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Leveraging competence in the use of leveraging collaborative tools competence: facilitating an Open Architecture approach to acquiring integrated warfare systems

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Leveraging Competence in the Use of Leveraging Collaborative Tools Competence: facilitating an Open Architecture Approach to Acquiring Integrated Warfare Systems

30 December 2006

by

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Abstract

A fundamental problem in reaping the benefits of using an Open Architecture (OA) approach to developing integrated warfare systems (IWS) is the requirement for the multiple parties involved to collaborate. This was less of a problem when single vendors managed the entire acquisition life cycle. To take advantage of the potential of OA to use common off the shelf software modules, multiple vendors, greater access and involvement of the acquisition professional and future users of the IWS, collaborative information technology is a necessary ingredient. And, to make collaborative tools useful in the IWS acquisition life cycle, users must leverage their competence with the collaborative tools.. To shed light on this requirement, this paper introduces the construct of ‘Collaborative IT Tools Leveraging Competence’ as the ability of various OA work groups involved in the IWS acquisition life cycle to effectively leverage collaborative IT tools to enhance their group performance. Collaborative IT Tools Leveraging Competence is conceptualized as a second-order construct formed by the group’s effective use of the following six key IT functionalities: workspace sharing, conferencing, file sharing, scheduling, chat, and email.

Collaborative IT Tools Leveraging Competence is hypothesized to facilitate group performance (process efficiency, project effectiveness, and situational awareness), particularly in intense work environments such as OA acquisition contexts. To enhance an OA work group’s ability to effectively leverage collaborative IT tools, the study proposes a set of enabling factors: customization of the collaborative IT tools, group habits in using collaborative IT tools, the group’s perceived usefulness and ease of use of collaborative IT tools, the group member’s mutual trust, and the degree of environmental intensity.

Data from 365 group managers support the proposed structural model with the antecedents and consequences of Collaborative IT Tools Leveraging Competence at different levels of environmental intensity. The paper discusses the

study’s contributions of better understanding the nature, antecedents, and consequences of Collaborative IT Tools Leveraging Competence on OA work group performance. Implications for the acquisition of IWS are discussed.

Keywords: Collaborative Tools, IT Leveraging Competence, Open Architecture Group Performance, Customization.

About the Authors

Tom Housel, specializes in valuing intellectual capital and knowledge value measurement. He is currently a tenured Full Professor for the Information Sciences (Systems) Department. He won the prestigious Society for Information Management award for best paper in the field in 1986. His work on measuring the value of intellectual capital has been featured in a Fortune cover story (October 3, 1994) and Investor's Business Daily, numerous books, professional periodicals, and academic journals (most recently in the Journal of Intellectual Capital vol. 2, 2005).

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Introduction

Collaborative information technology (IT) tools, such as the UGS PLM suite, Groove, and Oracle Collaboration Suite are integrated sets of IT functionalities that enable communication and information sharing among inter-connected entities. By enabling collaboration in OA based IWS acquisition processes where it was not feasible before and improving existing collaborative work among the multiple groups involved in the OA approach to IWS acquisition, collaborative IT tools have transformed the established nature of traditional collaborative group works, and have increased interest among academics and practitioners (e.g., Easley, Devaraj, and Crant, 2003). However, despite the widely publicized potential of collaborative IT tools to enhance group performance, we still know little about whether, how, and why these collaborative tools actually enhance group performance.

To shed light on this question, this study follows the proposed focus of Pavlou and El Sawy (2006) on the *leveraging* dimension of IT capability to introduce the notion of 'Collaborative IT Tools Leveraging Competence.' This is defined as the ability of work groups to effectively leverage the IT functionalities of collaborative IT tools to facilitate their group activities. Since collaborative IT tools can be viewed as generic information technologies whose IT functionalities cannot be differentiated across groups, the current study will enable differentiation of groups based on how well they leverage generic IT functionalities to create business value. Moreover, since collaborative IT tools are primarily used by groups to facilitate their group activities, the proposed construct is conceptualized at the process-level of analysis. This level of analysis was advocated by Ray, Muhanna, and Barney (2005) who argued that the process (not the organizational) level of analysis was the most appropriate level for observing the value of IT.

A review of numerous commercial software packages identified the core IT functionalities that are commonly found in collaborative IT tools - *workspace sharing*, *conferencing*, *file sharing*, *scheduling*, *chat*, and *email* functionality. Integrating these

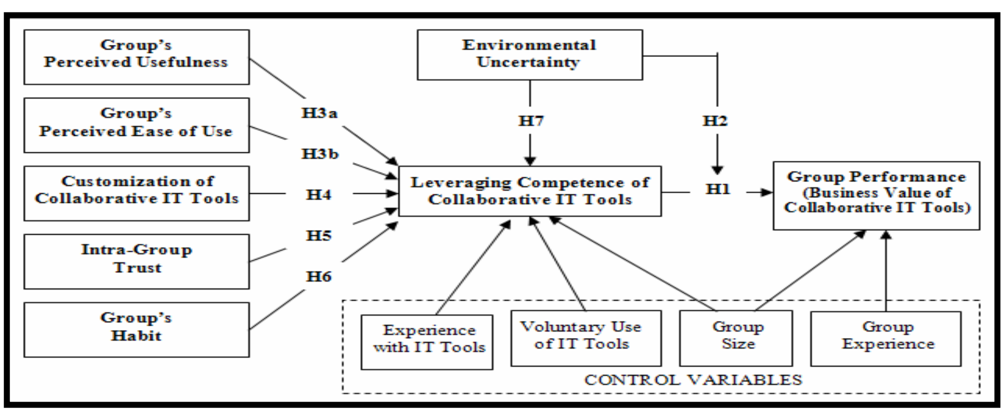
IT functionalities, Collaborative IT Tools Leveraging Competence (CITLC) is conceptualized as a formative second-order construct formed by the group's effective use of these six key functionalities.

To show the value of CITLC to facilitate an OA approach to IWS acquisition, we hypothesize its impact on group performance in terms of the group's process efficiency, effectiveness, and situational awareness. The proposed value of leveraging group competence in using collaborative IT tools is hypothesized to be positively moderated by the degree of environmental uncertainty in which the group operates, e.g., in a highly complex OA acquisition context.

Finally, the study identifies the key factors that enhance a group's CITLC. Extending the literature on the effective use of IT by work groups, a set of antecedent variables is proposed, namely *technology adoption* variables (the group's perceived usefulness and ease of using collaborative IT tools), *technology* variables (customization of collaborative IT tools), *social* variables (the group member's mutual trust), *post-adoption* variables (the group's habit in using collaborative IT tools), and *environmental* variables (the degree of environmental uncertainty in which a group operates).

Figure 1 summarizes the antecedents and consequences of Collaborative IT Tools Leveraging Competence.

Figure 1. The Proposed Research Model



Theory Development

Collaborative group work is considered foundational for modern organizational success by creating value for organizations (Leonard-Barton 1992, Pavlou and El Sawy 2006, Sole and Applegate 2000). Collaborative group work has been dramatically enhanced by the infusion of newer collaborative IT tools, which integrate IT functionalities enabling synchronous and asynchronous communication and information sharing among inter-connected entities from virtually any geographical location. Today's collaborative IT tools are new versions of computer-aided 'Group Communication Support Systems', 'Group Decision Support Systems', or 'groupware' (Licklider and Taylor, 1968, Nunamaker, Dennis, and Valacich, 1991), that also were designed to support collaborative work. Today, Internet-based collaborative tools are becoming the primary approach for geographically dispersed groups (Wheeler, Dennis, and Press, 1999). However, there is scant systematic research on their potential value in complex acquisition contexts such as in an OA environment.

Collaborative IT Tools Leveraging Competence

The development of the proposed CITLC construct is rooted in the IT capability literature (Barua *et al*. 1995, Bharadwaj 2000) that is underpinned by the resource based view (Barney 1991). The IT capability literature argues that various complementary IT resources combine to form an IT capability, which is valuable, rare, non-imitable, and non-substitutable (Mata *et al*. 1995). IT capability has been viewed as a multi-dimensional construct composed of three key dimensions: *acquisition*, *deployment*, and *leveraging* of IT resources.

While the literature has viewed IT capability at the firm level of analysis, Ray et al. (2005) argued that the primary effects of IT should be examined at the process level, stressing the need to look beyond the firm level of analysis. Moreover, Pavlou and El Sawy (2006) noted the need to look outside of the IT unit for understanding the IT capability of end users. The authors argued that the *leveraging* of IT resources is the primary differentiating dimension among end users, noting that the acquisition and deployment dimensions of IT capability are largely based on the IT investment decisions of IT executives and are primarily implemented by IT people within the IT unit. Moreover, collaborative IT tools are generic technologies that have little basis for differentiation in terms of acquisition and deployment. A notable exception is the collaborative tools suites that include product life cycle management capabilities (such as those found in the UGS product). Following this logic, we focus on the *leveraging* dimension of collaborative IT capability, that is more likely to differentiate performance among collaborating groups.[1] Therefore, CITLC is conceptualized at the group level of analysis as the effective leveraging of collaborative IT functionalities to enhance group activities and improve their performance. The practical result of improving performance among groups within an OA based IWS acquisition environment will be reduced cycle time, better management of the multiple parties involved, and enhanced ability to reuse system modules.

Components of Collaborative IT Tools Leveraging Competence

To identify the components of the CITLC construct, we examined over 30 commercial collaborative packages to identify their common IT functionalities. As summarized in Table 1, the common IT functionalities are *workspace sharing*, *conferencing*, *file sharing*, *scheduling*, *chat*, and *email* functionalities.

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[1] The acquisition and deployment of collaborative IT tools are likely to improve group performance in an absolute sense compared to not having acquired and deployed such IT tools. However, since most groups have acquired and implemented collaborative IT tools, their acquisition and deployment are unlikely to be a differentiating factor.

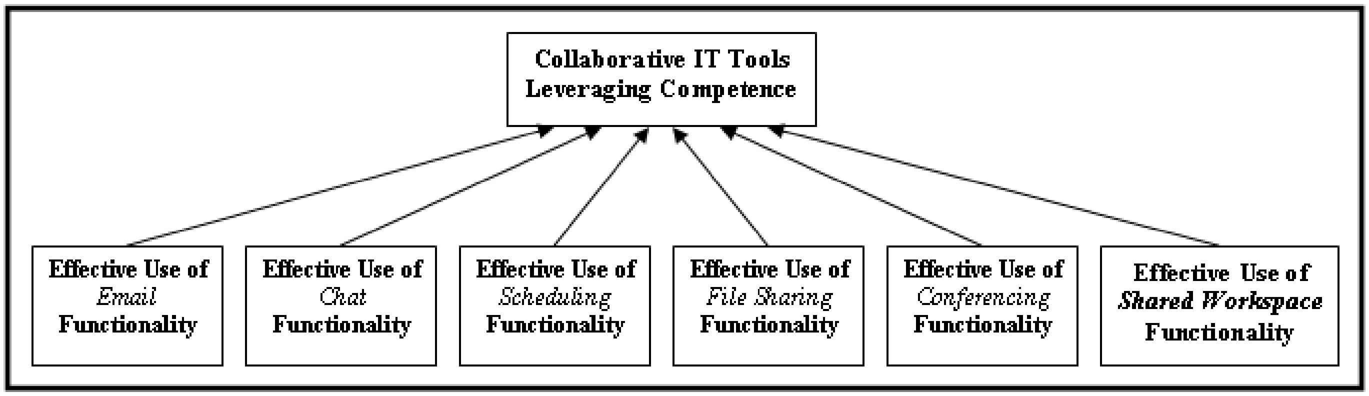
Collaborative IT Tools Leveraging Competence as a Formative Higher-Order Model

CITLC is proposed as a multi-dimensional latent construct. To model the proposed six IT functionalities under a unitary representation, we propose a second-order formative construct formed by the effective leveraging of these six IT functionalities (Figure 2). Formative second-order models provide a coherent and parsimonious depiction of multi-dimensional phenomena, and are herein employed to represent the individual effects of the key IT functionalities on a group's overall CITLC.

Table 1. Common IT Functionalities of Collaborative IT Tools

Common IT Functionalities of Collaborative IT Tools
Effective Use of *Email* Functionality
Email to exchange messages among group members.
Effective Use of *Chat* Functionality
Chat/Instant Messaging to share information in real-time.
Effective Use of *Scheduling* Functionality
Calendar for connecting time and location information for all team members
Scheduling for providing up-to-date calendar information.
Effective Use of *File-Sharing* Functionality
File sharing to store, archive, and reuse information and best practices.
Consolidation and synchronization of files into a single repository for easy access.
Effective Use of *Conferencing* Functionality
Conferencing for spawning new ideas and solutions.
Collaboration among team members to interact in real time.
Effective Use of *Workspace Sharing* Functionality
Shared workspace for simultaneously working together in real-time.
Whiteboard functionality for bringing together team members.

Figure 2. The Formative Second-Order Model of Collaborative IT Tools Leveraging Competence

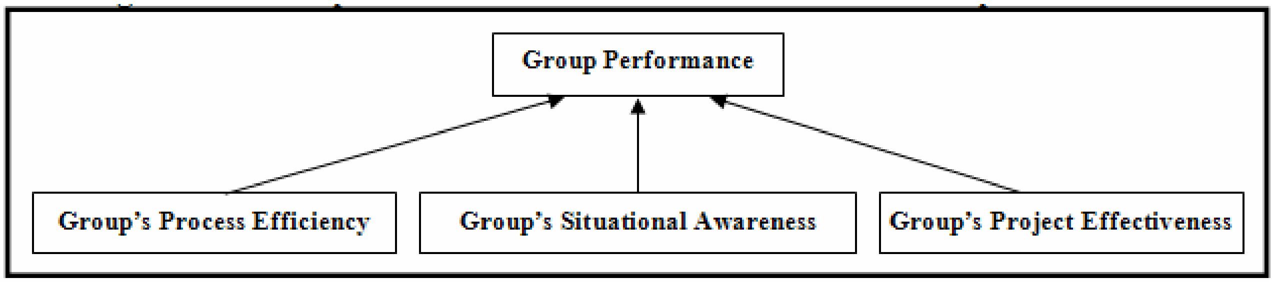


Since IWS acquisition and life cycle OA work groups are likely to use these IT functionalities with different degrees of effectiveness, the effective leveraging of each IT functionality is proposed to impact CITLC in a *formative* fashion. In addition, since an improvement in the group's ability to leverage any single IT functionality does not necessarily imply an equal improvement in the ability to leverage any other IT functionality, a reflective model is less likely. Thus, a formative second-order model is deemed appropriate for representing the proposed construct of collaborative IT tools leveraging competence.

Work Group Performance

CITLC is proposed to enhance work group performance by enabling work groups to complete their activities more efficiently, more effectively. We focus on three aspects of performance – process efficiency, situational awareness, and project effectiveness – which are important determinants of work group performance. Project effectiveness refers to project quality and innovativeness (Kusunoki et al. 1998). Process efficiency refers to time and cost savings (Kusunoki et al. 1998). Situational awareness reflects the group's understanding of their surroundings (Endsley 1996). These three performance components can be represented with a formative second-order model (Figure 3).

Figure 3. The Proposed Formative Second-Order Model of Group Performance



By supporting superior information processing and knowledge sharing through rich, reliable, and rapid communication and information flows, the effective use of collaborative IT tools can enhance the three elements of group performance (project effectiveness, situational awareness, and process efficiency), as briefly explained in what follows.

Project Effectiveness

The effective use of collaborative IT tools is proposed to enhance group project effectiveness. First, the effective use of email, chat, and conferencing functionality enables work groups to share relevant project knowledge by simultaneously viewing, discussing, and editing project documents. Second, the effective use of file sharing functionality facilitates easy access to knowledge, enabling groups to acquire, interpret, and synthesize knowledge. Third, the effective use of scheduling and workspace sharing functionality can enhance the group's problem-solving capacity, help generate new thinking, and enable groups to find better project solutions through rich communication (McGrath and Iansiti 1998). Taken together, the improved capabilities facilitated by the effective use of collaborative IT functionalities can help facilitate the OA approach to IWS acquisition by enhancing the group's project effectiveness.

Situational Awareness

The effective leveraging of collaborative IT tools is also proposed to enhance the group's situational awareness. First, the effective use of chat, email, and file sharing functionality helps groups stay current with their surroundings by obtaining and exchanging up-to-date information about their environment. Second, the effective use of scheduling and conferencing functionality enables groups to jointly assess real-time information about their surroundings (Sambamurthy *et al.* 2003). Finally, the effective use of workspace sharing functionality helps groups obtain visibility of real-time data, collectively analyze these data, thereby allowing them to have a real-time vision of their surroundings and helping them be more responsive and flexible (Wade and Hulland 2004). This is especially pertinent with collaborative suites that include product life cycle management capabilities in an OA environment where multiple parties must stay on the "same page" throughout the acquisition life cycle. Thus, the effective use of collaborative IT tools improves performance in an OA acquisition environment by enhancing the group's situational awareness.

Process Efficiency

The effective leveraging of collaborative IT tools is finally proposed to enhance the group's process efficiency. First, the effective use of chat and email functionality enables efficient communication and rapid information flows, which helps the overall group efficiency. Second, the effective use of scheduling functionality makes it easier for groups to identify and efficiently allocate available people and resources to the most appropriate tasks. Third, the effective use of conferencing functionality enables groups to avoid travel and face-to-face meeting, thus reducing project cost. Finally, the file and workspace sharing functionality enables groups to synchronize and simultaneously execute more activities in parallel, thereby cutting down the time required for completing group activities (Sethi *et al*. 2001). This synchronization capability is critical in managing an OA based IWS acquisition life cycle. By reducing the cost, time, and effort required to perform group activities, the effective use of collaborative IT functionalities helps increase the group's process efficiency while providing the necessary synchronization capabilities among the multiple parties in an OA system acquisition life cycle.

Summarizing the logic by which the leveraging competence of collaborative IT tools enhances a group's project effectiveness, situational awareness, and process efficiency, we propose the following hypotheses.

H1: CITLC **positively influences group performance.**

The Moderating Role of Environmental Turbulence on Business Value of Collaborative IT Tools

Environmental uncertainty or unpredictability describes whether the group's surrounding conditions are characterized by frequent changes that are difficult to forecast. This is often the case in system acquisition life cycles where costs and schedules frequently can be from 50% to 150% over targets. In uncertain environments, rapid communication and information flows are needed to quickly adapt to environmental changes and respond to unpredictable new conditions. In such unpredictable environments, the superior information processing and knowledge sharing capabilities of collaborative IT tools are likely to be conducive to enabling groups to better respond to environmental changes. First, sharing project knowledge, generating new thinking, and finding new solutions is more important in unpredictable environments. Therefore, the leveraging competence of collaborative tools will be more pronounced in enhancing project effectiveness in uncertain environments. Second, staying current with the environment and having up-to-date information is more crucial in uncertain environments. The effective use of collaborative IT tools thus becomes more important to enhance a group's situational awareness. Finally, uncertain environments make it more difficult to allocate people and resources to tasks and synchronize group activities. Therefore, the effective use of collaborative IT functionalities is likely to have a more pronounced impact on a group's process efficiency. Summarizing these arguments, we propose that the positive impact of CITLC on group performance to be higher in more uncertain environments. Hypothesis H2 follows from this logic.

> **H2: Environmental uncertainty positively moderates (reinforces) the positive impact of** CITLC **on group performance.**

Enhancing the Business Value Potential of CITLC

Having hypothesized that CITLC has value in terms of group performance, particularly in more uncertain environments, the next hypotheses focus on how the use of collaborative IT tools can be enhanced. We identified a group of antecedent variables that are proposed to enhance group performance using collaborative IT tools. These variables can be grouped into five categories: (1) *adoption* variables (group's **perceived usefulness** and **ease of using** collaborative IT tools); (2) *technology* variables (**customization** of collaborative IT tools); (3) *social* variables (group's intra-group **trust**); (4) *post-adoption* variables (group's **habit** of using collaborative IT tools); and (5) *environmental* variables (**environmental uncertainty** within which the group operates). The proposed effect of these variables is justified in what follows.

Group's Adoption of Collaborative IT Tools

An important prerequisite for building group competence in leveraging collaborative IT tools is for these tools to be adopted and used by the group. Following Davis' (1989) technology acceptance model, the major determinants of IT adoption are

- perceived usefulness - the extent to which a system user believes that using a system will enhance his/her job performance.
- and perceived ease of use - the extent to which a system user believes that using the system will be effortless.

While these two adoption variables have been defined at the individual user level, in terms of collaborative IT tools, the group's perceived usefulness and ease of using collaborative IT tools is described at the group level. Accordingly, perceived usefulness of IT tools captures the group's aggregate perception of whether the collaborative IT functionalities enable the group to accomplish its tasks more quickly, improve its job productivity, and facilitate improved performance. Also, perceived ease of use captures the group's aggregate perception in terms of whether the group's use of the collaborative IT tools is clear, intuitive, and effortless. Extending perceived usefulness and ease of use at the group level, the group's perceived usefulness and ease of using collaborative IT tools are proposed to enhance the group's collaborative IT tools leveraging competence. We thus hypothesize:

H3a: Group's perceived usefulness of collaborative IT tools positively influences the leveraging competence of collaborative IT tools.

H3b: Group's perceived ease of using collaborative IT tools positively influences the leveraging competence of collaborative IT tools.

Customization of Collaborative IT Tools

Collaborative IT tools can be viewed as general-purpose IT tools that can be purchased as off-the-shelf software and be deployed to help work groups accomplish their business tasks. Despite being general-purpose IT tools, collaborative IT tools have flexible functionalities that can be customized to better match a group's unique activities. For example, workspace sharing functionality can be customized to work with certain OA-based computer design software. Also, file sharing functionality can link to the group's design databases and this capability is particularly useful if the tools have product life cycle management functionality. If the collaborative IT tools are customized to the group's specific needs and are adapted to better match the group's processes, rules, and practices, they are likely to be more effectively leveraged by the group. The unique requirements of the IWS acquisition life cycle make the capability to customize very relevant. Hence, we offer the following hypothesis for testing:

H4: The customization of collaborative IT tools positively influences the leveraging competence of collaborative IT tools.

Intra-Group Trust

Intra-group trust reflects the extent to which group members trust each other. Trust among group members also captures whether promises to each other are reliable, whether group members are honest to each other, and whether they would go out of their way to help each other. Trust is considered to be a fundamental antecedent of successful collaboration by enhancing the willingness among collaborators to share knowledge (Nonaka 1994). Moreover, by making group members feel less vulnerable, trust enhances the group's comfort with sharing sensitive information. Finally, intra-group trust enables group members to work together well without interpersonal conflicts. In summary, if groups openly share sensitive information and knowledge, they are more likely to effectively use collaborative IT tools whose primary purpose is to facilitate rich communication and rapid information flows. In the IWS development environment, enhancing trust is critical when using the OA approach where the consequences of miscalculations, mistakes in developing the internal workings of an IWS system can have devastating consequences. While collaborative tools may not ensure a high level of trust among the multiple parties in an OA development environment, they will facilitate the development of trust among the multiple parties.

H5: Intra-group trust positively influences the leveraging competence of collaborative IT tools.

Group's Habit in using Collaborative IT Tools

Habit measures the frequency of repeated or automated performance of using a system (Limayem and Hirt 2003). The association between habit and repeated behavior suggests that the behavior is consistently performed over time (Ajzen 2002). Habit in using collaborative IT tools reflects the group's willingness to make the IT tools a part of the group's regular work routine. Since repeated use is one of the primary factors for enhancing the effectiveness of a behavior, the habitual use of collaborative IT tools is likely to enhance the leveraging competence of IT tools. All things being equal, increased frequency of use of the collaborative IT tools, on average, implies that the tools facilitate the group's outputs and thus contribute directly to the productivity of the group. One key to successful use of the OA approach in developing IWS systems is the need to make use of collaborative tools routine. Therefore, we hypothesize:

> **H6: Group's habit in using collaborative IT tools positively influences the leveraging competence of collaborative IT tools.**

Environmental Uncertainty

As noted earlier, environmental uncertainty reflects whether the group's surrounding environment is characterized by frequent changes that cannot be easily predicted. Unanticipated changes force groups to seek new information, develop new skills, and build new knowledge, which requires rapid information and knowledge flows. In such environments, groups will be forced to enhance their information processing and knowledge sharing capabilities to quickly adapt to the unpredictable environmental changes. Given the need to enhance their information processing capacity, groups will attempt to use their collaborative IT tools more effectively. We thus hypothesize:

> **H7: Environmental uncertainty positively influences the leveraging competence of collaborative IT tools.**

In contrast to the previous antecedents of collaborative IT tools leveraging competence (H3-H6), H7 is a descriptive (as opposed to a prescriptive) hypothesis, which simply suggests that groups that operate in uncertain environments, such as the complex system acquisition life cycle in an OA environment, are more likely to effectively use collaborative IT tools.

Control Variables

Experience with Collaborative IT Tools: In addition to habit that captures the group's automated use of IT tools, we also control for the group's experience with the collaborative IT tools on their leveraging competence.

Voluntary Use of Collaborative IT Tools: Voluntariness captures whether the collaborative IT tools are voluntarily used by the group, or whether they are mandatory. Groups who are forced to use collaborative IT tools may behave differently from those who have freedom in choosing to use, thus due to its potential impact on leveraging the competence of collaborative IT tools this characteristic is controlled for.

Group Size and Experience: The group's size and experience are controlled for their potential impact on both leveraging competence of collaborative IT tools and also on group performance.

Research Methodology

Measurement Development

Other than the leveraging competence of collaborative IT tools, all measurement items were adapted from existing scales. For the new measure and for measures that required significant adaptation, standard scale development procedures were used (Churchill 1979, Straub 1989). First, the content domain of each construct was specified. Second, a large pool of items was developed based on the conceptual definition, assuring that these items tap the construct's domain. From this pool, items were chosen based on whether they conveyed different, yet related shades of meaning (Churchill, 1979). The measurement items were refined based on a large-scale pretest of the survey instrument with 17 student groups. All measurement items were consistent with the study's unit of analysis being at the group level (Appendix 1).

Collaborative IT Tools Leveraging Competence: A new measure was developed to capture the extent by which groups leverage collaborative IT functionalities, following Pavlou and El Sawy (2006). Special care was taken to tightly link the proposed IT functionalities (email, chat, scheduling, file sharing, shared workspace, conferencing) with specific group activities (Lind and Zmud, 1995). A total of ten items were used.

Group Performance: Project effectiveness and process efficiency were measured with two items each, following Kusunoki et al., (1998). Situational awareness was measured with three items based on Endsley (1996).

Antecedents of Collaborative IT Tools Leveraging Competence: The group's perceived usefulness and ease of using collaborative IT tools was each measured with three items (Venkatesh, 2000). The customization of collaborative IT tools was measured with two standard items. Intra-group trust was measured with four items (Jap, 1999). Habit was measured with two items (Limayem and Hirt 2003).

Environmental uncertainty was measured with two items (Pavlou and El Sawy, 2006).

Survey Administration

A survey study was conducted among 400 work groups of a large multi-national corporation that specializes in software and services. The benefit of surveying groups from the same company that use the same collaborative IT tool suite was to ensure that all groups had the same collaborative IT functionalities. Since the study’s unit of analysis was the group, we employed key informant methodology by asking the group managers to respond on behalf of the entire group. Invitation e-mails were then sent, explaining the study’s purpose and requesting their participation. The email body assured that the responses would be treated confidentially, and the results would only be reported in aggregate. The respondents were asked to click on a URL link shown in the e-mail message that linked to our online survey instrument. The respondents were offered as incentive a customized report with the study’s results. To ex ante reduce the potential for common method bias, the study’s instructions specifically asked the respondents to consult with other group members to collectively respond to the survey items.

In total, out of the 400 invitees for the study, a total of 365 usable responses were obtained (91% response rate). The high response rate was due to the commitment by the company’s executives to promote the study and personally send the invitation e-mail to the respondents. Non-response bias was assessed by verifying that early and late respondents were not significantly different in terms of their demographic information (age, gender, education, experience with collaborative tools, and group size) (Table 1) and their actual survey responses (Armstrong and Overton 1976). Early respondents were those who responded within the first week (about 50%). All t-test comparisons between the means of the early and late respondents showed no significant differences, indicating lack of non-response bias.

Demographic information is shown in Table 1.

Table 1. Demographic Information

Manager's Age	Manager's Gender	Manager's Education	Group's Tool Experience	Group Size
43 (9)	90% Male	Some College	4.7 years (3.4)	78 (417)

Virtually all of the respondents indicated their position as group manager or leader. In terms of functional areas, groups had diverse activities, such as marketing and sales (20%), engineering and product development (18%), customer training and technical support (15%), accounts management (8%), product support (8%), among others.

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Data Analysis and Results

We used Partial Least Square (PLS) for measurement validation and testing the structural model. PLS employs a component-based estimation method, which places minimal restrictions on sample size and residual distributions (Chin et al., 2003). PLS is best suited for testing complex relationships (Fornell and Bookstein, 1982). Notably, Wold (1985) argued: "In large, complex models with latent variables, PLS is virtually without competition" (p. 590). We chose PLS to account for the presence of a large number of variables, formative factors, and moderating effects.

Descriptive statistics and the correlations among the principal constructs are shown in Table 2.

Table 2. Reliabilities, Correlation Matrix, and Average Variance Extracted

CONSTRUCT	Reliability	Mean	STD	1	2	3	4	5	6	7	8
1. Collaborative IT Tools	**0.88**	5.2	1.5	**.94**							
2. Group Performance	**0.92**	5.4	1.3	.68**	**.96**						
3. Group's Perceived Usefulness	**0.80**	6.2	1.0	.55**	.45**	**.85**					
4. Group's Perceived Ease of Use	**0.92**	5.9	1.2	.65**	.46**	.69**	**.98**				
5. Customization of IT Tools	**0.75**	5.2	1.4	.50**	.41**	.33**	.24*	**.82**			
6. Intra-Group Trust	**0.93**	5.9	1.2	.49**	.60**	.39**	.50**	.42**	**.98**		
7. Habit of using IT Tools	**0.95**	5.8	1.4	.65**	.50**	.60**	.29**	.50**	.42**	**.98**	
8. Environmental Uncertainty	**0.73**	5.8	1.3	.50**	.51**	.45**	.46**	.29**	.38**	.51**	**.80**
**** Significant at p < .01 - * Significant at p < .05 - Items on the diagonal (in bold) represent AVE scores.**											

Measurement Validation

Reliability: Reliability was assessed using the internal consistency scores (Werts, Linn, and Joreskog, 1974).[2] Internal consistencies of all variables are considered acceptable since they exceed .70, indicating tolerable reliability.

Convergent and Discriminant Validity: Convergent and discriminant validity is inferred when the PLS indicators (a) load much higher on their hypothesized factor than on other factors (own-loadings are higher than cross-loadings), and (b) when

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[2] The composite reliability score is: $(\Sigma\lambda_\iota)2 / [(\Sigma\lambda_\iota)2 + \Sigma_\iota Var(\varepsilon I)]$, where λ_ι is the indicator loading, and $Var(\varepsilon I)=1-\lambda_\iota 2$.

the square root of each construct's Average Variance Extracted (AVE) is larger than its correlations with other constructs (the average variance shared between the construct and its indicators is larger than the variance shared between the construct and other constructs (Chin, 1998). As shown in Table 2, the AVEs are all above 0.80, which are much larger than all correlations. Also, Appendix 2 suggests an excellent loading pattern in which all measurement items fall on their hypothesized principal constructs. These two tests suggest that all measures have adequate convergent and discriminant validity.

Common Method Variance: The extent of common method bias was first assessed with Harman's one-factor test by entering all the principal constructs into a principal components factor analysis (Podsakoff and Organ 1986). Evidence for common method bias exists when a general construct accounts for the majority of the covariance among all constructs. In this analysis, each principal construct explained roughly equal variance (range = 6 - 18%) (Appendix 2), indicating no substantial common method bias. Second, a partial correlation method was used (Podsakoff and Organ 1986). The highest factor from the principal component factor analysis was added to the PLS model as a control variable on all dependent variables. According to Podsakoff and Organ, this factor is assumed to "contain the best approximation of the common method variance if it is a general factor on which all variables load" (p. 536). This factor did not produce a significant change in variance explained in any of the three dependent variables, again suggesting no substantial common method bias. Third, we used Lindell and Whitney's (2001) method, which employs a theoretically unrelated construct (*marker* variable) to adjust the correlations among the principal constructs. *Social cohesion* (Sethi *et al*. 2001) was used as the marker variable. Any high correlation among any of the items of the study's principal constructs and social cohesion would be an indication of common method bias, as social cohesion is weakly related to the study's principal constructs. Since the average correlation among social cohesion and the principal constructs was r=.11 (average p-value=.1.44), this test showed no evidence of common method bias. Fourth, the correlation matrix (Table 2) did not indicate any highly correlated variables, while evidence of common method bias usually results in extremely high correlations (r>.90) (Bagozzi *et al.* 1991). In summary, these tests suggest that common method bias does not account for the study's results.

Multicollinearity among the independent variables was not a serious issue since all recommended tests (eigenanalysis, tolerance values, VIFs) did not suggest evidence of multicollinearity. Similarly, no evidence of heteroscedasticity was detected. Finally, outlier analysis did not denote any significant outliers.

In sum, the measurement properties of the study's principal constructs are deemed adequate.

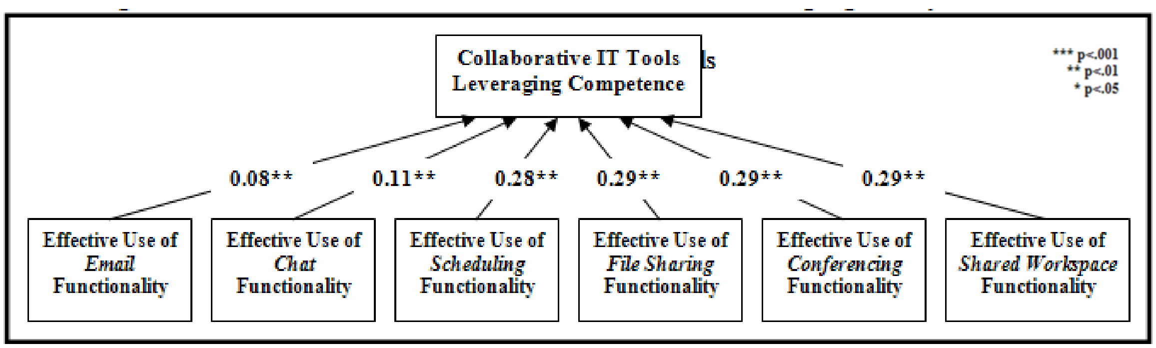
Validation of Formative Second-Order Models

To estimate the formative second-order models of CITLC and group performance, we modeled the coefficients (γi) of each first-order factor to the latent second-order factor following Diamantopoulos and Winklhofer (2001, p. 270).

Formative Second-Order Model of Leveraging Competence of Collaborative IT Tools

As shown in Figure 4, the impact of all first-order constructs that capture the effective use of the proposed six collaborative IT functionalities on collaborative IT tools leveraging competence is significant (p<.01).

Figure 4. The Formative Second-Order Model of Leveraging Competence of Collaborative IT Tools

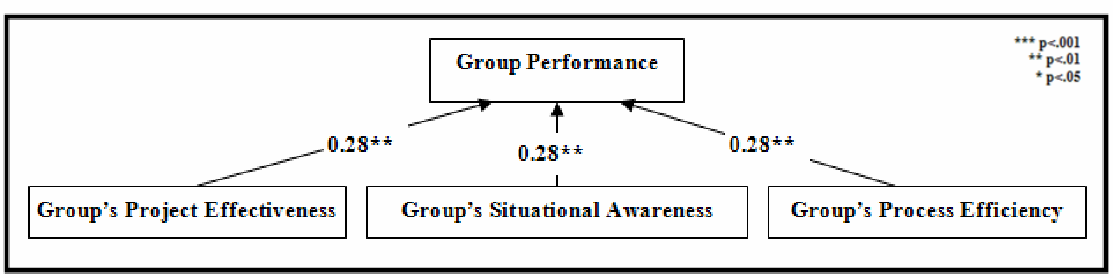


We also examined the correlations among the first-order constructs since significant correlations suggest that the first-order constructs may belong to the same set, even if formative constructs need not be correlated (Chin 1998). The correlations among the first-order factors ranged from .33 to .63 ($p<.01$). Since a reflective model would render extremely high correlations (often above 0.80), a formative model seems more likely. We also tested whether the second-order construct of the leveraging competence of the collaborative IT tools fully mediates the impact of the first-order constructs (effective use of specific IT functionalities) on group performance, using a mediation test (omitted for brevity). This step ensures that the second-order construct is a more parsimonious representation of the first-order constructs and fully captures their predictive power on the dependent variable. (Chin 1998). The CITLC measure is the only significant predictor when all first-order constructs are controlled for, confirming its primary mediating role. In sum, these tests support the proposed second-order formative model of collaborative IT tools leveraging competence and verify its construct validity.

Formative Second-Order Model of Group Performance

The proposed formative second-order model of group performance was assessed using a similar procedure to collaborative IT tools leveraging competence. As shown in Figure 5, all first order constructs (project effectiveness, situational awareness, and process efficiency) had a significant impact ($p<.01$) on overall group performance. Moreover, the correlations among the first-order factors ranged from .73 to .76 ($p<.01$). These results suggest the construct validity of group performance.

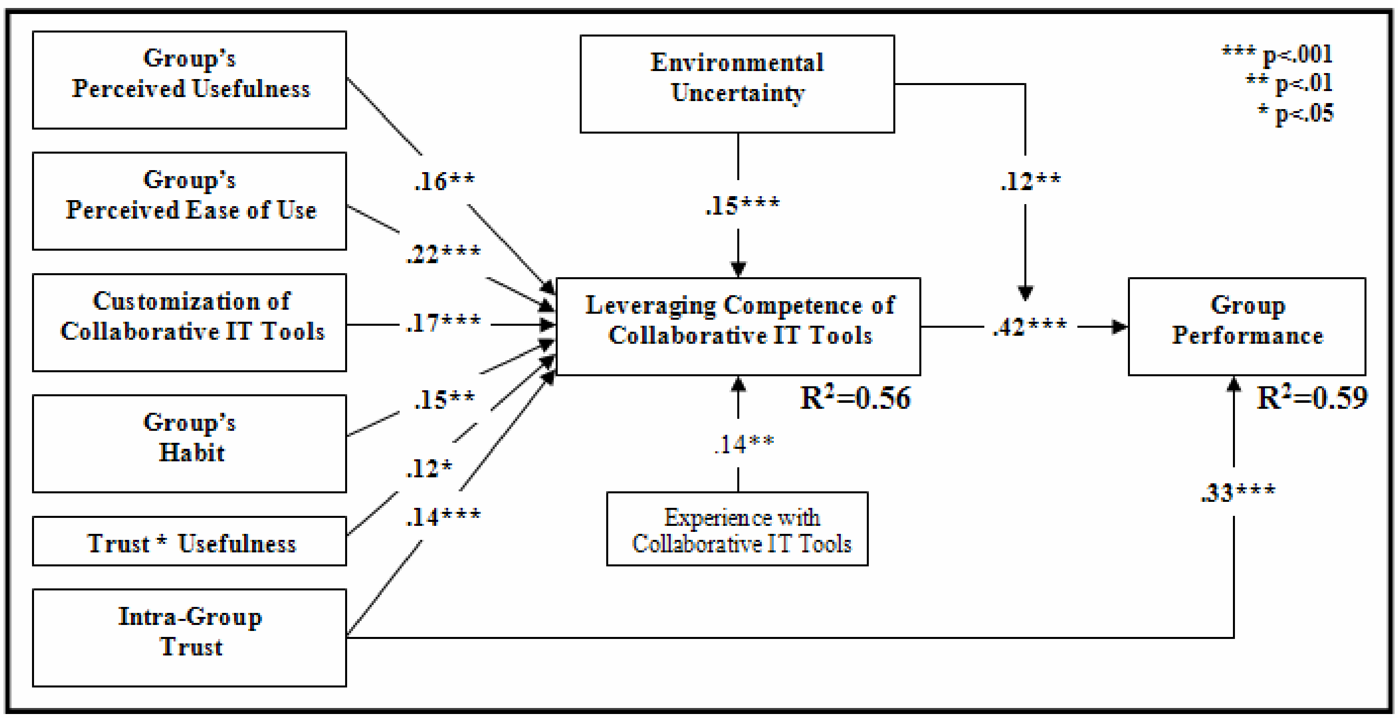
Figure 5. The Formative Second-Order Model of Group Performance



The Structural Model

The proposed research model was tested with PLS Graph 3.0. The PLS path coefficients (which can be interpreted as standardized regression coefficients) are shown in Figure 6, and the significance levels were assessed with 200 bootstrap runs. The moderating effect of environmental uncertainty with leveraging competence of collaborative IT tools were tested as part of the overall structural model with interaction terms formed by cross-multiplying all standardized items of each constructs (Chin et al. 2003). Moreover, we examined all possible interaction effects among the proposed antecedents of leveraging competence of collaborative IT tools, and also their direct effects on group performance. For clearer exposition, the PLS item loadings of each construct are omitted since they are all above 0.80, and also only significant relationships and control effects are shown.

Figure 6. PLS Results of Proposed Research Model



The impact of collaborative IT tools leveraging competence on group performance was significant (beta=.42, p<.01), validating H1. The moderating effect of environmental uncertainty on the relationship between leveraging competence on collaborative IT tools and group performance was also significant (beta=.12, p<.01). To examine the significance of this interaction effect, we performed the following tests (Carte and Russell 2003, Chin et al., 2003):

First, we calculated the additional variance explained due to the interaction effect, which was substantial (ΔR^2=5.6%).

Second, we examined if the variance explained due to the moderated effects is significant beyond the main effects, using the following equation (Carte and Russel 2003, p. 481):

$$\mathbf{F(df_{interaction-dfmain,\ N-dfinteraction-1})=[\Delta R^2 / (df_{interaction}-df_{main})]/[(1- R^2_{interaction})/(N-df_{interaction} - 1)]}$$

The F-statistic was 1.05, which was statistically significant (p<.05).

Third, the variance explained between the main and interaction effects was tested with Cohen's f^2 (Chin *et al.* 2003):

Cohen's f^2 = R^2 (interaction model) − R^2 (main effects model) / [1 − R^2 (main effects model)]

Cohen's f^2 was .12, which denotes a medium effect.

Taken together, these findings and additional tests render support for H2.

In terms of the antecedents of collaborative IT tools leveraging competence, the technology adoption variables (group perceived usefulness (beta=.16, p<.01) and perceived ease of using (beta=.22, p<.01) collaborative IT tools) were both significant, rendering support for H3a and H3b, respectively. The customization of collaborative IT tools also had a significant effect (beta=.17, p<.01), supporting H4.

Group's habit (beta=.15, p<.01) significantly influences the leveraging competence of collaborative IT tools, rendering support for H5. The impact of intra-group trust on collaborative IT tools leveraging competence was also significant (beta=.14, p<.01), supporting H6. Finally, environmental uncertainty had a significant impact (beta=.15, p<.01), rendering support for H7.

We also examined whether the proposed antecedents of collaborative IT tools leveraging competence had a significant direct effect on group performance. Only intra-group trust had a significant direct impact on the leveraging competence of collaborative IT tools (beta=.33, p<.01), while all other variables became insignificant when the mediating role of leveraging competence of collaborative IT tools was included. This relationship can be explained by the fact that trust has more comprehensive positive effects on groups beyond merely enhancing their effectiveness in using IT tools.

Moreover, we examined potential interaction effects among the proposed antecedents of collaborative IT tools leveraging competence. Only the interaction between intra-group trust and perceived usefulness was significant (beta=.12, p<.05, ΔR^2=4.2%). This relationship can be explained by the complementary effects between trust and perceived usefulness; if there is trust among the group members, the collaborative IT tools are more likely to be used more effectively, implying an interaction effect.

Finally, since non-linear (quadratic) effects for the antecedent variables may confound the proposed moderators (Carte and Russell 2003), we included quadratic (X^2) factors as additional antecedents in the proposed model. The results showed that none of the quadratic factors was statistically significant and that none explained a substantial amount of variance. Therefore, fears of quadratic confounds were alleviated. This was expected since none of the correlations among the antecedent variables was extremely high, nor there was evidence of multicollinearity.

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Discussion

In sum, the results strongly confirm the hypothesized relationship between CITLC and group performance. They clearly indicate that leveraging collaborative tools results in better group performance. It is relatively safe to infer that improving group performance leads to increased effectiveness across the acquisition life cycle. Overall, the results suggest that the acquisition of IWS in a complex OA environment would benefit from the use of collaborative tools if work groups are able to leverage their competence in using the tools. In addition, the results imply that as organizational work groups improve their ability to leverage collaborative technology, the performance of the entire organization should improve.

The results indicated that when groups leverage their competence in using collaborative IT, their performance improves. It follows, that improvements in group performance lead to greater organizational efficiency and effectiveness. It is possible to imagine organizations that have work groups who leverage their competence in collaborative IT but whose performance deteriorates. However, such an outcome would be the exception rather than the rule.

Organizations are making large investments in collaborative IT with the expectation that such investments will provide disproportionate returns. One way for this to happen is if work groups are given insufficient training in using these tools. Acquisition organizations must include training in the use of collaborative tools to help ensure positive outcomes in improving management of the systems acquisition life cycle. The study findings further suggest that given a sufficient level of competence in using collaborative tools, even in the complex OA environment group performance will improve. This is critical to the success of using an OA approach to IWS acquisition.

History suggests that it is entirely possible to acquire IWS systems without collaborative IT, this study's results suggest that the competent use of collaborative tools will lead to better performance among works groups. Further, because the OA environment is relatively new to the IWS acquisition world, collaborative tool use will help ensure its ultimate success. The very real outcomes of such success can mean shorter system acquisition life cycles, better requirements analysis, better retrofitting of legacy systems with new IWS components, and a lower risk of catastrophic failures. In addition, such tools when used throughout the life cycle can lead to reduced costs for maintenance and upgrades if all parties to the processes are connected through collaborative tools and if they are capable of competently using these tools.

If system acquisition work groups cannot leverage their competence in using the collaborative tools, the tools will become an additional overhead and a burden for the groups negatively affecting their performance. The critical issue may not be so much the presence of such tools but work groups ability to leverage such tools to support their productive activities. It follows that if organizations want to mitigate the downside risks of introducing collaborative IT, their leadership will have to find ways to help work groups leverage their competence in using such tools through active commitment by top leaders to the use of such tools and through sufficient training in the use of such tools.

Future Systems Acquisition Research

This study identified a viable set of collaborative functionalities that future acquisition researchers who focus on the group level of analysis may find useful. The concept of leveraging appears to be extensible to any IT tools that would enhance group performance and may be critical when conceptualizing the effects of IT on organizational performance.

The study raises interesting new avenues for collaborative IT research. For example, it may be useful to try to review group performance before and after the introduction of collaborative tools with the functionalities identified in this research in terms of the returns on investments (ROI) such tools provide. It may also be useful to identify the potential options such tools provide system acquisition leadership as well as the value and risk of such options. In assessing the ROI and options values, it would be useful to compare organizations with work groups that are able to effectively leverage collaborative IT competence with those that use collaborative tools but are not as adept at leveraging them.

Study Limitations

Future systems acquisition research should include multiple organizations that use collaborative IT. This study obtained its subjects from one very large organization. One reason for this was the great difficulty in securing the cooperation of multiple organizations to participate in such research efforts. Another limitation of the study was the need to tie group performance unambiguously to the resulting value created. This limitation is not unique to the current study. The debate about the value of IT continues and will do so unabated until a defensible way to allocate revenue to IT can be established.

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Appendix 1. Measurement items

COLLABORATIVE IT Tools Leveraging Competence (1: strongly disagree/7: strongly agree)
Email to exchange messages among team members.
Chat/Instant Messaging to share information in real-time.
Calendar for connecting time and location information for all team members
Scheduling for providing up-to-date calendar information.
File sharing to store, archive, and reuse information and best practices.
Consolidation and synchronization of files into a single repository for easy access.
Conferencing for spawning new ideas and solutions.
Collaboration among team members to interact in real time.
Shared workspace for simultaneously working together in real-time.
Whiteboard functionality for bringing together team members.
Group PERFORMANCE (1: strongly disagree/7: strongly agree)
Project Efficiency
We were able to meet our project timeline deliverables.
We efficiently managed our daily workflow.
Project Effectiveness
Our project deliverables were of high quality.
Improvements in quality of group's activities.
Situational Awareness
Do you have a coherent mental picture and good understanding of your project status?
Do you have the feeling that you are able to anticipate problems?
Perceived Usefulness
Using the system would enable me to accomplish tasks quicker.
Using the system would improve my job performance.
Using the system in my job would increase my productivity.
Ease of Use
My interaction with the system is clear and understandable.
Learning to use the system was intuitive and did not require a lot of my mental effort.
I find the system to be easy to use.
Intra-Group Trust
We trust each other.
Our promises to each other are reliable.
We are honest in dealing with each other.
We would go out of our way to help each other out.
ENVIRONMENTAL UNCERTAINTY
Our environment has a high operational tempo.

Our environment is continuously changing.
Environmental changes in our area are difficult to forecast.
CONTROL VARIABLES
System Voluntariness
My use of the system is voluntary.
Using the system is not compulsory to my job.
Given the choice I would choose to use the Collaborative System I now use.
System Customization
The collaborative system we use adapts to our business processes, rules, and practices.
The collaborative system we use is customized to our specific needs.
Habit
Using a collaborative system has become a habit for me.
Using my existing system has become natural for me.
DEMOGRAPHIC DATA
How many months has your group been using a Collaborative System?
Individuals in Group.
Your position in the Group:
How many years of work experience do you have?
Age/Gender/Educational Level

Appendix 2. Principal Components Factor Analysis

Principal Components Factor Analysis

		1	2	3	4	5	6	7	8
Collaborative IT Tools Leveraging Competence	Email	**.77**	.29	.22	.14	.13	.18	.21	.27
	Chat	**.74**	.16	.06	.22	.29	.19	.21	.26
	Scheduling1	**.82**	.17	.12	.28	.18	.11	.14	.27
	Scheduling2	**.79**	.11	.14	.26	.34	.04	.15	.29
	File Sharing1	**.65**	.29	.14	.10	.30	.27	.19	.22
	File Sharing2	**.67**	.28	.20	.23	.14	.29	.17	.27
	Conferencing1	**.69**	.24	.27	.15	.13	.12	.11	.11
	Conferencing2	**.70**	.31	.29	.37	.24	.20	.04	.20
	Workspace1	**.76**	.23	.12	.30	.19	.27	.21	.27
	Workspace2	**.79**	.13	.24	.14	.14	.29	.21	.29
Group Performance	Efficiency1	.11	**.79**	.15	.13	.12	.13	.12	.18
	Efficiency2	.15	**.74**	.24	.24	.22	.28	.35	.20
	Effectiveness1	.18	**.75**	.28	.15	.30	.11	.18	.27
	Effectiveness2	.32	**.64**	.24	.20	.14	.30	.24	.29
	Awareness1	.24	**.71**	.28	.21	.13	.27	.27	.13
	Awareness2	.19	**.67**	.27	.21	.24	.31	.31	.28
Intra-Group Trust	Trust1	.26	.33	**.81**	.12	.27	.12	.13	.24
	Trust 2	.19	.27	**.82**	.28	.29	.20	.20	.31
	Trust 3	.23	.29	**.84**	.30	.12	.27	.27	.29
	Trust 4	.13	.22	**.82**	.14	.28	.21	.29	.12
Perceived Usefulness	Usefulness1	.35	.24	.17	**.81**	.12	.29	.21	.20
	Usefulness2	.31	.17	.22	**.71**	.15	.16	.32	.27
	Usefulness3	.11	.25	.11	**.74**	.24	.28	.24	.21
Perceived Ease of Use	Ease of Use1	.22	.11	.24	.27	**.71**	.13	.12	.32
	Ease of Use2	.15	.24	.20	.29	**.81**	.15	.15	.24
	Ease of Use3	.20	.29	.21	.12	**.80**	.13	.30	.20
Habit	Habit1	.34	.24	.29	.17	.14	**.79**	.14	.23
	Habit2	.26	.24	.12	.25	.10	**.73**	.10	.24
Tools Customization	Customization1	.24	.17	.16	.15	.20	.24	**.64**	.21
	Customization1	.17	.22	.24	.20	.16	.21	**.81**	.29
Environmental Uncertainty	Uncertainty1	.25	.15	.27	.21	.26	.21	.17	**.72**
	Uncertainty2	.15	.17	.29	.21	.11	.12	.21	**.77**
Variance Explained (Total=.83%)		**.18**	**.14**	**.09**	**.11**	**.08**	**.07**	**.10**	**.06**

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- Optimizing CIWS Life Cycle Support (LCS)

Program Management

- Building Collaborative Capacity
- Knowledge, Responsibilities and Decision Rights in MDAPs
- KVA Applied to Aegis and SSDS
- Business Process Reengineering (BPR) for LCS Mission Module Acquisition
- Terminating Your Own Program
- Collaborative IT Tools Leveraging Competence

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