)

PISN1 I need to use e-mail to share information with coworkers in task coordination
PISN2 I need to use e-mail to transfer documents/files to coworkers in task coordination
PISN3 I need to communicate with coworkers through e-mail in coordinating my work

A.6. Perceived Coordination Performance (PCP)

PCP1 I have successfully used e-mail to accomplish task coordination
PCP2 I have used e-mail in coordinating tasks to save work time
PCP3 I have used e-mail in coordinating tasks to reduce my workload
PCP4 I have used e-mail in coordinating tasks to improve the quality of results

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