8-6-2011

Knowledge as a Contingency Factor in Virtual Organizations

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AMCIS 2011 Detroit

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ABSTRACT

Organizational research shows how mismatches between organizational design characteristics and contingency factors lead to lower performance. This research explores *knowledge* as a structural contingency factor in virtual organizations. Employing a computational organization model to generate theory driven experiments, the performance effects of different *types of knowledge* (i.e., tacit and explicit) interacting with organizational *coordination mechanisms* (e.g., direct supervision and mutual adjustment) in complex environments where multiple organizations rapidly develop reciprocal interdependencies is explored. Should managers understand how performance is affected by the interaction of knowledge types available and various coordination mechanisms? This research shows that a mutual adjustment coordination mechanism is most fit when teams are made up of people with a high level of tacit knowledge. There are interesting interaction effects across the different performance variables; hence, managers in virtual organizations faced with reciprocal interdependencies should apprise themselves of the knowledge types associated with interacting boundary spanning teams.

Keywords

Contingency theory, knowledge management, virtual organizations, computational modeling.

INTRODUCTION

"Basic to the theory of organizations is the premise that all organizations need coordination. Coordination means integrating or linking together different parts of an organization to accomplish a collective set of tasks." (Van De Ven, Delbecq and Koenig, 1976, p.322) Organizational research shows that mismatches between organizational design characteristics and well-understood contingency factors (e.g., task uncertainty and interdependence) lead to lower performance and potentially to an organization's obsolescence (Donaldson, 2001). Understanding relevant contingency factors is, therefore, critical to managing structural adaptation, especially the type of adaptation often required when operating in complex environments. While classic contingency factors (e.g., size and task interdependence) and design responses (e.g., centralization and coordination mechanisms) are well understood, *knowledge* is drawing attention in contingency research (Burton and Obel, 1995). Although knowledge management research is prevalent, organization design research that focuses on knowledge as a contingency factor remains sparse (Alavi and Leidner 2001). This research employs a contingency theoretic lens to investigate the influence that group knowledge level has on the ability of virtual organizations to coordinate mutually beneficial activities. "A virtual organization is a collection of geographically distributed, functionally and/or culturally diverse entities that are linked by electronic forms of communications and rely on lateral, dynamic relationships for coordination." (DeSanctis and Monge, 1999, p.693) This organizational design research looks at the performance of boundary spanning groups employing the different coordination mechanisms of direct supervision and mutual adjustment in a virtual environment.

This research explores the question, in a virtual organization context, what are the organizational performance effects of different *types of knowledge* interacting with organization design coordination mechanisms? That research question leads to a two factorial experiment design, see Table 1, where tacit and explicit types of knowledge are juxtaposed with direct supervision and mutual adjustment coordination mechanisms to provide a framework for comparing performance data. The research involves participant observation of virtual organizations to inform the building of a computational organization model. Observations of team structures, knowledge flows, and planning and coordination processes are used to develop an empirically grounded baseline computational model of the virtual organization. From that model and informed by organization and knowledge management theory, computational experimentation is conducted. The experiment consists of adjusting select model parameters and holding all other parameters constant, then multiple simulation runs using Monte Carlo techniques are conducted to generate the data to support statistical analysis (see Carley, 2002; Wong and Burton, 2001). The computational modeling tool used in this research, the Project, Organization and Work for Edge Research (POW-ER), comes from more than two decades of work in the Virtual Design Team (VDT) Research Program (VDT, 2005). VDT's extensively validated agent-based model is based on Galbraith's (1973) theory that organizations are information processing systems (Cohen, 1992).

		Coordination Mechanism	
		Direct Supervision	**Mutual Adjustment**
Knowledge Type	**Tacit**	Direct Supervision *interacting with* Tacit Knowledge	Mutual Adjustment *interacting with* Tacit Knowledge
	Explicit	Direct Supervision *interacting with* Explicit Knowledge	Mutual Adjustment *interacting with* Explicit Knowledge

Table 1. Factorial Experiment Design

BACKGROUND

Cooperation and coordination between organizations is an increasing organizational trend (Baker and Faulkner, 2002). Just as complex intraorganizational structures (e.g., the matrix form) marked by lateral relationships and weak ties (Granovetter, 1973) have grown in popularity over the past decade, networked or alliance interorganizational forms are appearing frequently in industry (Scott, 2003). Those forms appear to capitalize on the strength of loose coupling and weak ties—ties facilitated by the ubiquity of the internet and other communications channels (Kenis and Knoke, 2002). Contingency theorists stress that these popular forms are no organization panacea, and recommend that managers look at structural aspects of their firm and various contingency factors (e.g., elements of their external environment or task interdependencies) to see if they are in fit (Burton and Obel, 2004; Donaldson, 2001).

Interorganizational systems are defined as "planned and managed cooperative ventures between otherwise independent agents." (Kumar, Kuldeep and van Dissel, 1996, p. 280) They are becoming more prevalent today largely because they can share costs, spread risk, and access complementary resources, especially knowledge, to help them succeed in the face of growing environmental complexity (Mowery, Oxley and Silverman, 1996). Those who generate the dynamic information flows between the partnering organizations are known as *boundary spanners* (Mintzberg, 1979; Thompson, 1967). Hence, managers need to know how to manage work teams operating in the challenging environment of interorganizational alliances.

Often, *deliberate planning* by the boundary spanners and *time* are required for these organizations to become effective at achieving their interorganizational goals (Inkpen and Li, 1999). There are, however, instances where time is not a luxury, such as during a crisis (e.g., natural disaster). In most crisis events, government agencies, those bastions of bureaucracy, interface with firms and non-governmental organizations (NGOs). This research adds to the understanding of knowledge flows (see Nissen, 2006) and organization design issues at the interorganizational level of analysis—specifically focusing on virtual organizations. Virtual organizations are highly flexible and adaptable and able to respond quickly to market demands (Grabowski and Roberts, 1999). Those characteristics combined with the ubiquity of communications and collaborative applications, especially those that have a high level of media richness (Daft and Lengel, 1986), contribute to the growing efficacy of virtual organizations (Mowshowitz, 2002; Wong and Burton, 2000). With those characteristics in mind, the aforementioned research question is explored.

Coordination Mechanisms

Organization theorists tend to agree that a useful way of categorizing the different types of coordination mechanisms is based on their degree of complexity—see Figure 1 (Lawrence and Lorsch, 1967; Mintzberg, 1979). The degree of complexity for a coordination mechanism involves how workers in an organization handle the inevitable exceptions that arise during the conduct of their tasks. If a worker only has to look to his or her immediate supervisor to provide the answer regarding how to resolve an exception, then there is a low degree of complexity in that type of coordination mechanism called *direct supervision*. On the other hand, if workers are supposed to resolve exceptions without asking a supervisor, then they would need to consider alternative ways of handling the exception and the impact of those alternatives on tasks that others in the organization perform. That is an example of a highly complex coordination mechanism called *mutual adjustment*.

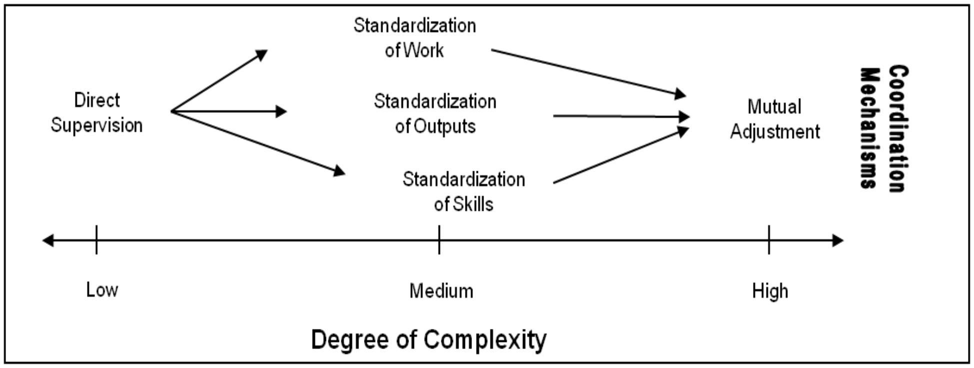

Figure 1. Coordination Mechanisms along a Continuum of Complexity (from Mintzberg 1979)

Central to contingency theory is the assumption that *there is no one best way to organize* to obtain desired goals (Donaldson, 2001; Scott, 2003). The theory proffers that to achieve high performance select structural elements of an organization must be in *fit* with relevant contingency factors. Thompson (1967) identified a contingency relationship between an organization's performance and the type of coordination mechanism used between subunits: performance is dependent on fit between the level of interdependence and the level of sophistication of the coordination mechanism (e.g., standard procedures, plans, and mutual adjustment) used. Galbraith (1973) and Mintzberg (1979) made similar conclusions about this fit relationship between the sophistication of coordination mechanisms and level of interdependence within organizations. These concepts are integrated here based on the correspondence between level of complexity of both *coordination mechanisms* and *type of interdependence*—see Figure 2.

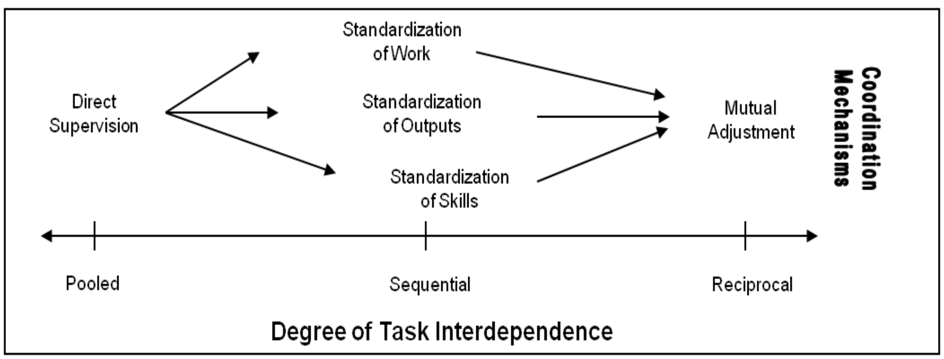

Figure 2. Continuum of Coordinating Mechanisms

Types of Knowledge

Knowledge in this context comes from the *tacit and explicit* construct (Polanyi, 1966). Tacit knowledge is the personal know-how and mental models developed through experiences. More importantly, it is tacit knowledge that, when combined with other resources (e.g., humans and machinery), enables action (e.g., producing products). A common characteristic of tacit knowledge is that it is not easily transferred from one person to another (von Hippel, 1994). Explicit knowledge is articulated knowledge (e.g., written procedures) that are easily stored and transferred. A key aspect of explicit knowledge is that it cannot completely capture all that is known tacitly. Nonaka (1995) theorizes that knowledge, especially tacit knowledge, is a powerful resource that firms use and create to positively affect performance.

Some organization research has highlighted the idea that organizations tend to prefer autonomy, especially in complex and dynamic situations (Levine and White, 1961; Tierney, 1985). This single-provider perspective is not a realistic condition in the global marketplace, nor in complex and dynamic environments such as disaster response operations where myriad organizations with varying degrees of skills and local knowledge converge (Chua, 2007; Dynes and Quarantelli, 1976). The main barriers to interorganizational effectiveness in crisis response are insufficient organization, education, and levels of awareness. To overcome those barriers, organizations must "…learn about themselves and disaster behavior…plan together and with other relevant community groups, and…give high priority to coordination of effort." (Tierney, 1985 p. 83)

Interorganizational Theory

Warren's (1967) seminal work describes a continuum of interorganizational governance structures (see Figure 3) ranging from social choice to an independent unitary organization. Social choice is where autonomy in goal setting and decision making by each organization is paramount and coordination is achieved by weak ties and informal communications (Granovetter, 1973; Warren, 1967). A merger is an instantiation of the independent unitary organization. Between those extremes, a coalition's governance structure entails a strategic intent to work together (e.g., coordinate activities) made by each participating organization, while the federation structure entails multiple organizations agreeing to formally allow a "third party" to coordinate their activities (e.g., a sports league with its commissioner). An example of a coalition is where multiple countries' militaries and non-governmental aid organizations work together in the wake of a disaster.

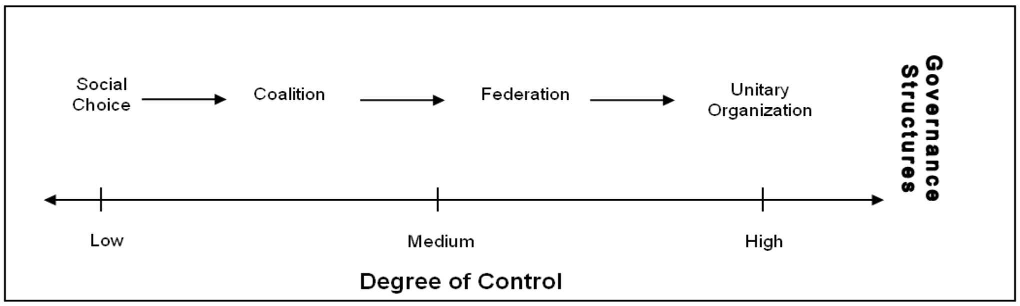

Figure 3. Continuum of Interorganizational Coordination Structures

In a disaster situation, organizations face high uncertainty and reciprocal interdependencies, hence, mutual adjustment mechanisms are most fit (Comfort, 1994; Dynes and Aguirre, 1976; Harrald, Cohn and Wallace, 1992). Others propose that hierarchical responses are the best mechanism for interorganization coordination in crisis response situations (Bigley and Roberts, 2001; Moynihan, 2006). The essence of the disagreement involves the assumption that interorganizational systems emerge to deal with increased environmental uncertainty and that the formation generally begets reciprocal resource interdependencies. Topper and Carley (1999) investigate the emergent network of organizations that they call the integrated crisis management units (ICMU): an instantiation of an interorganizational phenomenon in response to disasters. They draw into focus three competing theoretic perspectives (1) the emergent coordinating group (e.g., see Harrald et al., 1992; Perrow, 1984), (2) the centralized system (e.g., see DiMaggio and Powell, 1983; Pfeffer and Salancik, 1978), and (3) the distributed system (e.g., Comfort 1994; Dynes and Quarantelli, 1976).

Debate remains regarding the effectiveness of different coordination mechanisms in achieving high performance in crisis response operations where interorganizational systems frequently operate in the face of high uncertainty. It has been shown that knowledge types (e.g., trans-specialist and specialist) within an organization produce varying performance results (Nissen, Orr and Levitt, 2008). In this research, two types of knowledge, tactic and explicit, are investigated to note their effects on performance of interorganizational systems that respond to disaster event. A group of boundary spanners that are highly experienced (i.e., high tacit knowledge) in responding to crisis events, but thrust into the new role of collaborating in a virtual team environment will have performance differences based on the coordination mechanism employed to govern the boundary spanning activities (i.e., collaborating to produce a mutually supporting plan for integrated action).

Null Hypothesis H0: During crisis response operations, no performance differences exist in virtual teams based on different types of knowledge resident within the teams and the coordination mechanisms used to manage the integration of action.

Hypothesis 1: Virtual team performance with respect to the speed of integrating activities will be affected by the knowledge type composition of each team interacting with different coordination mechanisms.

Hypothesis 2: Virtual team performance with respect to the functional integration risk (i.e., risk to component quality) will be affected by the knowledge type composition of each team interacting with different coordination mechanisms.

Hypothesis 3: Virtual team performance with respect to the project integration risk will be affected by the knowledge type composition of each team interacting with different coordination mechanism.

Hypothesis 4: Virtual team performance with respect to communication risk (i.e., ratio of missed to total communications) will be affected by the knowledge type composition of each team interacting with different coordination mechanisms.

RESEARCH DESIGN

This section provides a brief overview of the model used to assess interorganizational performance, and the qualitative field research used to understand the virtual organization and its processes. The interested reader is directed to the corresponding references for additional background on the computational organization model.

Computational Tool

The POW-ER application is an extension of the Stanford University led VDT program (VDT, 2005), an ongoing interdisciplinary research effort begun in the late 1980s to develop “new micro-organization theory and embedding it in software tools that can be used to design organizations in the same way that engineers design bridges, semiconductors or airplanes: through computational modeling, analysis, and evaluation of multiple alternate prototype systems.” (Nissen and Levitt, 2004, p.172) VTD’s has strong internal and external validity (Jin and Levitt 1996, VDT 2005). Guided by information processing theory, organizational models are built by modeling the “knowledge work through interactions of *tasks* to be performed, *actors* communicating with one another and performing tasks, and an *organizational structure* that defines actors’ roles and constrains their behaviors. In essence, this amounts to overlaying the task structure on the organization structure and to developing computational agents with various capabilities to emulate the behaviors of organizational actors performing work.” (Nissen and Levitt, 2004, p.173) An illustration of how these elements interrelate is exhibited in Figure 4. This research uses POW-ER version 3.5a, which is in beta test, hence, some results may reflect hidden error and affect the findings and conclusions. That said, POW-ER’s results have been verified in other projects, and all of the comparisons are relative to one another, so errors inherent are generally controlled across each model.

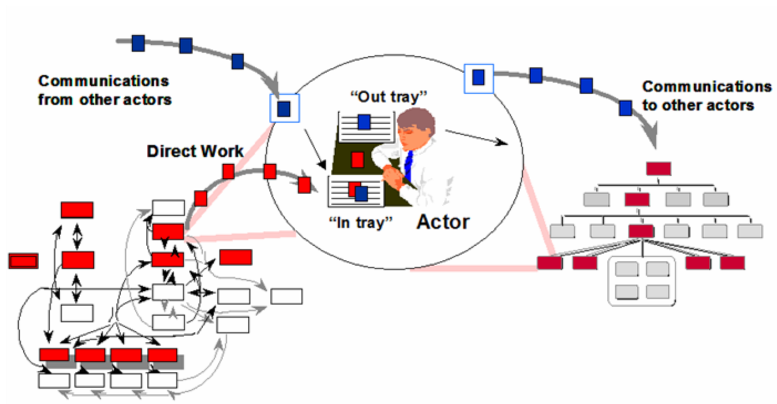

Figure 4. Information Processing View of Knowledge Work (Jin and Levitt, 1996)

Qualitative Field Work

Teams of researchers simultaneously conduct qualitative field research at multiple high-level military headquarters during a field event involving disaster response. Each headquarters was geographically separated and relied on electronic communications to coordinate their crisis response actions. A driving objective agreed for all participants was to explore collaboration and the ability to harmonize activities between headquarters as each developed a plan to coordinate the activities of their own subordinate forces as each simultaneously converged on the same disaster. This qualitative fieldwork focuses on answering the following multi-part question: How do these organizations collaborate with one another to (1) coordinate problem solving activities, (2) coordinate planned actions of subordinate forces, and (3) create new knowledge or share existing knowledge?

The case study involved observing a planning team at each of six independent military maritime headquarters. Over an eleven-day period, these organizations collaborated with each other while each worked to build its own plan of action to respond to a developing crisis scenario. Headquarters from three different countries and a multi-national alliance were represented. Each planning team was staffed by cross-functional personnel (e.g., logistics and medical specialists). The teams consisted of between six and eight planners that were actively involved in boundary spanning activities. Four of the six were experienced planning teams. While each team had its own process for building a plan, none of the organizations had a process for simultaneously collaborating with other organizations to harmonize efforts into a mutually supporting operation.

Figure 5 is a screen capture of the baseline POW-ER model developed from the observed field events. The project entails three co-equal and non-collocated organizations working through their crisis action planning process to produce a decision briefing for their respective commanders. The observations facilitated building a baseline model where the direct supervision and high tacit knowledge conditions exist because the actors were very experienced and one manager was designated to supervise the coordination activities to ensure that each plan was mutually supportive. Figure 5 shows the actors in each organization arranged in a familiar three level hierarchal configuration. The Commander (Cdr) is designate a *project manager*, the Plan Manager (Plan Mgr) is designated a *subteam leader* and the Operational Planning Team (OPT) is designated as a *subteam*. These roles affect the speed and type of exception handling that occurs in the project. For ease of viewing, the connections between the actors (green person figure) and their tasks (rectangles) are hidden, but each task has an assigned actor. Tasks flow from left to right and darker rectangles are assigned to OPTs, medium shaded rectangles to Plan Mgrs, and the lightest to each Cdr. Since this baseline represents a direct supervision case, Plan Mgr A is the supervisor and has multiple attached subordinate actors. The red arrows at the top of the task boxes represent *rework* links. For example, during a task, a Cdr or Plan Mgr could change some recommendation or detect a problem and ask for some element(s) of a previous task to be modified. Finally, the green arrows that connect overlapping boxes represent the high level of communications that must occur to successfully accomplish interdependent tasks such as COA coordination. In the direct supervision baseline, the OPTs from each organization (i.e., A, B and C) perform their tasks independently; hence, all coordination is left to the Plan Mgrs. Note that no work is performed in the blue hexagons; they represent transitions to phases or synchronized tasks such as a the coordination tasks performed by the Plan Mgrs. The observations showed similar four-phase processes for each team: (1) the mission was analyzed, (2) courses of action (COA) were developed, (3) COAs were analyzed, and (4) each Cdr received COA recommendations and decided on a Plan. Of note, the actors were subject to other daily staff responsibilities; this extra load builds backlogs and causes exceptions to occur.

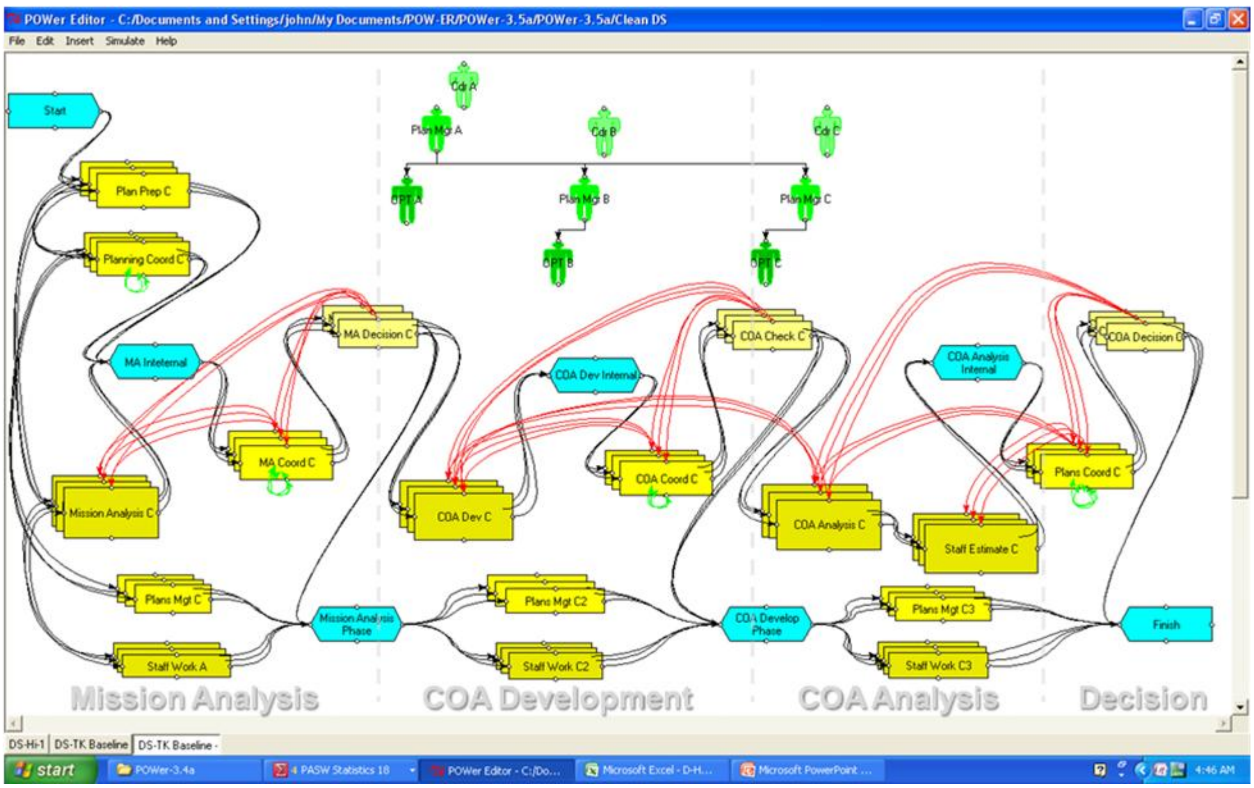

Figure 5. POW-ER Baseline Model of Direct Supervision Coordination Mechanism for Planning in an Interorganization System

Each object in the figure has a number of model parameters (i.e., independent variables) that are set to guide the behavior of the agent-based model. These settings reflect empirical observations from the immersive fieldwork phase, empirically determined "normal" levels for organizations in general (see Jin and Levitt 1996; Nissen and Levitt, 2004), or draw on prior related research (see Wong & Burton 2000; Looney & Nissen 2006). Table 2 summarizes the baseline model's parameters. The following brief description of the model parameters is drawn from the SimVision User Guide.

Parameter	Setting
Centralization	Medium
Formalization	Low
Matrix strength	Medium
Communication probability	0.7
Noise probability	0.5
Functional exception probability	0.05
Project exception probability	0.10
Team experience	Low
Planning skill	High
Application experience -Cdr & Plan Mgr -OPT	 Low High
Role -Cdr -Plan Mgr -OPT	 Project Manager Subteam Leader Subteam

Table 2. Baseline POW-ER Model Parameter Settings

The first three parameters represent the organization design specifications. *Centralization* describes the degree to which communication flows and decision making are hierarchical. In the baseline model, *centralization* is set to "medium" to reflect the interorganizational alliance nature of the case. *Formalization* describes the degree to which communication flows and work tasks follow formal standardized procedures. This parameter is set to "low" to reflect the propensity of highly experienced planners to not rigidly follow the defined steps of their planning process and do their best to equally respond to both formal and informal communications. *Matrix strength* represents the degree that managers supervise subordinates and are relied upon to handle exception situations that occur during tasks. This parameter is set to "medium" to reflect the combined nature of some designated supervision along with the necessary informal communication that take place during virtual team coordination activities.

The next four parameters reflect probabilities for *communications, noise, functional exceptions* (FE), and *project exceptions* (PE). The intensity of communications and the frequency of interruptions (e.g., misunderstanding) are governed by the *communications* and *noise* probability settings. In virtual organization collaboration, these parameter settings are guided by Wong and Burton (2000) and supported by the empirical observations of this case study. Likewise, the FE and PE settings are guided by Looney and Nissen (2006) and supported by the empirical observations of this case study. FE represents the probability that an exception occurs in a task, and that the exception will only affect the quality of that task. PE represents the probability that an exception occurs in a task, and that the exception will affect any related tasks (i.e., tasks connected by red *rework* links).

The next three parameters reflect the knowledge available in the project. *Team experience* reflects the experience level of all the actors facing the project. Both the unique nature of crisis event and the virtual collaborative planning situation drive this parameter setting to "low." *Planning skill* accounts for the competency of the actor at performing the planning tasks of the project; since all had years of experience, it is set to "high." The *application experience* setting is "high" for experienced planning teams, but "low" for leaders since they were conducting unfamiliar work of virtual simultaneous interorganizational collaboration and generally unfamiliar with the concept of co-equal military organizations coordinating operations without the typical military hierarchy in place providing strict unity of command.

Model Settings for Experimentation

Using the baseline model described above, manipulations informed by theory and field observations were made to create three new models to populate the three remaining cells factorial experiment design. The parameters (i.e., independent variables) for these models are listed in Table 3. The parameter settings for the baseline direct supervision-tacit knowledge (DS-TK) are listed in the second column and are explained in the previous section. The last three columns present the modification to the baseline model in **bold** font, and the column heading underscores the unique treatments—i.e., direct supervision-explicit knowledge (DS-<u>EK</u>), mutual adjustment-tacit knowledge (<u>MA</u>-TK), and mutual adjustment-explicit knowledge (<u>MA</u>-<u>EK</u>).

Parameter	DS-TK	DS-EK	MA-TK	MA-EK
Centralization	Medium	Medium	**Low**	**Low**
Formalization	Low	**Medium**	Low	**Medium**
Matrix strength	Medium	Medium	**High**	**High**
Communication probability	0.7	0.7	0.7	0.7
Noise probability	0.5	0.5	0.5	0.5
Functional exception probability	0.05	0.05	0.05	0.05
Project exception probability	0.10	0.10	0.10	0.10
Team experience	Low	Low	Low	Low
Planning skill	High	**Medium**	High	**Medium**
Application experience -Cdr & Plan Mgr -OPT	 Low High	 Low **Low**	 Low High	 Low **Low**
Role -Cdr -Plan Mgr -OPT	 Proj Mgr SubTm Ldr Subteam	 Proj Mgr SubTm Ldr Subteam	 Proj Mgr SubTm Ldr Subteam	 Proj Mgr SubTm Ldr Subteam

Table 3. POW-ER Model Manipulations for Experimentation

Quantitative Results

Each of the four models is run 30 times using a seed value of 1 to 30 to initialize the Monte Carlo simulations. The seed values are chosen to enable reproducibility and maximize control. 50 trials for each seed value are conducted. The dependent variables of *speed*, *functional risk*, *project risk* and *communication risk* meet the assumptions for performing parametric statistical analysis techniques; hence, there is confidence in the reliability of the results (Kerlinger and Lee, 2000). Using the Kolmogorov-Smirnov test for normality, each dependent variable is determined ($p < 0.05$) to come from a normal distribution. Levene's Test for equality of variance shows that only *speed* fails ($p < 0.05$) to meet the homoscedasticity assumption. The dependent variable of *speed* has an F-statistic of 3.859 which corresponds to a 0.011 level of significance that does not meet the $p < 0.05$ test; however, "In terms of violations of the assumptions of homogeneity of variance, ANOVA is fairly robust when sample sizes are equal." (Field 2005 p. 324)

Table 4 shows the results of *Hypothesis 1* that predicts that knowledge types interacting with coordination mechanisms will have a statistically significant impact on the speed that a virtual team completes the project. The ANOVA test finds significant main effects at $p < 0.05$ for both the knowledge type and the coordination mechanism. There is also an interaction effect between coordination mechanism and knowledge type.

Source	Sum of Squares	df	Mean Square	F	Sig.	Effect Size ω^2
Coordination Mechanism	277.287	1	277.287	7502.847	.000	0.074
Knowledge Type	3456.224	1	3456.224	93518.575	.000	0.922
Coordination Mechanism * Knowledge Type	7.446	1	7.446	201.483	.000	0.002
Error	4.287	116	.037			
Total	109774.886	120				

Table 4. Tests Between-subjects Effects on the Dependent Variable: Speed

Hypothesis 2 considers the effects on functional risk from the different coordination mechanisms and knowledge types. Table 5 shows significant main effects at $p < 0.05$ for knowledge type; however, there is a non-significant main effect for the coordination mechanism. The interaction effect between coordination mechanism and knowledge type is also not significant

Source	Sum of Squares	df	Mean Square	F	Sig.	Effect Size ω^2
Coordination Mechanism	.001	1	.001	1.305	.256	< 0.001
Knowledge Type	.232	1	.232	231.671	.000	0.667
Coordination Mechanism * Knowledge Type	.001	1	.001	1.149	.286	< 0.001
Error	.116	116	.001			
Total	14.500	120				

Table 5. Tests Between-subjects Effects on the Dependent Variable: Functional Risk

Hypothesis 3 considers the effects on project risk from the different coordination mechanisms and knowledge types. Table 6 shows significant main effects at $p < 0.05$ for knowledge type. There is a non-significant main effect based on coordination mechanism, and a non-significant interaction effect between coordination mechanism and knowledge type

Source	Sum of Squares	df	Mean Square	F	Sig.	Effect Size ω^2
Coordination Mechanism	.005	1	.005	2.733	.101	0.012
Knowledge Type	.049	1	.049	28.262	.000	0.165
Coordination Mechanism * Knowledge Type	.002	1	.002	1.129	.290	< 0.001
Error	.203	116	.002			
Total	24.041	120				

Table 6. Tests Between-subjects Effects on the Dependent Variable: Project Risk

Hypothesis 4 considers the effects on communication risk from the different coordination mechanisms and knowledge types. Table 7 shows significant main effects at $p < 0.001$ for both the knowledge type and the coordination mechanism. The interaction effect between coordination mechanism and knowledge type is also significant.

Source	Sum of Squares	df	Mean Square	F	Sig.	Effect Size ω^2
Coordination Mechanism	.007	1	.007	67.218	.000	0.071
Knowledge Type	.016	1	.016	167.803	.000	0.093
Coordination Mechanism * Knowledge Type	.131	1	.131	1352.039	.000	0.786
Error	.011	116	.0001			
Total	29.579	120				

Table 7. Tests Between-Subjects Effects on the Dependent Variable: Communication Risk

CONCLUSION

Structural contingency theory is generally used to explain organization performance based upon recognized structural organization design variables interacting with relevant contingency factors. This research extends the traditional focus of structural contingency theory to the important and relevant activity of exploring design issues that potentially affect performance of interorganizational systems such as virtual organizations.

In this research, the fit of traditional structural design coordination mechanisms (i.e., direct supervision and mutual adjustment) interacting with different knowledge types (i.e., tacit and explicit) is explored at the interorganizational level of analysis. While there are many other relevant units of analysis to explore this interorganizational phenomena, this research focuses specifically on boundary spanning teams (planners) of multiple interacting organizations, in this case relatively homogeneous military headquarters. The statistical analysis, summarized in Table 8 clearly shows some relevant performance effects of those interactions. This knowledge is important to managers when interorganizational systems, specifically virtual teams, are in the early stages of formation.

Coordination Mechanism / Knowledge Type	Direct Supervision	Mutual Adjustment
Tacit	*Functional Risk*% *Project Risk*%	*Speed** *Functional Risk*% *Project Risk*% *Comm. Risk**
Explicit	*Speed*#	*Comm. Risk*#

Based on statistical significance where $p < 0.001$, the following legend applies:
*Best performance. % Tied for best performance. #Worst performance.

Table 8. Performance Summary of 2-Factorial Experiment

This research looks into a relevant condition where virtual teams of planners from different organizations collaborate to achieve coordination without having to experience the significant organizational changes that come with moving from their organization and going to work with another organization at a new location. In general, that would entail (1) a formation process to learn new applications and procedures, and (2) removing people from direct and familiar means to interface with their parent organization's knowledge network. Both of those take time, a commodity in short supply during a crisis response operation. Networking technologies and information processing applications point to potential interorganizational system performance implications of virtual teams (Wong and Burton, 2000).

This research finds different effects on virtual organization performance metrics based on the interaction of *direct supervision* and *mutual adjustment* coordination mechanisms and *tacit* and *explicit* knowledge types. Hence, managers faced with reciprocal interdependencies with other organizations should apprise themselves of the knowledge types available to perform interorganizational collaboration work, especially in the context of *virtual teams*: knowledge type has a contingent effect on performance based on the fit of different coordination mechanisms.

The findings here support the idea that where experienced and knowledgeable teams are present, a distributed system of self-organizing boundary spanners will be highly effective. Where experience and skills are not prevalent in the boundary spanning team, the communications risk is highest in the self-organizing mode, thus its feedback mechanisms and informal communications may cause performance problems in crisis response events. The effects that different knowledge types have on communication risk for a centralized coordination system shows that boundary spanning teams that are highly experienced and knowledgeable incur a greater communications risk than teams armed with only explicit knowledge. It is reasonable to conclude, that when operating in a virtual team condition, missed formal and informal communications opportunities under the direct supervision coordination mechanism adversely impact the ability to achieve integration quality among the participating organizations.

This research is but one step into understanding the complex field of virtual organizations since it focuses on relatively homogeneous organizations facing a crisis. The humanitarian disaster field is replete with heterogeneous organizations needing to collaborate to achieve mutual goals (e.g. relieve suffering or enable near and long term economic development). Aid organizations, entrepreneurs, security forces and other governmental organizations will work alongside each other in some of the most dynamic and complex environments where timely actions are critical. Each of these organizations has to manage its expertise and physical resources, and this research points to the need to shed light on ways to facilitate productive collaborations to harmonize actions with other heterogeneous organizations.

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