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ORGANIZATIONAL RESPONSES TO UNCERTAINTY IN THE AIRLINE INDUSTRY: CHANGES IN PATTERNS OF COMMUNICATION NETWORKS

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Abstract

Changing environmental conditions introduce uncertainty into organizational operations, and airlines respond in various ways. Scholars traditionally explore responses to environmental uncertainty by drawing upon theories of communication networks, coordination, organizational resilience, and high reliability organizing. Yet, the research has competing communication predictions, which makes planning and designing organizational responses challenging, as the level and type of uncertainty changes over time. Research also does not address variations in responses across different groups of employees. Using longitudinal network data from the United Airlines operations tower in Newark Airport (USA), this research examines communication for the purpose of relational coordination in a dynamically adaptive organizational network. Results reveal different patterns of organizational communication as different employee groups (frontline, cross-functional boundary spanners, and managers) face varying conditions of uncertainty. This paper concludes with theoretical contributions and practical recommendations for managing complex communication networks to respond to dynamic conditions of uncertainty in the airline operations settings.

Keywords: High reliability organizations; Relational coordination; Problem solving; Uncertainty; Resilience; Cross-functional boundary spanners; Social network analysis

1. Introduction

Changing environmental conditions often present challenges for organizational performance, particularly the uncertainty related to the unpredictable occurrence of external threats. Traditionally, high reliability organizations (HROs) —organizations that strive to maintain high levels of reliability as they operate in environments where high uncertainty occur infrequently— such as airline operations control centers (OCCs), have attempted to manage environmental uncertainty through a variety of responses, including the creation of organizational networks that support communication to facilitate the coordination of integrated work tasks (Gittell and Douglass, 2012, Gittell et al., 2010 and Siomkos, 2000). Despite the wealth of research on workplace coordination, there is contradictory evidence regarding the ways in which formal work structures and hierarchically different categories of employees deal with environmental uncertainty. Furthermore, little research exists to date on the ways less formal, horizontal networks respond to different levels and types of environmental uncertainty in the airline industry (Bamber et al., 2009).

Several theoretical perspectives exist regarding how organizational structures best cope with organizational uncertainty. Some scholars suggest that communication will progress from vertical, hierarchical patterns to more horizontal, non-hierarchical patterns to meet the increased information processing demands that accompany increased uncertainty (Erhardt et al., 2009, Galbraith, 1972 and Gittell, 2016). Others argue that HROs tend to respond by becoming increasingly centralized, with rigid organizational structures characterized by restricted information flow and increased control (Staw et al., 1981). A third school of thought suggests that impending uncertainty necessitates a redistribution of control toward players in the organization who hold the necessary expertise, regardless of where these players are situated in the organizational hierarchy (Weick et al., 1999). These theories offer competing

views of the communication patterns taking place beyond formal, preordained hierarchical channels, particularly in dynamically adaptive organizational networks.

Our research seeks to contribute and provide insight into these competing predictions by drawing on relational coordination theory in HROs, and to shed light on: first, how HROs leverage formal hierarchical responses or more flat dynamics when responding to various levels of uncertainty (Weick and Sutcliffe, 2001); second: to what extent different actors (i.e., management, cross-functional boundary spanners or 'reliability professionals' (Gittell, 2005, Marrone, 2010 and O'leary et al., 2011), and front-line employees) respond to uncertainty; and finally, what are the managerial implications for HROs with respect to preparing its workforce to effectively operate in a context of on-going levels of uncertainty?

As such, our research team sought to study workplace communication network dynamics in United Airlines' OCC tower at Newark's Liberty Airport, which operates in an environment with changing levels and types of uncertainty and where the consequences of errors are high. The OCC tower naturally provides opportunities to observe and collect data on how HROs organize horizontal communication to support relational coordination among different employee groups working under different levels of uncertainty. Hence, we contend that the OCC is an HRO, offering unique opportunities for the study of relational coordination and decision making across formal work roles. We collected social network data, which is a suitable method to study workplace relationships and the impact of levels of uncertainty on dynamic workplace communication networks. The study includes a unique dataset of three types of employees: frontline employees, cross-functional boundary spanner employees and managers. Using social network analysis, this research examines an HRO's dynamic work networks over six days representing three different conditions of organizational uncertainty: low (i.e. normal operating days), medium (i.e. holidays such as Thanksgiving and Christmas Eve), and high (i.e. unanticipated snow days).

The following section is organized by examining the relevant literature on organizational uncertainty, organizational resilience and communication networks in HROs, highlighting their often competing findings and predictions.

2. Theoretical background

2.1. HROs, resilience and relational coordination

Weick and Sutcliffe (2001) describe HROs as a type of organization that has succeeded under trying conditions, in particular in the face of severe threats that are highly uncertain in nature. Reliability is defined as the capacity to continuously and effectively manage working conditions, even those that fluctuate widely and are extremely hazardous and unpredictable (Weick et al., 1999). Building on the work of Wildavsky (1988), the literature defines resilience as the ability to persevere, sustain, and bounce back when faced with a threat (Sutcliffe and Vogus, 2003), as well as the capacity to maintain desirable functions or outcomes in the face of external pressure (Bunderson and Sutcliffe, 2002). One contribution of the resilience literature is the development of a framework to classify the nature of the threats that organizations and, specifically, HROs' employees face.

The literature defines threat as an impending event with potentially negative consequences (Sutcliffe and Vogus, 2003). Thus, organizational responses may be required for both actual and impending threats. Smoldering crises that originate from an organization's environment and threaten their organizational members include strategic threats such as economic pressure and customer-related demands, as well as operational threats such as changes in supplier capacity or changes in demand. Although these contingencies pose different levels of threat to organizational members, they all potentially impact work processes, decision-making and coordination. Furthermore, time pressure intensifies strategic and operational threats and uncertainty (Argote et al., 1989). Even when a threat is impending, such as low-cost competitors poised to enter into one's market so service quality may be drastically changed, the

potential threat can turn into an actual threat with real consequences if not responded to in a timely way. That is, the speed at which an airline must respond to a threat amplifies the level of the threat (Leveson et al., 2009).

The resilience literature suggests a further distinction between types of threats based on the degree to which they can be predicted in advance, thus introducing the notion of uncertainty (Wildavsky, 1988). For example, some research focuses on uncertainties resulting from complex information-processing requirements, where the appropriate response or solution is unclear (e.g., Gittell, 2002). Resilient responses to external threats are not inevitable however. Organizational members can also respond to threat in a non-resilient way by withdrawing support from each other, losing sight of their common goals, and failing to provide critical information in a timely way.

Certain HROs such as nuclear power plants, airlines, and firefighting crews develop ways of acting and styles of leading that enable them to manage uncertainty and threats (Bigley and Roberts, 2001, Roberts, 1990 and Weick and Roberts, 1993). The HRO literature has presented several arguments to explain and predict organizational responses to uncertainty, notably the "threat/rigidity" approach and the relational coordination or "dynamic deference to expertise" approach.

Several scholars note that coordination is likely to centralize under threatening conditions, or when decision-making is needed quickly. Conventional organizational theorists (e.g., Burns and Stalker, 1961) generally argue that deferring to expertise is equivalent to deferring to managers. The threat/rigidity view suggests that increasing the centrality of those in positions of formal authority represents a rigid response to threat. For example, Staw et al. (1981) suggest that stress due to external uncertainty tends to cause information and control processes to become more rigid, leading to a more centralized organizational structure and reliance on

formal procedures. That is, during looming external threats, leadership has a tendency to resume control even in an otherwise empowering organizational structure.

Conversely, high reliability theory suggests that authority should gravitate toward those with the most relevant expertise, without regard for hierarchical position (Weick et al., 1999). Expertise in the contemporary workplace may be widely distributed, and thus may not follow hierarchical lines. By implication, organizational coordination could become more or less centralized, depending upon where the relevant expertise happens to reside. Increasing centrality of those who hold relevant expertise, whether or not they are in positions of formal authority, is a resilient response to threat.

While Staw et al. (1981) argue that sometimes a rigid response is appropriate, others more recently argue that in airline OCC these rigid responses would be ineffective (Igbo et al., 2013). The day-to-day OCC is a very structured environment with pre-established decision-making patterns: formal hierarchy regulates the workplace and standard operating procedures (SOPs) govern in any given situation (Bruce, 2016). However, for OCCs and HROs at large, organizational rigidity and goal disparity could carry negative consequences between certain operations—such as the need to improve customer satisfaction while achieving more efficient control of an airport's OCC (Giles, 2013). Together with formalization, a certain level of horizontal coordination must be achieved among functions in order to ensure on-time performance, accurate baggage handling, customer satisfaction, as well as efficient use of costly resources including gates, aircraft and employees themselves. Magalhães et al., (2015) noted the positive consequences of introducing operational flexibility to accommodate external pressures in airport management.

This alternative “dynamic view” suggests that coordination does not only involve management of interdependencies between tasks but also management of interdependencies between the people who carry out those tasks. Increasingly, coordination has come to be viewed as a

relationship-intensive process (Gittell, 2001). Relational coordination is defined as communicating and relating for the purpose of task integration. Relational coordination theory suggests that coordination occurs through a network of communication and relationship ties (Gittell, 2005). Its emergence in management science denotes an important step in understanding horizontal coordination. Building upon more traditional information processing approaches to coordination (Daft and Lengel, 1986), relationships can be viewed as a source of bandwidth or information processing capacity for coordinating work. Due to greater bandwidth, relational forms of coordination are expected to be more effective to the organization under greater uncertainty (Gittell and Douglass, 2012 and Gittell, 2002). This brief overview of relational coordination in HROs reveals some consistency of concerns about the diverse forms of communication in organizational settings in the face of external uncertainty, which we explore next.

2.2. Communication networks: organizational responses to uncertainty

Scholarship on organizational communication and coordination examines how communication patterns change in response to environmental uncertainty. One source of uncertainty this literature identifies arises when HROs must react quickly, under tight deadlines and with serious consequences associated with failure (Argote et al., 1989). Communication literature notes that densely-connected communication networks, in which a high proportion of group members are communicating with one another, may be chaotic and disorienting (Johnson, 2010 and Krackhardt, 1994). Some researchers suggest that communication channels will contract and centralize when uncertainty increases as a way to increase order and streamline decision-making (Argote et al., 1989, Driskell and Salas, 1991 and Gladstein and Reilly, 1985), which echoes the threat/rigidity view noted earlier. In these circumstances, group members may grant

discretion to group leaders, which may lead in turn to more centralized communication structures (Kelly and McGrath, 1985).

On the other hand, scholars of organizational communication also find that stressful environmental contingencies can lead to significantly decentralized communication patterns, as group members seek information to reduce uncertainty and inform decision-making (Erhardt et al., 2014 and Martin-Rios, 2014). Seminal scholarship by Burns and Stalker (1961) suggests that groups facing stressful task environments are more often successful when employees' communications were diversified, rather than centralized. These decentralized linkages follow a similar logic to that of the relational coordination theory. They, provide a way for groups to accommodate stringent information-processing requirements, and lateral relations are one way that work groups respond to increased uncertainty (Galbraith, 1972 and Alam, 2016). Moreover, extending this logic, it seems reasonable to expect that resilient responses to both expected and unexpected uncertainty depend on the communication relationships among individuals. Along these lines, scholars have advanced the need of promoting network synergies through social capital (Adler, 2002) or holding central positions (and having broader network ties) (Burt, 2004) to address questions of quality of relationships in organizations. Several studies offer evidence that certain structural conditions of relationships (social organization of the group and the types of ties and relations) increase information sharing, task coordination, problem solving, and decision making (Bamber et al., 2009).

Regardless of the prediction of centralized or decentralized responses to uncertainty, the shared assumption in these conflicting predictions is that communication patterns necessarily change. These responses call for alternative organizational roles necessary to support organizational communication. That is, following a dynamic view, responding to uncertainty encourages OCCs to develop a broad and varied repertoire of routines, potentially through the use of SOPs, an emphasis on horizontal communication, and the development of new roles to address lateral

coordination (formal but less programmed). Scholars have used different labels to describe this role, e.g., reliability professional, liaisons or integrators (Gittell, 2005 and Marrone, 2010). We use the notion of cross-functional boundary spanners, which has received more attention in research focusing on flat organizations and dynamic responses needed for coordination (Gittell, 2005). The role of these boundary spanners is to build bridges across functional boundaries to facilitate the cross-functional relational coordination of tasks (Manev and Stevenson, 2001; Vogus et al., 2010), as well as the building of trust (Perrone et al., 2003). Boundary spanners enable coordination between departments or functions by sharing knowledge through social network ties across the organization (Granovetter, 1973). Consistent with this notion, Gittell (2016) finds in her study of care provider groups that cross-functional boundary spanners increase information processing capacity by strengthening relational coordination ties across functional boundaries, improving both quality and efficiency. However, as for other competing views and theories (e.g., threat/rigidity view by Staw et al., 1981), we know very little about the role of these boundary spanners when faced with different types of uncertainty.

3. Research questions

The review of the literature indicates an array of competing predictions. The HRO and resilience theories predict that centralization should gravitate toward those groups with the most relevant expertise for the threat at hand, without regard for hierarchical position (Weick et al., 1999), implying that, for airlines, coordination could become more or less centralized depending upon where in the organizational hierarchy the relevant expertise happens to reside. However, some communication network theories predict that organizational patterns may become more centralized under conditions of high stress largely based on uncertainty in order to streamline decision-making (e.g., Kelly and McGrath, 1985). Yet still, relational coordination theory suggests that groups may decentralize when uncertainty is high, facilitated

by lateral roles such as cross-functional boundary spanners when the occupational boundaries in question are not easily bridged (e.g., Gittell, 2016). The threat/rigidity literature predicts that coordination patterns will, and perhaps should, become less dense as formal hierarchies are followed, and decision making becomes more centralized. Given these competing predictions, the extant literature generates a set of unanswered questions particularly pertinent in the context of airline OCCs:

- When airline OCCs face different types of uncertainty, do patterns of group coordination-response differ under various types of uncertainty?
- Do airlines OCCs operating under varying conditions of uncertainty develop more than one coordination response to these conditions?

Airlines face uncertainty of all types, particularly in OCCs where they must coordinate across multiple functions to achieve reliable, safe, and efficient performance under varying conditions of uncertainty (Franke and John, 2011, Gittell, 2001 and Gittell, 2005). This study seeks to provide insight into these competing predictions by exploring, in detail, how patterns of network communication for the purpose of coordination change dynamically under different conditions of uncertainty.

4. Method

4.1. Research setting

The data for this research come from a study of the United Airlines' OCC tower in Newark, New Jersey. Newark Liberty International Airport is the tenth busiest international air gateway into the United States, handling about 30 million passengers per year, and also one of United's central operations hubs. Due to the combination of weather and congestion, Newark Airport has “the worst airspace in the world” (Flint, 2001). With about 12,000 employees and $4 billion

per year in revenue, the Newark operation is operationally challenging for United due to the high volume of both domestic and international flights.

Two types of operational challenges further exacerbate the day-to-day complexity of airline OCC: 1) high volumes of passenger traffic such as that experienced around holidays, and 2) bad weather days. On high volume days, airlines often exceed scheduled turnaround times at gates due to the high volumes of travelers. Exacerbating these delays are holiday travelers who less accustomed to air travel, and thus take longer to check baggage, board flights, and require more information. Exceeding scheduled turnaround times at a gate causes departure delays, and therefore arrival delays for other flights that cannot park at assigned gates because other aircraft are still occupying them. The additional impact of high volume days is that passengers from any flight that might be cancelled, due to a mechanical or scheduling problem, are difficult to rebook due to the heavy load factors on the remaining flights. Although high volume days are predictable, anticipated and planned for, processing requirements are significantly heightened and more complex than normal operations. Therefore, days before and after holidays are classified as representing a moderate level of uncertainty due to the stress of high volume.

By contrast, on bad weather days, many flights go off-schedule due to delays in arrivals and departures. The number of planes taking off and landing slows to accommodate reduced visibility, ice, and snow. In addition, aircraft de-icing often delays departures. Snowy weather days cannot be anticipated very far in advance and are therefore more unpredictable than holidays. Furthermore, time pressure is exceedingly high as projected flight arrival/departure times continually change when planes are cancelled, delayed, or re-routed to new locations. Bad weather days represent a high level of uncertainty. These two types of days pose different kinds of uncertainty on the tower organization – holidays, while predictable, stress the system with high volume, while bad winter weather days pose more uncertainty and introduce greater

time pressure. Both high volume holidays and bad winter weather days will be contrasted to the relatively low level of uncertainty found on a normal day—a day that is neither a holiday nor marred by snow/ice accumulation.

In an effort to reduce hierarchical complexity and to facilitate employee coordination (thus enhancing the coordination of functional units' activities), in 2003 (Continental Airlines before the 2010–12 merger) built the NOOC, Newark Operations Coordination Center, a state-of-the-art building with a 360-degree open view of the airport. The operations tower, NOCC, co-locates all 165 employees (team agents and NOOC agents), who were previously dispersed across different locations in the airport. The second floor contains top management offices and large meeting rooms, as well as common rooms. The upper floor is the main operations room, a round room encircled by smoked windows through which the airport facilities can be seen. Facing the windows and the airport apron are some 70 desks, all equipped with computers. Zone coordinators with responsibility for coordinating individual flight arrivals and departures are all seated around the perimeter of the NOCC, along with maintenance, cargo, catering, fueling, air traffic systems, and international connections. More centrally located in the tower are the customer service, connection planning, plane move, and gate planning functions. Ramp activities are located in the rear part of the floor as they involve the maintenance and movement of aircraft itself (in addition to the loading and unloading of bags, freight, provisions, and fuel), and do not require direct view of the apron. Customer service is located in the rear right side. Its activities involve interacting with customers and their particular needs, including ticketing, connections, and the movement of baggage. Ramp and customer services together include 18 job functions and report to the airport division, which directs all the key airline functions at the airport, which we analyzed as an aggregated frontline employee group.

Moreover, in line with coordination research (Gittell, 2005), the management team launched and promoted a group of employees who could bridge the gaps between the knowledge of the

different functional groups represented in the air tower and, therefore, facilitate coordination across functions, advance cross-functional communication, and increase joint responses to external threats and uncertainty. They pursued a broader mission than employees specialized on a single task, and operated as cross-functional boundary spanners (Gittell, 2005). They were either self-nominated or expressly selected by management. They escalated vertically in the collaborative chart by expanding their job duties and horizontally by enriching their functional role. They held substantial training and expertise in several areas and operated as substitute managers in case regular managers were not on the floor. As subject matter experts, these boundary spanners do not have their own workstations. They can use any desk in the tower. Managers hold a briefing prior to the start of a new shift. They are regularly required to sit nearby and collaborate closely with functions both ramp and customer service.

4.2. Data collection

A social network perspective has proven to be a powerful tool for understanding social dynamics. Social network analysis provides an alternative method with which to investigate group relationships, interactions, the emergence of horizontal communication, and to describe their relations and coordination dynamics (Gittell and Weiss, 2004, Martin-Rios, 2014 and Rubinstein and Kochan, 2001). These works demonstrate how the assessment of coordination in an airline tower might be better developed and examined through the lens of social network analysis. The design of the network questionnaire was developed through a pilot study by the authors and through previous studies (Martin-Rios, 2014, Rubinstein, 2000 and Rubinstein and Kochan, 2001), informed by personal interviews, and by the network literature (in particular, Borgatti et al., 2002 and Scott, 2001). The network survey asks each respondent to indicate who (from all the other employees listed on the roster) in the NOCC they had communicated with on that day, the number of times communication had taken place, and the purpose of the communication, which included information sharing, task coordination, and problem-solving.

By asking employees about these three dimensions of coordination instead of more specific task related questions we avoided any bias that differences in status among employees would have on the analysis of developing through network ties. These questions were taken from the theory of relational coordination which argues specifically that the effectiveness of coordination is determined by the quality of communication among participants in a workplace (Gittell et al., 2008).

Prior to data collection, we visited the NOCC to conduct informal training sessions as to how to complete the network survey, which was also reinforced by our research teams during fieldtrips to the tower. Our data collection strategy was to administer the survey to as many employees in the tower as possible at the beginning of each shift. Each respondent was instructed to keep the survey next to his or her workstation and populate it during one shift instead of at the end of it in order to improve the reliability of the data. The NOCC hosts 165 employees who worked across three different shifts. The questionnaire included a list of all of these individuals.

Work in the tower follows two eight-hour dayshifts and a night shift but our data collection focused on the dayshifts across six different days. One shift included about 70 people. While the personnel in the NOCC could vary during a shift, our unit of analysis was job function (i.e., senior management, cross-functional boundary spanners and front-line employees), which allowed us to aggregate and compare data across each of the six shifts. As such, we expected variability in the composition of the overall network. To capture the types of operational uncertainties explained above, we collected data on six days, including two days of normal operations (i.e., low uncertainty), two high volume holidays—Thanksgiving and Christmas Eve (i.e., medium uncertainty), and two bad winter weather days, both with significant snow accumulations) (i.e., high uncertainty).

Table 1 presents the breakdown of the number of informants across three job functions (i.e., senior management, cross-boundary, and frontline employees) who participated in each survey. Data on which of the 165 NOCC employees were surveyed shows that 82% of managers were surveyed six times, 80% cross-functional and 65% of frontline employees. Respondents thus provided complete network data on six different days. The 4,188 communication ties (six days combined from all the network rosters) among these employees constitute the network data for our analyses.

------Insert Table 1 about here--------

4.3. Network analysis

The research team aggregated the communication data to create separate networks for each of the three types of days (low, medium, or high levels of uncertainty). The networks under each condition of uncertainty were analyzed by employee occupational group using UCINET software (Borgatti et al., 2002). Structural network analyses include centrality, density, centralization, and I-E Index.

Degree centrality (Freeman, 1979) analyzes each employee with regard to the number of ties they have to others—sends (out-degree) or receives (in-degree). Therefore, centrality measures each group's level of participation in the network (within and across groups of employees) in each of the three contexts investigated. Thus, centrality compares which employees play dominant roles in each of the three types of days, and if or how their roles change depending upon the level of uncertainty.

Density (Scott, 1991) measures the percentage of links between network members out of the total number of possible links. Density indicates how close-knit (Wasserman and Faust, 1994) a network is. Density values range from 0 to 1. This study calculates the density of ties within and across employee occupational groups in each of the three conditions. Partitioning of networks by employee groups allows for a comparison of their similarities and differences, and

an exploration of how they are interconnected (George and Allen, 1993). Comparing densities highlights how group-level communication differs across the three types of days.

Centralization measures the variance in individuals' centrality within the overall network. The centralization index measures the unique ability of a few members in a network to control access to information for the other members (these more central members are the links between others). For a given binary network with vertices v1 … vn and maximum flow betweenness centrality cmax, the network flow betweenness centralization measure is (cmax – c(vi)) divided by the maximum value possible, where c(vi) is the flow betweenness centrality of vertex vi (Borgatti et al., 2002).

The I-E index measures the relationship between external and internal ties to any given group. Krackhardt and Stern (1988) contend that the index is a measure of dominance of external over internal ties, since the index decreases with a decrease in external ties but also decreases by increasing the internal ties. I-E index values range from −1.0 to +1.0. As the I-E index approaches +1.0, all the links would be external to the sub-unit. A score of −1.0 would indicate that all the links are internal. If the links are divided equally, the index will equal zero (Everett and Borgatti, 2012).

5. Results

As noted above, airlines traditionally organize work around functional job categories. In the NOCC, United Airlines provides an opportunity for these employees to be co-located in order to facilitate communication and the coordination of their work. Interviews suggest that organizational leaders saw the tower as a way for the organization to improve reliability in the face of uncertainty. In an interview, the Assistant Director of Daily Operations states, "[The tower] has to reinvent itself as stress conditions change and it is not always easy to find the right change pattern: more flexibility, more coordination, better communication, empowerment …". Management hoped the tower would add value, particularly under conditions of increasing

uncertainty, when employees playing different functional roles need to work closely together and communicate effectively to coordinate across functional boundaries. Table 2 presents the occurrence of communication among employees across the three uncertainty conditions. Differences in frequency of communication across the three functions and three uncertainty conditions were analyzed. A p-value of <0.05 is considered significant.

------Insert Table 2 about here--------

5.1. The network under conditions of low uncertainty

The network graph in Fig. 1 illustrates the communication patterns under conditions of low uncertainty. Blue nodes represent regular front-line employees, green nodes represent boundary spanning employees, and red nodes represent managerial employees. The size of the node represents the centrality of a particular individual in the network – the larger the node, the greater the centrality. The lines between nodes indicate links between individuals. The network graph shows that front-line employees are most central under conditions of low uncertainty and tend to communicate directly among themselves.

------Insert Figure 1 about here--------

5.2. The network under conditions of moderate uncertainty

Multi-skilled or cross-functional boundary spanning employees are able to perform both ramp and customer service operations to facilitate coordination with the aim of improving service quality. One of these employees remarked: "The more knowledgeable, the less finger-pointing." The boundary spanning employees who were interviewed were frank in expressing their enthusiasm for this position. Analysis reveals that these boundary spanners become more central to the network under conditions of moderate uncertainty, with more complex demands for coordination and information, relative to conditions of low uncertainty (see Fig. 2).

------Insert Figure 2 about here--------

5.3. The network under conditions of high uncertainty

Under conditions of high uncertainty, the network coordination patterns change again from the patterns found under the other two conditions. Under high uncertainty, the tower relies much more heavily on management employees. Both front-line employees, who are most central under low uncertainty, and boundary spanning employees, who are most central during times of moderate uncertainty, became less central. Instead, management employees become most central in the network. In addition, ties among management employees, as well as between managers and the other two employee groups, become the densest. Fig. 3 graphically demonstrates this finding.

------Insert Figure 3 about here--------

Observational and interview data were consistent with findings from the survey data. We observed that meetings were held with high frequency among managers on bad winter weather days, while the rest of employees—whether front-line or boundary spanners – did not always take part in these meetings. When snow storms hit, managers left their offices below the tower and took the elevator upstairs to be at the heart of the action. Other employees sometimes moved from their seats to allow managers access to their computer terminals. At one point during our observation, managers and boundary spanners even walked out on the tarmac to physically supervise the de-icing of the planes. Front-line employees and boundary spanners at the operations tower acknowledge the role of management in coordinating operations during times of high uncertainty. Some highlighted the need they perceived for more centralized coordination under highly uncertain conditions.

5.4. Communication content under three types of uncertainty

Table 3 details the centrality that each of the three groups (specialized employees, multi-skilled or boundary spanning employees, and management) had regarding communication and coordination at the NOCC. Results of the network analysis (Table 3), numbers in bold indicate

the highest centrality for each employee type, show that front-line employees are most central under conditions of low uncertainty. Cross-functional boundary spanning employees are most central under conditions of moderate uncertainty, while management employees are most central under conditions of high uncertainty, a classic instance of decision-making and information sharing going up the formal chain as uncertainty increases. In addition, overall network centralization is highest under conditions of high uncertainty. A similar pattern can be seen when examining network density. Table 4 shows the density of ties among front-line employees, between front-line and boundary spanning employees, among boundary spanning employees, between boundary spanning and management employees, among management employees, and between management and front-line employees, under each of the three conditions – low, moderate, and high uncertainty. The table also compares ties based on information sharing, task coordination, and problem solving. The results show a pattern similar to the centrality results in Table 3 – density among front-line employees is greatest under low uncertainty, density among boundary spanning employees is greatest under moderate uncertainty, and density among managers is greatest under high uncertainty. This pattern is consistent across information sharing, task coordination, and problem-solving communications.

------Insert Table 3 about here--------

------Insert Table 4 about here--------

The data provide a picture of differing emphasis on differing roles under varying environmental conditions. When the NOCC faces conditions of moderate uncertainty, front-line employee centrality decreases, while centrality increases among boundary spanning employees. In addition, density increases between boundary spanning employees and front-line employees, so the coordinating functions also move outward from the functional task level. These findings are consistent with boundary-spanning positions providing benefit—specifically when

uncertainty is elevated. On the high volume days, boundary spanners were more central in the social networks for task coordination, problem solving and general information sharing. Moreover, these days show high task coordination (i.e. more important) than on low volume days. On winter weather days, managers became most central in the social networks—across all three communication needs (task coordination, problem solving and general information sharing). On these days with the greatest uncertainty, managers were considerably more central with respect to problem solving. The higher centrality of management employees appears to occur at the expense of front-line and boundary spanner coordination capacity, as Table 3 reflects that the centrality of these employees decreases respectively.

These data suggest that different employee groups play a central role in the network under differing conditions of uncertainty, and also suggest that employees with more training and expertise play a central role as uncertainty increases. The network centralization index in Table 3 shows that with increasing uncertainty, networks become relatively more centralized (i.e., from 1.36 to 1.56 in information sharing or 1.72 to 1.83 in task coordination). However, in addition to these variations in the centralization indices, the analysis needs to consider whether these changes represent a substitution of one type of employee for another, or whether instead a net addition of new capacity is utilized as uncertainty increases, from low to moderate, and from moderate to high. Overall, as the level of uncertainty increases, so does the centrality and density of managers in the communication network, while the number of ties actually decreases. The next section explores the reasons that account for that shift in communication patterns during different uncertainty settings.

5.5. Intra vs. inter-group relationships

To better understand the reasons behind changes in communication patterns during varying conditions of uncertainty, I-E indices for each of the three groups (front-line employees, boundary spanning employees, and managers) were calculated under each of the three

uncertainty conditions. Results are shown in Table 5. I-E index values describe the tendency toward group closure, or the propensity of each group to have ties within their group. In line with other studies that employ an I-E index (Krackhardt and Stern, 1988), this study interprets more external links relative to internal links (a more positive I-E index) as suggesting greater inter-group relationships, rather than intra-group relationships, and therefore, signifying greater coordination capacity.

------Insert Table 5 about here--------

Observations show that the I-E indices of the three employee groups are fairly similar across the three uncertainty conditions, suggesting that the ratio of internal to external ties is more embedded in job roles than responsive to changing environmental conditions. Front-line employees show negative I-E indices (i.e., a greater number of internal links relative to external links) under all three conditions, particularly under conditions of low and moderate uncertainty in the communications networks for information sharing, task coordination, and problem solving. Boundary spanners have positive I-E indices under conditions of low and moderate uncertainty, especially for information sharing and task coordination. These indices are slightly less positive (i.e., fewer external links) under high uncertainty. Finally, management's I-E indices are always positive across all three conditions of uncertainty.

Taking together the negative I-E indices of front-line employees, the positive I-E indices of boundary spanners, and the highly positive I-E indices of management, the evidence reveals that the successive participation of different employee groups, from frontline to boundary spanners to management, represents an increasing organizational capacity to engage in communication for coordination under increasing levels of uncertainty, and not merely a substitution of the centrality of one group for the centrality of another, suggesting that coordination is increasing without increasing control.

6. Discussion

This paper departs from current research on organizational response to uncertainty, which is marked by competing theories and outcomes. Current research on coordination and communication networks occurring in HROs in the face of uncertainty, suggest either a threat/rigidity response through formal hierarchical lines (Staw et al., 1981) or a dynamic response following a flat horizontal structure– as relational coordination theories suggest (Gittell, 2016 and Weick et al., 1999). Part of reconciling these competing views, may be resolved by accounting for different types of uncertainty, as well as differing responses by different groups of employees. Our findings from the NOCC follows relational coordination theory, and show that communication networks for coordination respond dynamically to changes in uncertainties, due to more complex coordination and information needs and increased time pressure. The findings are consistent with the theoretical expectation that HROs' organizational networks do indeed change in response to changes in uncertainty. The fact that communication networks varied so sharply with the environmental contingencies suggests that these variations are indeed varying responses to uncertainty.

However, the existing theory does not anticipate the way that they change. Our findings reveal that coordination is not simply different in airline OCCs as they face different conditions of uncertainty, but that the same organization changes and adapts its coordination patterns dynamically to adjust to changes in external conditions. This finding is a departure from classic contingency arguments that postulate that network patterns are specific to the environments in which airline OCC operate (Bamber et al., 2009). Instead, the findings highlight the possibility that organizational networks are not static, but rather can continuously adapt and flex their coordination capacity as conditions unfold. The data also suggest that organizational networks do not necessarily change in their overall centrality and density as the level of uncertainty increases – rather the change may be in the type of employee who becomes central and whose networks become denser. When networks change in response to increases in uncertainty, the

net impact can be an increase in overall coordination capacity, rather than a displacement of one type of capacity for another. This dynamic capability is particularly relevant for airline OCCs but may be broadly relevant for HROs that seek to be resilient in the face of uncertainty, without having to operate consistently at the highest levels of alert.

Moreover, the findings demonstrate that under conditions of moderate uncertainty, cross-boundary spanning employees became more central in the organizational network. Based on these observations, this paper proposes that reliability or functional boundary spanners become more central and develop denser networks than other employee groups as the OCC comes under moderate levels of uncertainty and complexity increases. Specifically, results from the I-E index suggest that cross-functional boundary spanners add operational capacity to that of front-line employees under conditions of moderate uncertainty. Boundary spanners become more central, and their networks became denser, adding capacity and replacing front-line employees as the most central participants in organizational networks facing conditions of higher complexity and moderate uncertainty.

Under conditions of high uncertainty, findings show that management becomes more central in the OCC network. In addition to the higher levels of uncertainty, there is the added dimension of time pressure. Employees in the tower often have to make decisions quickly, and this time pressure further increases during the periods of high uncertainty. Decision making under these conditions needs to be immediate. Boundary spanners play an increased role in periods of moderate uncertainty, where the predictability of higher volumes provides the time needed to discuss options and gain consensus. However, as the nature of the information and decision making becomes increasingly difficult under conditions of high uncertainty due to severe weather, and as the time pressure to make decisions increases, the network searches for alternative ways to process information and make decisions. This task falls to the managers who have the necessary training and expertise.

This finding extends the relational coordination theory by suggesting that increasing managerial centrality represents a resilient response to the threat posed by the highest levels of uncertainty. Deference to expertise means relying on the person with the most relevant expertise during times of crisis, in this case experience in making decisions with a high level of uncertainty in short time frames. This theoretical expectation would be consistent with the dense communication patterns found between front-line employees during normal operating conditions. During times of heightened uncertainty, regular employees and boundary spanners play a more secondary role, as the nature of the information becomes increasingly complex, and therefore too difficult or chaotic to transfer over overly dense networks of intermediaries (Johnson, 2010 and Krackhardt, 1994). Under these conditions, managers with more extensive experience step in to play the central coordinating and decision-making roles, replacing the coordination capacity of front-line and boundary spanning employees (actually, the number communication ties drops under high uncertainty).

The analyses of the coordination patterns in the tower raise important implications for manager-employee roles in the context of environmental uncertainty. The optimal position in the organizational hierarchy for coordinating work under different conditions of uncertainty will depend on which kind of expertise is needed under the conditions that arise, and where that expertise resides in a given organizational context. Depending on the kind of expertise that is needed and where that expertise resides, coordination gravitates either to front-line employees, to cross-functional boundary spanners, or to management. Expectations would include that, in general, front-line employees have the most specialized knowledge, that boundary spanners have the most cross-cutting knowledge, and that managers, if they have been developed and promoted from within the organization, have the most extensive specialized experience.

But even this expectation does not yield a general principle of who plays the most central role as uncertainty increases. Much will depend on job design, in particular which types of expertise

are designed into which jobs, and where those jobs are found in the organizational hierarchy. In addition, temporal dimensions add complexity– short time horizons may also play a significant role in determining who in the network becomes central under high levels of uncertainty. A design challenge to consider may be to design jobs and the distribution of expertise across them in such a way that enables the distribution of decision-making to remain responsive under conditions of high uncertainty; this issue deserves further study.

Although this study offers important clues for better understanding patterns of organizational response to uncertainty, several limitations are worth noting. These findings are exploratory and must be interpreted with caution given that a single case study was conducted. Further research at an additional site, would provide a basis for comparison thus strengthening this study's arguments and conclusions. Furthermore, while the findings offered above are grounded in empirically-observed phenomena, they will require systematic testing to assess their usefulness. For example, this analysis cannot conclude how these changes in coordination capacity are associated with performance outcomes. Scholars concerned with airline responses to uncertainty are encouraged to pursue these issues through further research.

6.1. Implications for practice

Our findings raise several practical implications worth noting. The analysis of organizational responses to uncertainty suggests that airlines strive to improve organizational resilience under varying degrees of uncertainty. Airline OCCs are highly formalized around SOPs. The day-to-day complexity of airline operations is further exacerbated by two types of operational threat: bad weather conditions and high volumes of passenger traffic, such as on holidays. Airlines must find a balance between increasing centrality of those in positions of formal authority and encouraging a resilient response to uncertainty.

The distinguishing factor may be whether managers take control on the basis of their formal authority, or take control on the basis that their expertise is more relevant to address the threat

at hand. Significant training is required along with new direction from leadership. Airlines must train their OCCs managers to balance between SOPs and relational coordination based on expertise. Training plans will better allow OCCs to prepare for uncertainty and train employees for varied roles based on the type of uncertainty they face. Airline OCCs could set in place a flexible workforce that will groom future leaders needed during high uncertainty.

Our study also raises an additional question for airline OCCs regarding the relationship between resilience and deference to expertise. Findings imply that there is a need to develop cross-boundary positions, and to set in place developmental plans to offer high performing employees opportunities to develop broad portfolio of OCC-specific knowledge and skills related to a set of tasks across processes and functions. Moreover, these developmental systems need to include cross-functional or rotational assignments to promote organizational-specific expertise needed during moderate to high uncertain conditions. For example, the case of the boundary-spanner in our study, these high performing employees were given cross-training and developmental opportunities during low and moderate uncertainty conditions to prepare them for more trying conditions.

7. Conclusions

This study sheds light on the ways that employees in airline OCCs develop organizational networks and communicate to achieve coordination in the face of different types of uncertainty, and how different employee groups can play a more or less central role as the type of uncertainty changes. Drawing on a social network perspective of organization, this research suggests a dynamic interplay between front-line employees, boundary spanning employees, and management employees, which varies in response to the level of uncertainty. This work suggests that not only might the overall centrality and density of organizational networks change as uncertainty changes, but that, whether or not those network characteristics change, significant changes may occur in which employee group plays the most central role, with the

greatest network density. Additionally, as different employee groups take on more central roles in network communications, their participation can represent a net increase in coordination capacity, rather than a displacement of baseline capacity, thus enabling OCCs to achieve a flexible and dynamic response to increasing uncertainty, rather than a static response. These results entail important consequences on effective relational coordination for airline OCC management.

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Tables

Table 1. Number of Informants across Three Job Functions

	Management	Cross-Boundary	Front-Line	Total
Low Uncertainty (October 23rd and November 3rd)	8	8	45	61
Moderate uncertainty (Thanksgiving and Christmas Eve)	5	5	47	57
High uncertainty (Two blizzard days)	8	8	54	70
Total	21	21	146	188

Table 2: Communication and Relationship Ties, by Three Conditions of Uncertainty

	Low uncertainty	Moderate uncertainty	High uncertainty	p-value
Number of people surveyed	61	57	70	--
Number of ties reported	1245	1564	1379	--
Within function (total) (%)	383 (31%)	512 (33%)	408 (30%)	--
Between function (total) (%)	835 (69%)	1037 (66%)	932 (70%)	--
Frequency of communication per tie (mean) (SD)	7.28 (18.19)	5.59 (14.59)	8.96 (34.35)	0.0007
Within function (mean) (SD)	8.70 (19.42)	7.59 (17.19)	13.08 (56.90)	0.0531
Between function (mean) (SD)	3.66 (5.88)	3.24 (6.43)	5.32 (10.95)	0.0000

Table 3. Mean Centrality for each Employee Type under Low, Medium, and High Uncertainty

Employee Type By Uncertainty	**Information Sharing Networks**			**Task Coordination Networks**			**Problem Solving Networks**		
	Low Uncertainty	Medium Uncertainty	High Uncertainty	Low Uncertainty	Medium Uncertainty	High Uncertainty	Low Uncertainty	Medium Uncertainty	High Uncertainty
Front-Line	**12.3**	9.3	8.4	**10.6**	10.0	7.1	**11.4**	10.5	7.2
Boundary Spanners	15.1	**20.1**	12.6	9.2	**22.1**	11.8	13.2	**24.8**	11.8
Management	18.9	18.5	**26.7**	12.3	11.7	**26.9**	8.4	7.7	**20.2**
Network Centralization Index	1.36	1.47	1.56	1.72	1.5	1.83	1.35	1.51	1.88

Table 4. Mean Density for Each Employee Type under Low, Medium, and High Uncertainty

Employee Type	**Information Sharing Networks**			**Task Coordination Networks**			**Problem Solving Networks**		
	Low Uncertainty	Medium Uncertainty	High Uncertainty	Low Uncertainty	Medium Uncertainty	High Uncertainty	Low Uncertainty	Medium Uncertainty	High Uncertainty
Front-Front	**0.118**	0.091	0.059	**0.122**	0.076	0.067	**0.107**	0.088	0.052
Front-Boundary	0.116	**0.251**	0.096	0.13	**0.183**	0.102	0.103	**0.219**	0.084
Boundary-Boundary	0.143	**0.483**	0.134	0.306	**0.466**	0.157	0.107	**0.400**	0.145
Boundary-Mgmt.	0.061	0.082	**0.247**	0.139	0.184	**0.274**	0.016	0.100	**0.346**
Mgmt.-Mgmt.	0.476	0.350	**0.678**	0.679	0.69	**0.857**	0.643	0.600	**0.839**
Mgmt.-Front	0.033	0.050	**0.130**	0.134	0.139	**0.200**	0.061	0.073	**0.190**

Table 5. I-E Index for each Network under Low, Medium, and High Uncertainty

	Information Sharing				**Task Coordination**				**Problem Solving**			
Uncertainty Condition	Front-line employees	Boundary spanners	Mgmt.	Network Index	Front-line employees	Boundary spanners	Mgmt.	Network Index	Front-line employees	Boundary spanners	Mgmt.	Network Index
Low uncertainty t1	-0.418	0.542	0.892	-0.107	-0.416	0.532	1.000	-0.092	-0.644	0.545	1.000	-0.380
Low uncertainty t2	-0.306	0.503	0.845	0.041	-0.399	0.273	0.745	-0.101	-0.363	0.245	0.647	-0.070
Med uncertainty t1	-0.261	0.573	0.923	0.088	-0.195	0.518	0.740	0.127	-0.309	0.234	0.536	-0.056
Med uncertainty t2	-0.598	0.442	0.810	0.326	-0.664	0.394	0.826	-0.429	-0.500	0.472	0.680	-0.191
High uncertainty t1	-0.177	0.431	0.820	-0.119	-0.205	0.438	0.918	0.092	-0.259	0.328	0.855	0.038
High uncertainty t2	-0.467	0.453	0.943	-0.133	-0.195	0.441	0.797	0.125	-0.287	0.409	0.744	0.071

Figures

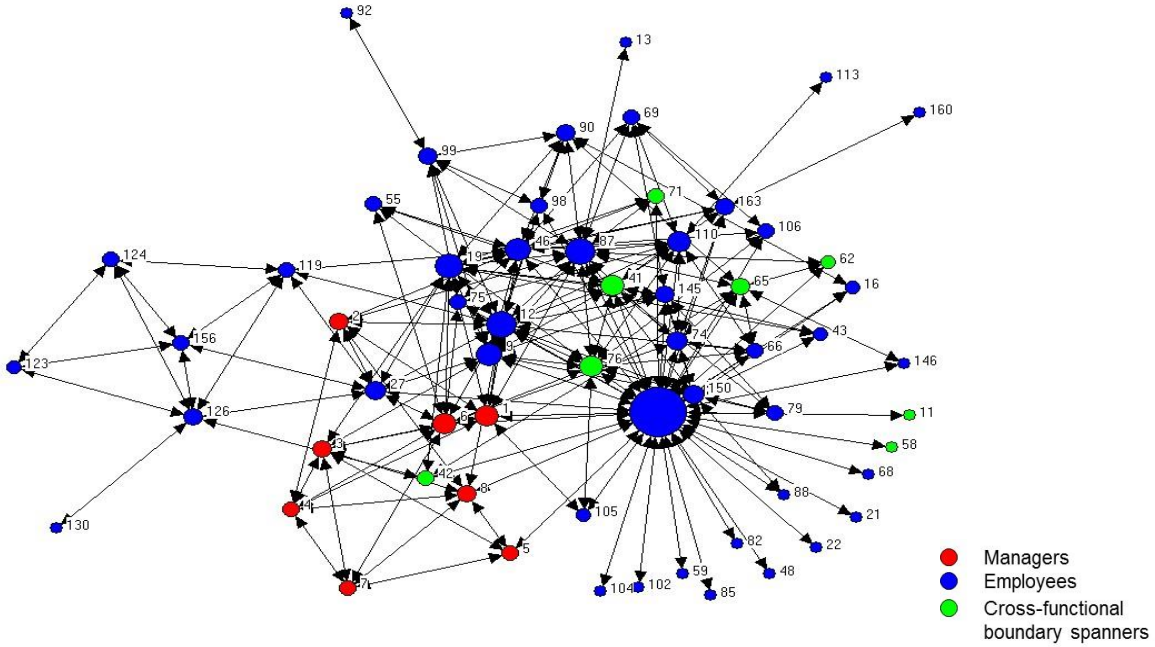

Figure 1. Network under Low Organizational Uncertainty (isolates removed).

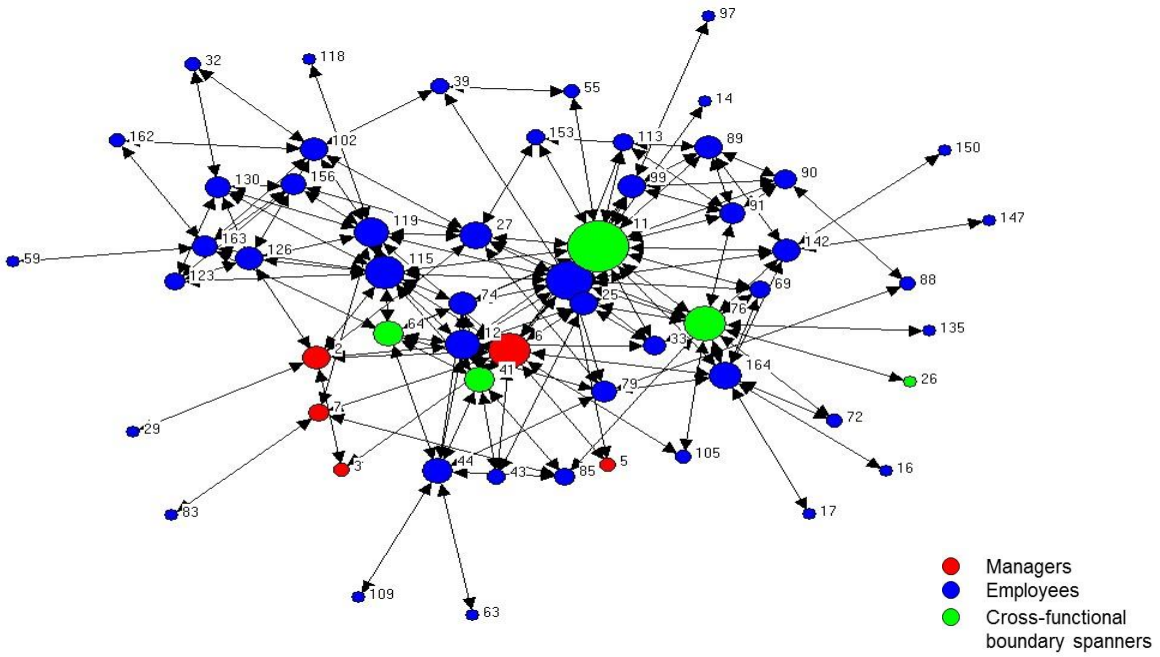

Figure 2. Network under Medium Organizational Uncertainty (isolates removed).

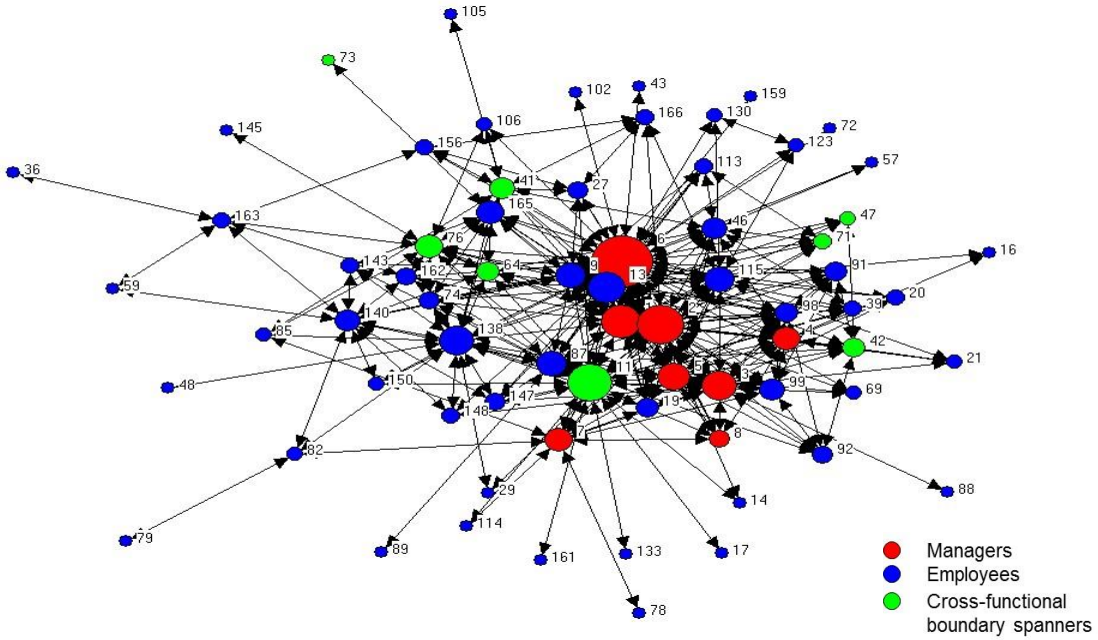

Figure 3. Network under High Organizational Uncertainty (isolates removed).