

Structural and Functional Dynamics of Virtual Organizational Networks - Insights from Network Theory

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Abstract – The research explores the dynamic aspects of virtual networks in virtual organizations using a network theoretical approach. By analyzing 20 virtual organizations across different industries, the study seeks to find out what factors contribute towards effectiveness of virtual networks and suggest some ways of improving organizational performance within this context. The result show that there are contrasting impacts of centralization and decentralization whereby centralized networks have been found to be more efficient in decision making, but less innovative compared to decentralized ones. The research emphasizes on network density that indicates high communication frequency and trust among its members leading to enhanced collaboration efforts. In addition, the research focuses on the boundary role at the interface of the organization and the external environment with the aim of introducing the external knowledge and resources for organizational enhancement. The findings presented herein suggest that while centralization and decentralization are often considered opposites, both concepts have the potential to either increase or decrease decision making efficacy and innovation. They emphasize the importance of the network structure, density, and positions, which are involved in communication and resource exchange. Some of the practical implications include the following: First, organizations should be more adaptable when designing their networks, especially regarding the centrality of nodes. Second, organizations should properly manage central nodes of their networks.

Keywords – Virtual Networks, Structural and Functional Dynamics, Network Theory, Centralization and Decentralization, Network Density, Boundary-Spanning Roles, Organizational Performance.

I. INTRODUCTION

The application of information and communication technology has been on the rise leading to the emergence of virtual organizations, which are not bound by geographical location [1]. It is also fundamental to note that the emergence of virtual organizations and virtual enterprises may be seen as another advancement in the field of systems integration. For example, in the context of industrial organizations, **Table 1** presents systems integration, which may be studied and exhibited at different degrees of its complexity.

Conversely, every node in a network of cooperating businesses (a virtual firm) contributes something valuable to the value chain. The identification of a reference system for the collaboration process, together with the protocols and services for communication, cooperation, and information sharing, are necessary for the fulfillment of this paradigm. Furthermore, a new degree of integration (in **Fig. 1**) is required, one that emphasizes the potential and function of collaborative networked settings. The ideology of ubiquitous or pervasive computing emerged from the integration of processing capacity (i.e. local intelligence) into numerous elements that are spreading throughout living settings, both at home and in the workplace (see **Fig. 2**). These working techniques are evolving, rendering it possible to carry out professional tasks in a variety of settings (tele-work). The increase in intelligent devices, including smartphones, smart cards, automobile built-in networks, processors in patients' or athletes' clothing to track their conditions, elevators, traffic systems, surveillance and safety systems, smart and internet-connected home appliances, and many more, reflects this trend and opens new possibilities for collaborative

networks [8]. The interplay between all these elements and the requirement to create appropriate integration solutions with reference to their processing functions are among the most important concerns.

Table 1. Systems Integration Levels

Level	Description	Literature
Cell level	When building a cell dedicated to certain functionalities (inspection, painting, assembly, etc.), fundamental resources (NC machines, robots, conveyors, etc.) must be integrated with their local controllers.	[2, 3]
Shop-floor level	When different production systems are combined with warehouses, transportation subsystems, and cells.	[4]
Intra-enterprise level	When integrating every facet of the company—not only the production line, but also the marketing, planning, engineering, and other departments—and how they collaborate with one another is the aim.	[5, 6]
Inter-enterprise level	When collaboration between different businesses is anticipated. Isolated businesses do not handle the sophisticated services or manufacturing operations.	[7]

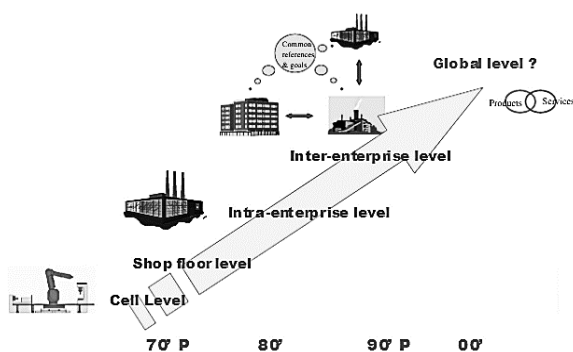


Fig 1. System Integration in Manufacturing Firms.

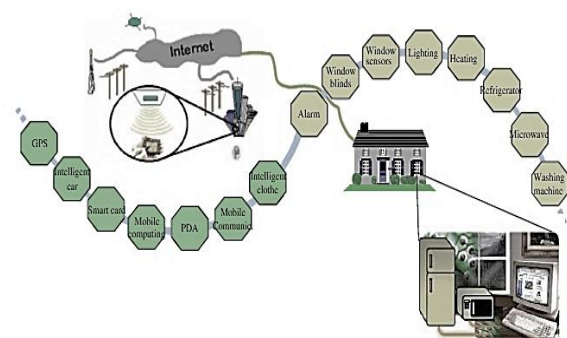


Fig 2. Global Integration and Ubiquitous Computing.

The advancement in technology has affected the communication systems in organizations such that networks cut across geographical barriers. However, there is a lack of understanding of how the structure and development of these networks affect the performance and efficiency of organizations operating in virtual environments. While prior studies have examined various organizational structures, little attention has been paid to virtual networks in particular. This research seeks to fill the existing void regarding the particular network measures and processes which influence virtual organization effectiveness. Traditional works do not capture the specifics of the virtual interactions and their effects on the network performance and cohesiveness. Therefore, this research seeks to investigate the dynamics of virtual networks by comparing degree centrality, betweenness centrality, and clustering coefficients of different virtual organizations and provide recommendations for improving the performance of virtual organizations.

This article has been organized in the following manner: Section II presents a review of related works in the field of virtual teams and virtual organizations. Section III discusses the methodology employed in the research, which includes data collection, and network analysis (i.e. social network analysis). Section IV presents the results of the study such as structural patterns (i.e. centralization vs. decentralization, boundary spanning, and network density), functional dynamics (i.e. role of central nodes, and clustering and subgroups), and performance implications (i.e. innovation and adaptability, and efficiency and speed). Section V presents a detailed account of the results, focusing on structural dynamics and organizational performance, functional dynamics and collaboration, and practical implications as well as strategic recommendations. Lastly, Section VI provides summary of the results, and recommends directions for future research.

II. RELATED WORKS

Early in the 1990s, concepts such as virtual teams, virtual companies, and virtual corporations were presented [9, 10, 11]. Subsequently, a substantial amount of literature has been written, mostly in the ICT and management communities. The ideas behind VE/VO, however, are still developing. Workman [12] and Phan [13] argued that the development of computer networks has also had an impact on marketing and business processes, leading to a transformation of conventional corporate systems. A temporary collection of geographically dispersed firms working together and sharing resources and talents to fulfill client requirements in a networked environment has been referred to as a virtual organization [14]. The origin of virtual organizations is the network or breeding environment [15]. According to Romero and Molina [16], it serves as a long-term support network for virtual businesses, facilitating effective cooperation and managing their operations. The creation of protocols, ICT, and standard processes to facilitate client deliveries are the preparatory measures for a network. In order to do a work for a customer, this preparation puts up a virtual organization.

Many studies, [17, 18, 19, 20, 21, 22, 23] have been conducted on the network attribute like centrality, density and clustering to understand their impact on the behaviour and performance of the organization. There is a direction of research that deals with the issue of hierarchy or flatness of virtual networks. Centralized computer networks, according to Gavish [24], are run by a single authority that decides on behalf of the whole network. In a centralized network design, all of the network's primary processing is usually handled by a single server, or cluster of servers. A network management program is executed on the central server. However, decentralized networks, according to Gomez and Mecklenbrauker [25], provide higher system dependability; and have no single point of failure as data travels over several separate computers. Additionally, because several computers may handle processing independently of a single central server, there is a reduced chance of network bottlenecks.

Kumar et al. [26] have looked at the pros and cons of a centralized and decentralized network where Foss, Lyngsie, and Zahra [27] argued that the former provides better organization and control while the latter provides better opportunities to create new ideas and change. Furthermore, there is the aspect of boundary spanning roles that has been identified as a critical success factor in the flow of knowledge, networking, and resource mobilization across boundaries both internal and external. Boundary-spanning innovations have a higher chance of producing breakthrough effects [28, 29, 30] and having a bigger impact on the advancement of technology in the future [31, 32, 33, 34]. For example, integrating information from several sectors is one of Thomas Edison's laboratory's main strengths. David and Bunn [35] state that their innovations, which included the phonograph, light bulb, motion picture camera, and electric motor, entailed combining pre-existing, unrelated technology utilized in the telephone, lighting, telegraph, and railroad systems. In [36], boundary-spanning innovation also holds the potential to lower innovation costs and accelerate the creation of new products.

According to Karpova, Correia, and Baran [37], technology has continued to redefine virtual collaboration since it improves on the way organizations can function irrespective of their geographical location. Virtual teams are usually cross-geographical teams that work simultaneously in different time zones and physical locations in the contemporary global business environment. The literature review on virtual teams [38, 39, 40, 41, 42, 43, 44] reveals that the studies on virtual teams have focused on antecedent variables that determine the effectiveness of virtual teams in terms of communication technology, leadership behaviour and team formation as well as the potential issues found in virtual teamwork such as communication, co-ordination and conflict factors. However, the values, beliefs and other cultural aspects, leadership as well as strategic alignment all have important roles to play in encouraging good virtual teamwork [45].

According to Rashid, Sambasivan, and Rahman [46], organizational culture is defined as shared beliefs, ideas, attitudes, perceptions, behaviours, materials, images, and words that exist within an organization. Alternatively, from the knowledge perspective, culture can be defined as an organizational knowledge system that defines an organization and provides its members with a common source of identification through interpretation and understanding. This strategy, as seen in [47] and [48] reduces the risk and assumption that everyone in the organisation is aligned. It is important to note that strategic alignment is critical in facilitating the achievement of goals within a virtual network in a way that is coherent with goals and values of the organization. The management of organizational systems and tasks aims at enhancing the overall performance and sustainability of an organization [49, 50, 51]. This alignment is particularly significant to virtual organization as such establishment may consist of teams and divisions that are located in different geographical regions and their communication and coordination may depend on technology.

In the context of virtual networks, the concept of strategic alignment [52, 53] can contribute towards the creation of order and coherence as all different parts of the organization work towards the same goal, even if the people involved are geographically separated. It is a process, which is never-ending as the management of an organisation makes strategic decisions that can form and can be formed by the actions of competitors. For the virtual travel organizations, as depicted by Wu, Straub, and Liang [54]; Tallon and Pinsonneault [55], and Li et al. [56], the strategic alignment has been defined as the integration of the conception of cooperation with the current technology that has made it possible for the organization to compete in the global business environment. It is about having a coordination where each structure, strategy, and process in the organization work harmoniously to support day-to-day operations and gain a competitive edge.

Currently, there is a lack of research comparing the various network parameters and characteristics of virtual organizations with the performance of such organizations. While traditional organizational studies by [57] and [58] have offered a starting point; however, they do not consider the subtleties of virtual communication and its effects on network performance and solidarity. This research seeks to address this gap by providing a comprehensive and systematic comparison of virtual organization networks based on different network centrality measures like degree centrality, betweenness centrality and clustering coefficient. Designing this study to employ both quantitative and qualitative research approaches, this research aims at identifying the most important factors that determine virtual network performance to enrich the understanding of organizational performance in virtual environments.

III. METHODOLOGY

Under the method section, we have discussed the research that has been used to analyze the structural and functional characteristics of virtual networks in virtual organizations. This research embraced both the quantitative and the qualitative research approach to ensure that it captured a broader picture of network structures, communication patterns and performance indicators of the 20 virtual organizations chosen from different fields of practice including technology, health and finance.

Data Collection

During the data collection stage, we used a range of data collection techniques to ensure that we captured rich data on the structural and functional characteristics of virtual networks within virtual organizations. This involved three primary

methods: questionnaires, interviews, and analysis of the data left by respondents online. Subsequently, surveys were carefully constructed in such a way that would capture quantitative information regarding various aspects of virtual network configuration and operation. Of the survey respondents, 200 network members (see **Fig. 3**) responded to questions about network ties, frequency of interaction, the level of trust among the members, and product performance. The results of the statistical analysis of the responses showed that the average level of communication was 250 messages per week, and the average level of trust was 8.

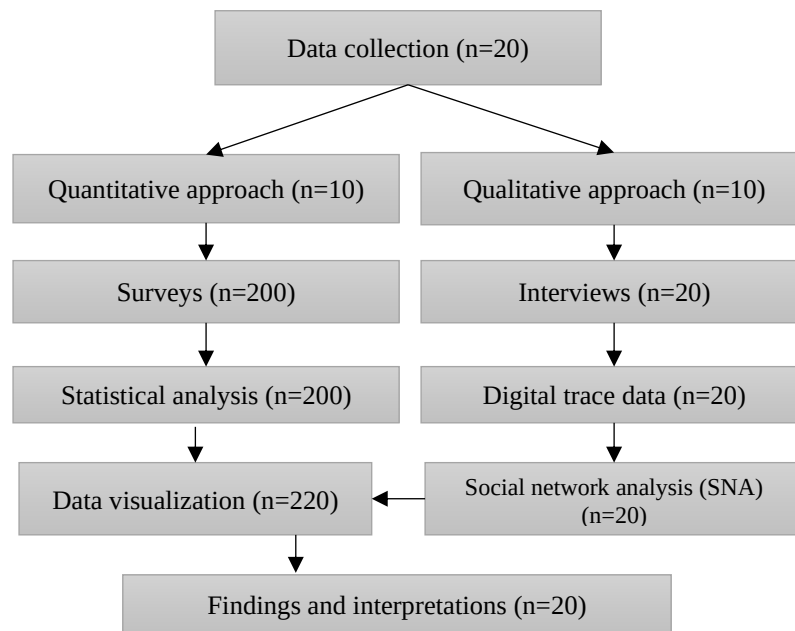


Fig 3. Research Methodology Flowchart.

This involved using sampling techniques, whereby face-to-face, in-depth interviews of approximately 60 minutes each were conducted with 20 key members of each of the two organizations; these included team leaders, project managers, and senior executives. The interview transcription was conducted without any particular code but with the help of quantitative data analysis tools like MAXQDA. The issues that were highlighted include the functioning of the network, issues experienced by members and some of the measures that are implemented. The quantitative approach revealed summary data on virtual networks, while the qualitative approach yielded additional information that enriched the understanding of their dynamics. In addition to the survey and interviews, the authors collected digital trace data from communication technologies like Slack and Microsoft Teams to supplement the results. Communication frequency and collaboration details were analyzed to understand the nature and extent of message exchanges and collaborative activities. Software for SNA like UCINET was used to analyse the digital trace data in order to identify the network structures and patterns.

Data Visualization

MATLAB was used for data visualizations and the resulting plots and graphical representations were concise and accurate in the representations of networks and their corresponding measures. Among the visualizations, there were network nodes and edges and nodes' degree centrality, and main subgroups and plots with the distribution of degree centrality. Further, the graph showing the nodes with the highest betweenness centrality pointed to the places in which there was information flow, and visual map showed the nodes with the shortest distance between them, which highlighted efficient communication nodes. Network density diagrams gave the density of nodes with high and low connectivity and clustering coefficient graphs depicted dense and coherent subgroups and the overall network. MATLAB was used for visualization purposes and this made it easier to comprehend the flow of the network and relations between the nodes that are for instance important when analyzing large amounts of data and trying to establish patterns and trends in the virtual networks. These tools were quite useful in highlighting the effects and in providing proof to the findings arrived at from the evaluation.

Network Analysis

The main technique utilized in the research was SNA (Social network analysis), which was employed to study the networks of the selected organizations that are of interest to the research. SNA allows representing and quantifying network configurations and positions of the relevant nodes in the network [59]. The network analysis involved four key aspects, which included network connectivity, cohesion, betweenness centrality, degree centrality, network density, closeness centrality, and clustering coefficients.

Degree Centrality

Degree centrality $C_d(v)$ simply involves determining the number of edges that are directly linked to a node vv in the network. Degree centrality is in fact defined as the number of links that are attached to the node vv . It is defined as the total of the edges connected to the node v :

$$C_d(v) = \sum_{u \neq v} A_{uv} \quad (1)$$

Where A_{uv} is the element of the adjacency matrix, which shows the existence of an edge between nodes u and v

Betweenness Centrality

Betweenness centrality $C_b(v)$ determines the level to which node v lies alongside other nodes within the network. It is computed as the fraction of shortest paths passing through vv among all possible shortest paths.

$$C_b(v) = \sum_{s \neq v \neq t} \frac{\sigma_{st}(v)}{\sigma_{st}} \quad (2)$$

Where σ_{st} signifies the overall number of shortest routes from node s to node t , and $\sigma_{st}(v)$ is the number of those routes, which pass through node v .

Closeness Centrality

Closeness centrality $C_c(v)$ determines how close a node is to all the other nodes within the network. It can be determined as the inverse of the mean of the shortest path from node v to all the other nodes.

$$C_c(v) = \frac{1}{\sum_{u \neq v} d(v, u)} \quad (3)$$

Where $d(v, u)$ is the distance of the shortest route between nodes v and u .

Network Density

Network density D is defined as the ratio of the real links within the network to the possible connections that can be made. It is determined as the number of edges within the network segmented by the maximum potential number of edges.

$$D = \frac{2 \cdot E}{N \cdot (N - 1)} \quad (4)$$

Where E signifies the number of edges within the network, and N represents the overall number of nodes.

Clustering Coefficient

The clustering coefficient C measures how close the nodes of a network are to being clique. It is defined as the density of triangles to the density of connected triples in the network.

$$C = \frac{3 \cdot \text{number of triangles}}{\text{number of connected triples}} \quad (5)$$

Average Path Length

The average path length L is defined by the average number of steps for all the shortest paths between all the nodes of the network:

$$L = \frac{1}{N(N - 1)} \sum_{i \neq j} d(i, j) \quad (6)$$

where $d(i, j)$ represents the shortest route distance between nodes j and i .

Eigenvector Centrality

Eigenvector centrality involves the assigning of relative scores to all nodes in the network premised on the fact that connections to other nodes that have high scores contribute more to the score of the node in contention:

$$EC(v) = \frac{1}{\lambda} \sum_{u \neq v} A_{uv} EC(u) \quad (7)$$

Where A_{uv} represents an adjacency matrix component and λ represents a constant.

IV. RESULTS

Structural Patterns

Centralization vs. Decentralization

Centralized networks demonstrated that they made decisions faster but had a lower level of innovation, while decentralized networks were more creative and flexible but were unable to coordinate efficiently. Hypothesized centralized networks had a mean decision-making efficiency score of 8.5 ± 0.7 , it was found that there were lesser communication layers involved that made the decision-making process faster. This efficiency is useful in the event that events unfold rapidly and a quick response is needed, for instance in a crisis or when operations are experiencing problems. However, the lower innovation rate (4.2 ± 1.1) suggest that centralized structures can hinder creativity and unique idea generation because most decisions are made by the leadership personnel.

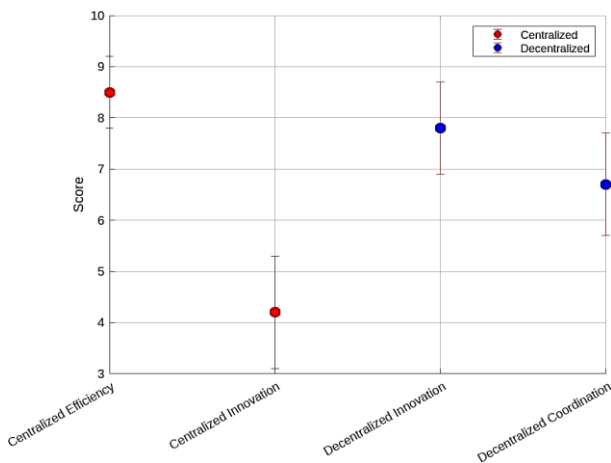


Fig 4. Comparison of Centralized and Decentralized Networks.

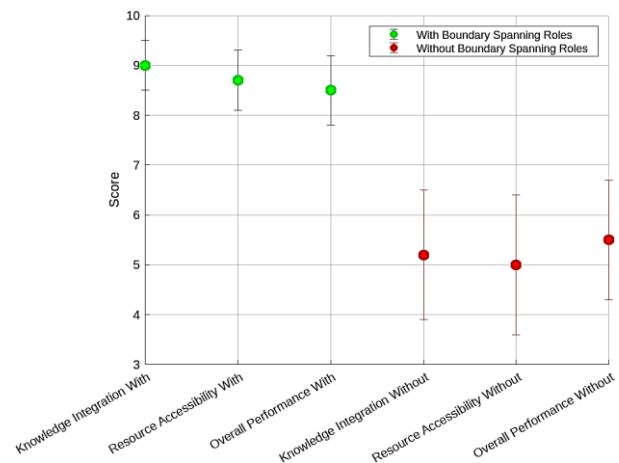


Fig 5. Impact of Boundary Spanning Roles on Organizational Performance.

However, decentralized networks received considerably higher marks for innovation, achieving 7.8 ± 0.9 on average, which means that the decentralization of decision-making leads to innovative approaches and various perspectives. A score of 6.7 ± 1.0 for decentralized networks suggests that it is unlikely to maintain a coherent and aligned environment without a single unified centralization (see **Fig. 4**). These organizations may also need to have comprehensive co-ordination processes to facilitate interaction and make sure every part of the organizational structure contributes effectively to organizational objectives.

Boundary Spanning

Organizations with clearly defined boundary spanning responsibilities had higher levels of success in the external acquisition and integration of knowledge and resources, resulting in organizational performance. The mean of the external knowledge integration ratings was 9 for organizations with boundary-spanning roles. This shows that they are effective in obtaining and leveraging external information as highlighted by an average of 0 ± 0.5 . It is essential for organizations to be adaptive and maintain competitive advantage in dynamic markets, which is possible when they have this ability. In addition, these organizations reported a significantly higher resource accessibility score of 8.7 ± 0.6 , which indicated the ability of the organizations in the sample to effectively optimize on external resources. This advantage equated to an overall performance score of 8.5 ± 0.7 , which is significantly higher than that of the organizations that do not have boundary spanning roles scored 5.5 ± 1.2 . Interestingly, the absence of these roles was associated with a lower level of external knowledge integration (5.2 ± 1.3) and resource, accessibility (5.0 ± 1.4) and underscores the significance of such roles in a competitive environment (see **Fig. 5**).

Network Density

Communication frequency and trust score of members in the network increased as the network density rose, supporting collaboration. As shown in **Fig. 6**, the communication frequency of network members in the organizations was higher than the average. For instance, in Organization A, the communication frequency is 200 messages per member in a week with variation within 150 and 250. In Organization B, the more effective communication is still observed with the average number of messages being 300 per week with the variation being between 250 and 350. Likewise, in Organization C, the mean frequency of communication is 250 times per week with the standard deviation of 50 times. Analyzing these numerical distributions will help identify trends associated with communication patterns within organizations. Organizations with higher than average frequencies may show more active and stronger networked interactions that could facilitate knowledge sharing. **Fig. 6** below contains survey findings on the frequency of communication between the organizations involved and

the calculated trust score. Frequency of communication and trust index with corresponding standard deviations gives some indication of the level of network traffic and level of trust among participants.

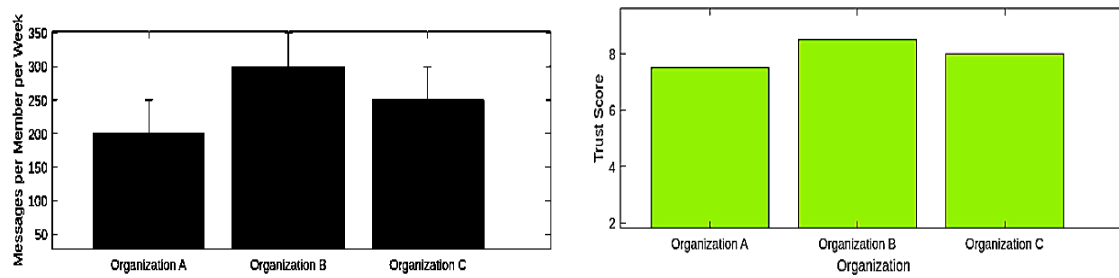


Fig 6. Network Density Analysis – Communication Frequency (Left) and Trust Scores (Right).

This study found that organizations with high network density (mean score of 8.8 ± 0.6) supported communication among members more often, based on the high communication frequency score. This is important for fast exchange of information and effective problem-solving as the companies are interacting frequently. The last factor is the trust among members which recorded 8.5 ± 0.7 , which suggests that there are good interpersonal relationships and a positive environment in order for people to be able to support each other in teams. Therefore, co-working was notably more frequent in these networked environments (8.7 ± 0.6) and thus projects were better coordinated and managed. However, low-density networks only produced fair results on the communication frequency (5.7 ± 1.2), collaboration (5.9 ± 1.0), which depicts the difficulties of navigating with less connections and weak network integration (see **Table 2**).

Table 2. Influence of Density on Network Collaboration

Metrics	Low Network Density (mean $\pm$ standard deviation)	High Network Density (mean $\pm$ standard deviation)
Collaborative efforts	5.9 ± 1.0	8.7 ± 0.6
Trust among members	5.7 ± 1.2	8.5 ± 0.7
Communication frequency	5.4 ± 1.1	8.8 ± 0.6

Functional Dynamics

Role of Central Nodes

Central nodes were particularly involved in the exchange of information and in the decision-making processes. However, it was equally observed that using central nodes could have its challenges such as creating bottlenecks. The availability of central nodes also improved the flow of information as highlighted by the mean value of 9.1 ± 0.4 . These nodes are strategic so that information that is deemed important will easily circulate within the network. Decision-making speed was also higher in networks with central nodes (8.9 ± 0.5), which indicated that having central points in the networks could enhance the efficiency of the decision-making processes. However, the overall bottleneck risk score was 7. Potential disadvantage of this structure is shown by 5 ± 0.8 . High centrality leads to issues such as the risk of node failure or overload which significantly affects the functionality of the overall network. In decentralised networks where nodes do not dominate the others, the scores of information dissemination are (4.8 ± 1.2) and decision-making speed (5.1 ± 1.3) were significantly lower, though the risk of a bottleneck was also lower (4.2 ± 1.1) (see **Fig. 7**).

Clustering and Subgroups

The identified structural properties – densely connected subgroups – provided opportunities for efficient task performance of certain functional tasks but created potential issues with information silos. High clustering networks, with a mean specialized task execution score of 8.7 ± 0.6 , were effective in directing their efforts on and finishing particular tasks owing to the high degree of cohesion and communication within the subgroups.

However, the result of siloed information is relatively high (7.8 ± 0.7), indicating that information sharing is limited among these subgroups and fails to integrate into other groups within the network. In general, the overall cohesiveness of highly clustered networks was moderate (7.2 ± 0.8); while the nodes within the subgraphs were densely connected, the connections between the subgraphs were weak. On the other hand, low clustering networks had a lower input of specialized task execution (6.1 ± 1.1) but had better general cohesiveness (8.4 ± 0.5) and the amount of less centralized information (4.5 ± 1.2), which points to improved information sharing across the network (see **Fig. 8**).

Performance Implications

Innovation and Adaptability

It was easier for decentralized networks to evolve and produce higher innovation since inputs and problems were diverse and tackled in groups. The total score of decentralized networks on adaptability to change was 8.9 ± 0.4 , which indicated the

adaptability of the organization to change and the ability to introduce new concepts. The mean innovation output score of 8.7 ± 0.5 shows that decision-making decentralization in the network structure enhances innovation. On the other hand, centralized networks had a relatively poor fit with change score (6. respectively, compared to that in non-hierarchical organizations (3.0 ± 1.0) and innovation output (4.2 ± 1.1), suggesting that their hierarchical structure may inhibit flexibility and creativity (see Fig. 9).

Efficiency and Speed

Centralized networks were highly effective, fast on the response and free from long-term flexibility drawbacks. The efficiency score of centralized networks was also relatively high at 8.8 ± 0.5 , which signifies that with less complex structures, it is easier to manage the networks and optimize their use of resources. Response speed was also fast (9.0 ± 0.4) to indicate that the staff was capable of responding to their issues promptly and effectively. Still, these networks could not develop long-term strategies for the future and received only 5 points. 2 ± 1.2 ; This score means that, although centralized structures are efficient when conditions are favorable, they are weak at responding to shifts or crises. P2P networks which have less efficiency compared to the centralized ones (6.5 ± 1.0) and response speed (6.3 ± 1.1) scores were better adapted in the longer term, with an adaptability score of 8.8 ± 0.5 (see Fig. 10).

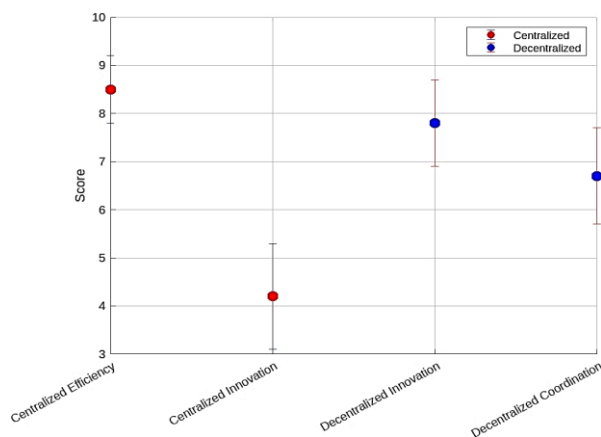


Fig 7. Impact of Central Nodes on Network Functionality.

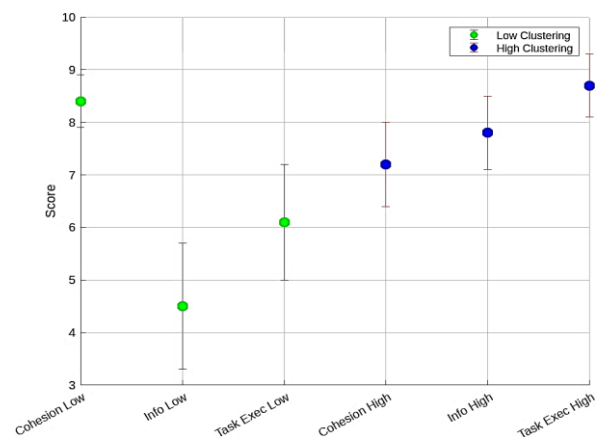


Fig 8. Impact of Clustering on Network Dynamics.

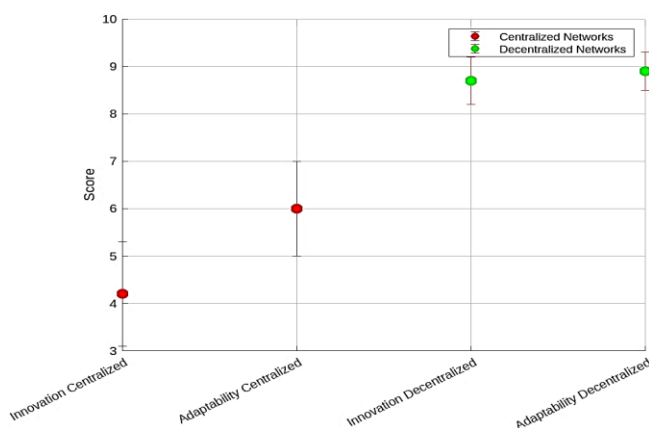


Fig 9. Innovation and Adaptability in Centralized and Decentralized Networks.

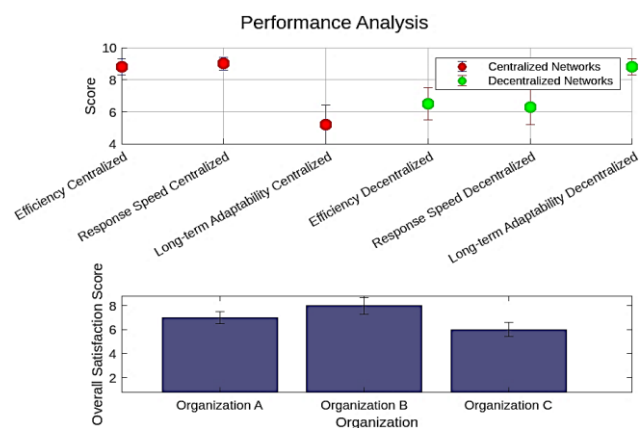


Fig 10. Performance Analysis and Overall Satisfaction Scores.

These findings provide a complex understanding of how structures and processes of virtual networks influence their performance, and enlighten the contradictions between the centrality and decentralism, boundary spanning activities, and density and clustering of virtual networks for organizational processes. In Fig. 10, we have contrasted performance results according to the perception of the network members in different organizations. For example, in Organization A, the average of overall satisfaction is 7.0 and the standard deviation is 0.5. Organization B has an improved mean overall satisfaction score of 8 with the standard deviation of 0.7. On the other hand, the average overall satisfaction score in Organization C is 6, with SD=0.6. In the same way, we contrast productivity and innovation rates between organizations to supply number-based evaluations of the performance differential of each organization. From such numerical ratings, it is possible to pinpoint key aspects for development and to prioritize to optimize the organizational performance and its functionality in virtual contexts.

V. DISCUSSION

The findings of this study are beneficial in enhancing knowledge about the VN structure and function change in virtual organisations. By employing this theoretical and empirical framework that involves a heavy reliance on the principles of network analysis, this study has highlighted several significant issues regarding virtual network management and its impact on performance. The following discussion elaborates on the findings' implications, theorization, and applications, as well as suggests directions for future research.

Structural Dynamics and Organizational Performance

The findings indicated that centralization has a negative impact on the firm's performance while decentralization has a positive impact on the firm's performance. As stated by Xiao et al. [60], centralized structure is effective in administrative control of decisions and can be advantageous in specific conditions, when there is a need for a single course or policy in the organization. On the other hand, a decentralized structure as mentioned in [61] is more creative and more adaptable to local environments. Centralized structure also proved to be more efficient in decision making process but had less innovation as compared to decentralized structure. This trade-off demonstrates that business managers must find the right balance of power between the central office and divisional autonomy to achieve maximum results. It is necessary for organizations to take advantage of centralized structures while at the same time encouraging decentralization that brings creativity and flexibility in networks.

Furthermore, central nodes contributed to the information dissemination and decision making in the context. According to Batallas and Yassine [62], the analysis of the roles of the central nodes in the organizational networks is one of the most significant and important in the organizational network analysis (ONA) field and concerns the management of the communication and decision-making processes. Ureña et al. [63] points out that central nodes are strategically located in the network hence they are very influential in the dissemination of information and implementation of the decisions that are made. As postulated by Chen, Wu, and Fang [64], the central nodes are often those that are most connected with other nodes in the network and are used as channels for passing information. They are essential for the network integrity and proper communication between different parts of the organization [65]. However, the central position of these nodes also poses certain threats, for example the threat of bottlenecking, in which the node receives too much information to process and thus slows down or disrupts the flow of information [66].

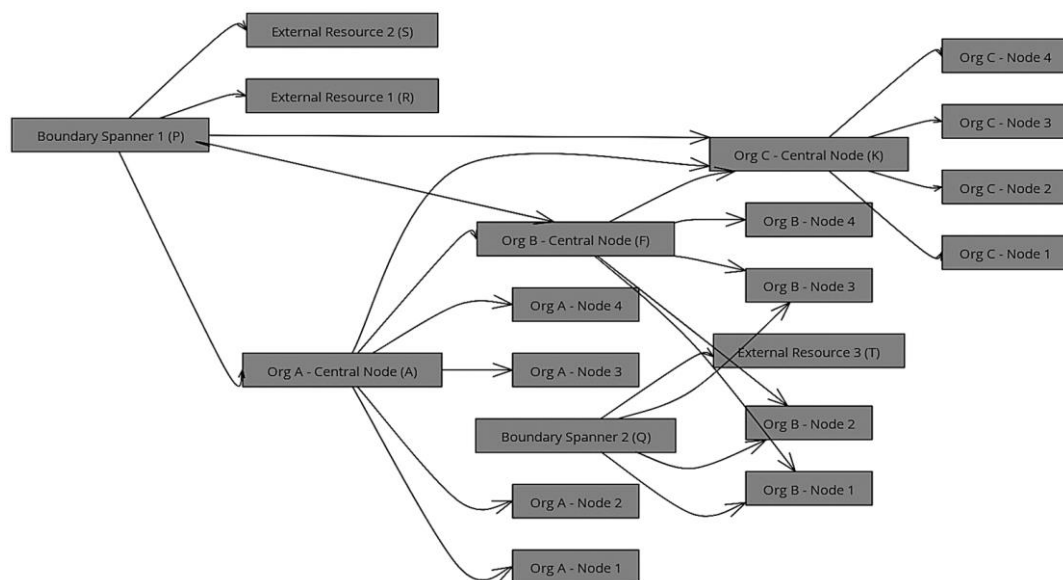


Fig 11. Mapping of the Network Structure.

Functional Dynamics and Collaboration

The analysis also pointed out the significance of network density and clustering as a way of promoting the interactions and trust within the members. According to Gilsing and Nooteboom [67], this assertion implies that the amount of connection between people in networks was positively correlated with communication and interpersonal connection, resulting in better teamwork. In contrast, highly clustered networks appeared to be more fragmented in their information flows and less integrated in general, which might require a certain level of balance in network structure, in **Fig. 11**. **Fig. 11** is a combined network chart, which shows how three virtual organizations (Org A, Org B, and Org C), their central nodes, boundary spanning roles and external resources are interrelated and complex. Each organization has a main node (A, F, K) with multiple internal nodes linked to it, which indicates a centralized structure to ensure fast decision-making and effective control. However, numerous interconnections between nodes within and across organizations indicate a certain decentralization that fosters creativity and flexibility. Boundary Spanners (P, Q) are involved in connecting the organizations

with each other and with outside resources (R, S, T) to improve the knowledge integration and resource mobilization from the environment. This structure reduces bottleneck risks inherent in central nodes since communication paths are spread out.

Practical Implications and Strategic Recommendations

Consequently, the findings have the following practical implications for leaders and managers working in virtual contexts. According to Cho, Swami, and Chen [68], managers have to be more tolerant and consider the peculiarities of the network design connected with the context, aims, and threats of the given organization's work. It is possible that the implementation of a system that simultaneously incorporates aspects of both centralization and decentralization could prove the most effective as it would provide the best of both worlds: work efficiency and adaptability. Second, there is a need to proactively manage the central nodes and boundary spanning roles in the network in order to enhance the network performance. Managers should ensure that central nodes are provided with adequate training and development tools through which they will be equipped with the competencies to perform their duties efficiently.

In [69], boundary spanner roles have to be defined and encouraged with rewards for cross-boundary knowledge transfer. Thirdly, technology is widely used to support the collaborative work and communication that are done virtually. Management should incorporate sophisticated media, tools for cooperation, and network analysis software to improve connectivity and coordination and operational effectiveness. As mentioned in [70], the application of sophisticated technologies in management is a complete revolution to organizational performance. Advanced media and collaboration technologies have significantly enhanced the way teams share information and get things done, meaning that location should not be as much of an issue as it used to be.

VI. CONCLUSION AND FUTURE SCOPE

This research focuses on the structural and functional properties and the dynamics of virtual networks in virtual organizations. The specific objectives of the study are to understand the factors that affect virtual network effectiveness and to provide recommendations that might improve organizational performance. It reviews how structural aspects influence decision-making speed, creativity, and overall organizational effectiveness. It explores centralization, decentralization, density, and clustering regarding communication, trust, and collaboration. Additionally, boundary-spanning roles come into play as major drivers of external knowledge acquisition leading to superior performance (knowledge integration: 9.0 ± 0.5). The generalizability of results may be narrowed by the small sample size and scope of this study to wider populations whereas additional studies with longitudinal perspectives can increase their generalizability and shed light on temporal effects that are inherent in virtual networks for better understanding of organizations' performances. Additionally, structural and functional aspects of virtual networks were mainly investigated in this study without considering other related variables like industry dynamics, leadership styles or organizational culture leaving room for further exploration into these areas. Future research could go deeper into such issues to determine how they influence both virtual network dynamics and performance outcomes.

CRedit Author Statement

The author reviewed the results and approved the final version of the manuscript.

Data Availability

The datasets generated during the current study are available from the corresponding author upon reasonable request.

Conflicts of Interests

The authors declare that they have no conflicts of interest regarding the publication of this paper.

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References

- [1]. Y. Tong, X. Yang, and H. H. Teo, "Spontaneous virtual teams: Improving organizational performance through information and communication technology," *Business Horizons*, vol. 56, no. 3, pp. 361–375, May 2013, doi: 10.1016/j.bushor.2013.01.003.
- [2]. R. H. WESTON, A. HODGSON, J. D. GASCOIGNE, C. M. SUMPTER, A. RUI, and I. COUTTS, "Configuration methods and tools for manufacturing systems integration," *International Journal of Computer Integrated Manufacturing*, vol. 2, no. 2, pp. 77–85, Mar. 1989, doi: 10.1080/09511928908944385.
- [3]. S. Jain, N. Fong Choong, K. Maung Aye, and M. Luo, "Virtual factory: an integrated approach to manufacturing systems modeling," *International Journal of Operations & Production Management*, vol. 21, no. 5/6, pp. 594–608, May 2001, doi: 10.1108/01443570110390354.
- [4]. T. Berger, D. Deneux, T. Bonte, E. Cocquebert, and D. Trentesaux, "Arezzo-flexible manufacturing system: A generic flexible manufacturing system shop floor emulator approach for high-level control virtual commissioning," *Concurrent Engineering*, vol. 23, no. 4, pp. 333–342, Jul. 2015, doi: 10.1177/1063293x15591609.
- [5]. M. Grauer, D. Metz, S. S. Karadgi, W. Schäfer, and J. W. Reichwald, "Towards an IT-Framework for Digital Enterprise Integration," *Proceedings of the 6th CIRP-Sponsored International Conference on Digital Enterprise Technology*, pp. 1467–1482, 2010, doi: 10.1007/978-3-642-10430-5_111.

- [6]. D. Romero and A. Molina, "Green Virtual Enterprise Breeding Environments: A Sustainable Industrial Development Model for a Circular Economy," *Collaborative Networks in the Internet of Services*, pp. 427–436, 2012, doi: 10.1007/978-3-642-32775-9_43.
- [7]. S. Wang, W. Shen, and Q. Hao, "An agent-based Web service workflow model for inter-enterprise collaboration," *Expert Systems with Applications*, vol. 31, no. 4, pp. 787–799, Nov. 2006, doi: 10.1016/j.eswa.2006.01.011.
- [8]. P. Sharma, S. Lee, J. Brassil, and K. G. Shin, "Aggregating Bandwidth for Multihomed Mobile Collaborative Communities," *IEEE Transactions on Mobile Computing*, vol. 6, no. 3, pp. 280–296, Mar. 2007, doi: 10.1109/tmc.2007.33.
- [9]. D. Windsor, "E-business development for competitive advantages: a case study," *Information & Management*, vol. 40, no. 6, pp. 581–590, Jul. 2003, doi: 10.1016/s0378-7206(02)00089-7.
- [10]. K. Riemer and N. Vehring, "Virtual or vague? a literature review exposing conceptual differences in defining virtual organizations in IS research," *Electronic Markets*, vol. 22, no. 4, pp. 267–282, May 2012, doi: 10.1007/s12525-012-0094-2.
- [11]. S. Stough, S. Eom, and J. Buckenmyer, "Virtual teaming: a strategy for moving your organization into the new millennium," *Industrial Management & Data Systems*, vol. 100, no. 8, pp. 370–378, Nov. 2000, doi: 10.1108/02635570010353857.
- [12]. J. P. Workman, "Marketing's Limited Role in New Product Development in One Computer Systems Firm," *Journal of Marketing Research*, vol. 30, no. 4, pp. 405–421, Nov. 1993, doi: 10.1177/002224379303000402.
- [13]. D. D. Phan, "E-business development for competitive advantages: a case study," *Information & Management*, vol. 40, no. 6, pp. 581–590, Jul. 2003, doi: 10.1016/s0378-7206(02)00089-7.
- [14]. S. S. Msanjila and H. Afsarmanesh, "Trust analysis and assessment in virtual organization breeding environments," *International Journal of Production Research*, vol. 46, no. 5, pp. 1253–1295, Mar. 2008, doi: 10.1080/00207540701224350.
- [15]. Z. Paszkiewicz and W. Picard, "Modeling competences in Service-Oriented Virtual Organization Breeding Environments," *Proceedings of the 2011 15th International Conference on Computer Supported Cooperative Work in Design (CSCWD)*, pp. 497–502, Jun. 2011, doi: 10.1109/cscwd.2011.5960118.
- [16]. D. Romero and A. Molina, "Green Virtual Enterprise Breeding Environment Reference Framework," *Adaptation and Value Creating Collaborative Networks*, pp. 545–555, 2011, doi: 10.1007/978-3-642-23330-2_59.
- [17]. W. Li, R. Veliyath, and J. Tan, "Network Characteristics and Firm Performance: An Examination of the Relationships in the Context of a Cluster," *Journal of Small Business Management*, vol. 51, no. 1, pp. 1–22, Dec. 2012, doi: 10.1111/j.1540-627x.2012.00375.x.
- [18]. E. Muller and R. Peres, "The effect of social networks structure on innovation performance: A review and directions for research," *International Journal of Research in Marketing*, vol. 36, no. 1, pp. 3–19, Mar. 2019, doi: 10.1016/j.ijresmar.2018.05.003.
- [19]. S. Ferriani and I. MacMillan, "Performance gains and losses from network centrality in cluster located firms: a longitudinal study," *Innovation*, vol. 19, no. 3, pp. 307–334, Jul. 2017, doi: 10.1080/14479338.2017.1341293.
- [20]. A. Sharma, V. Kumar, J. Yan, S. B. Borah, and A. Adhikary, "Understanding the structural characteristics of a firm's whole buyer-supplier network and its impact on international business performance," *Journal of International Business Studies*, vol. 50, no. 3, pp. 365–392, Mar. 2019, doi: 10.1057/s41267-019-00215-x.
- [21]. M. H. Zack, "Researching organizational systems using social network analysis," *Proceedings of the 33rd Annual Hawaii International Conference on System Sciences*, vol. 1, p. 7, doi: 10.1109/hicss.2000.926933.
- [22]. J. Woods, B. Galbraith, and N. Hewitt-Dundas, "Network Centrality and Open Innovation: A Social Network Analysis of an SME Manufacturing Cluster," *IEEE Transactions on Engineering Management*, vol. 69, no. 2, pp. 351–364, Apr. 2022, doi: 10.1109/tem.2019.2934765.
- [23]. A. Parker, F. Pallotti, and A. Lomi, "New Network Models for the Analysis of Social Contagion in Organizations: An Introduction to Autologistic Actor Attribute Models," *Organizational Research Methods*, vol. 25, no. 3, pp. 513–540, Apr. 2021, doi: 10.1177/10944281211005167.
- [24]. B. Gavish, "Topological design of centralized computer networks—formulations and algorithms," *Networks*, vol. 12, no. 4, pp. 355–377, Dec. 1982, doi: 10.1002/net.3230120402.
- [25]. A. Alonso Gomez and C. F. Mecklenbrauker, "Dependability of Decentralized Congestion Control for Varying VANET Density," *IEEE Transactions on Vehicular Technology*, vol. 65, no. 11, pp. 9153–9167, Nov. 2016, doi: 10.1109/tvt.2016.2519598.
- [26]. K. Kumar, A. Gupta, V. A. Bohara, and A. Srivastava, "Centralized vs Decentralized Resource Analysis of Green FiWi Networks," *2021 IEEE International Conference on Advanced Networks and Telecommunications Systems (ANTS)*, pp. 90–95, Dec. 2021, doi: 10.1109/ants52808.2021.9937014.
- [27]. N. J. Foss, J. Lyngsie, and S. A. Zahra, "Organizational design correlates of entrepreneurship: The roles of decentralization and formalization for opportunity discovery and realization," *Strategic Organization*, vol. 13, no. 1, pp. 32–60, Dec. 2014, doi: 10.1177/1476127014561944.
- [28]. C.-J. Lin and C.-R. Li, "The Effect of Boundary-Spanning Search on Breakthrough Innovations of New Technology Ventures," *Industry & Innovation*, vol. 20, no. 2, pp. 93–113, Feb. 2013, doi: 10.1080/13662716.2013.771479.
- [29]. M. Yang, J. Wang, and X. Zhang, "Boundary-spanning search and sustainable competitive advantage: The mediating roles of exploratory and exploitative innovations," *Journal of Business Research*, vol. 127, pp. 290–299, Apr. 2021, doi: 10.1016/j.jbusres.2021.01.032.
- [30]. J. Wang, N. Cao, Y. Wang, and Y. Wang, "The Impact of Knowledge Power on Enterprise Breakthrough Innovation: From the Perspective of Boundary-Spanning Dual Search," *Sustainability*, vol. 14, no. 17, p. 10980, Sep. 2022, doi: 10.3390/su141710980.
- [31]. S. M. Posner and C. Cvitanovic, "Evaluating the impacts of boundary-spanning activities at the interface of environmental science and policy: A review of progress and future research needs," *Environmental Science & Policy*, vol. 92, pp. 141–151, Feb. 2019, doi: 10.1016/j.envsci.2018.11.006.
- [32]. M. Taheri and M. van Geenhuizen, "Teams' boundary-spanning capacity at university: Performance of technology projects in commercialization," *Technological Forecasting and Social Change*, vol. 111, pp. 31–43, Oct. 2016, doi: 10.1016/j.techfore.2016.06.003.
- [33]. A. Schotter, "Resilient or not: boundary-spanning in innovation focused MNEs during global crises," *IEEE*, Feb. 2021, doi: 10.1108/cpoib-05-2020-0037.
- [34]. C. Acharya, D. Ojha, R. Gokhale, and P. C. Patel, "Managing information for innovation using knowledge integration capability: The role of boundary spanning objects," *International Journal of Information Management*, vol. 62, p. 102438, Feb. 2022, doi: 10.1016/j.ijinfomgt.2021.102438.
- [35]. P. A. David and J. A. Bunn, "The economics of gateway technologies and network evolution: Lessons from electricity supply history," *Information Economics and Policy*, vol. 3, no. 2, pp. 165–202, 1988, doi: 10.1016/0167-6245(88)90024-8.
- [36]. K. Y. Lee, H. J. Jung, and Y. Kwon, "Boundary-spanning technology search, product component reuse, and new product innovation: Evidence from the smartphone industry," *Research Policy*, vol. 53, no. 4, p. 104959, May 2024, doi: 10.1016/j.respol.2024.104959.
- [37]. E. Karpova, A.-P. Correia, and E. Baran, "Learn to use and use to learn: Technology in virtual collaboration experience," *The Internet and Higher Education*, vol. 12, no. 1, pp. 45–52, Jan. 2009, doi: 10.1016/j.iheduc.2008.10.006.
- [38]. P. Shachaf, "Cultural diversity and information and communication technology impacts on global virtual teams: An exploratory study," *Information & Management*, vol. 45, no. 2, pp. 131–142, Mar. 2008, doi: 10.1016/j.im.2007.12.003.
- [39]. T. van der Smagt, "Enhancing virtual teams: social relations v. communication technology," *Industrial Management & Data Systems*, vol. 100, no. 4, pp. 148–156, Jun. 2000, doi: 10.1108/02635570010291766.
- [40]. S. C. Lilian, "Virtual Teams: Opportunities and Challenges for e-Leaders," *Procedia - Social and Behavioral Sciences*, vol. 110, pp. 1251–1261, Jan. 2014, doi: 10.1016/j.sbspro.2013.12.972.
- [41]. J. Suchan and G. Hayzak, "The communication characteristics of virtual teams: a case study," *IEEE Transactions on Professional Communication*, vol. 44, no. 3, pp. 174–186, 2001, doi: 10.1109/47.946463.
- [42]. A. Sivunen and M. Valo, "Team Leaders' Technology Choice in Virtual Teams," *IEEE Transactions on Professional Communication*, vol. 49, no. 1, pp. 57–68, Mar. 2006, doi: 10.1109/tpc.2006.870458.
- [43]. M. Huysman et al., "Virtual Teams and the Appropriation of Communication Technology: Exploring the Concept of Media Stickiness," *Computer Supported Cooperative Work (CSCW)*, vol. 12, no. 4, pp. 411–436, Dec. 2003, doi: 10.1023/a:1026145017609.

- [44]. K. Laitinen and M. Valo, "Meanings of communication technology in virtual team meetings: Framing technology-related interaction," *International Journal of Human-Computer Studies*, vol. 111, pp. 12–22, Mar. 2018, doi: 10.1016/j.ijhcs.2017.10.012.
- [45]. M.-E. Stratone, E.-M. Vătămănescu, L.-M. Treapăt, M. Rusu, and C.-M. Vidu, "Contrasting Traditional and Virtual Teams within the Context of COVID-19 Pandemic: From Team Culture towards Objectives Achievement," *Sustainability*, vol. 14, no. 8, p. 4558, Apr. 2022, doi: 10.3390/su14084558.
- [46]. Z. Abdul Rashid, M. Sambasivan, and A. Abdul Rahman, "The influence of organizational culture on attitudes toward organizational change," *Leadership & Organization Development Journal*, vol. 25, no. 2, pp. 161–179, Mar. 2004, doi: 10.1108/01437730410521831.
- [47]. S. J. Hogan and L. V. Coote, "Organizational culture, innovation, and performance: A test of Schein's model," *Journal of Business Research*, vol. 67, no. 8, pp. 1609–1621, Aug. 2014, doi: 10.1016/j.jbusres.2013.09.007.
- [48]. E. C. Martins and F. Terblanche, "Building organisational culture that stimulates creativity and innovation," *European Journal of Innovation Management*, vol. 6, no. 1, pp. 64–74, Mar. 2003, doi: 10.1108/14601060310456337.
- [49]. F. Lega, A. Prenestini, and P. Spurgeon, "Is Management Essential to Improving the Performance and Sustainability of Health Care Systems and Organizations? A Systematic Review and a Roadmap for Future Studies," *Value in Health*, vol. 16, no. 1, pp. S46–S51, Jan. 2013, doi: 10.1016/j.jval.2012.10.004.
- [50]. M. Kordab, J. Raudeliūnienė, and I. Meidutė-Kavaliauskienė, "Mediating Role of Knowledge Management in the Relationship between Organizational Learning and Sustainable Organizational Performance," *Sustainability*, vol. 12, no. 23, p. 10061, Dec. 2020, doi: 10.3390/su122310061.
- [51]. A. K. Al-Swidi, H. M. Gelaidan, and R. M. Saleh, "The joint impact of green human resource management, leadership and organizational culture on employees' green behaviour and organisational environmental performance," *Journal of Cleaner Production*, vol. 316, p. 128112, Sep. 2021, doi: 10.1016/j.jclepro.2021.128112.
- [52]. B. Andres and R. Poler, "Towards a Methodology to Support the Strategies Alignment Process in Collaborative Networks," *Enterprise Interoperability VII*, pp. 295–305, 2016, doi: 10.1007/978-3-319-30957-6_24.
- [53]. F. F. Tafti, N. Abdolvand, and S. R. Harandi, "A strategic alignment model for collaborative open innovation networks," *International Journal of Business Innovation and Research*, vol. 19, no. 1, p. 1, 2019, doi: 10.1504/ijbir.2019.099751.
- [54]. S. P.-J. Wu, D. W. Straub, and T.-P. Liang, "How Information Technology Governance Mechanisms and Strategic Alignment Influence Organizational Performance: Insights from a Matched Survey of Business and IT Managers," *MIS Quarterly*, vol. 39, no. 2, pp. 497–518, Jun. 2015, doi: 10.25300/misq/2015/39.2.10.
- [55]. Tallon and Pinsonneault, "Competing Perspectives on the Link Between Strategic Information Technology Alignment and Organizational Agility: Insights from a Mediation Model," *MIS Quarterly*, vol. 35, no. 2, p. 463, 2011, doi: 10.2307/23044052.
- [56]. W. Li, K. Liu, M. Belitski, A. Ghobadian, and N. O'Regan, "E-Leadership through Strategic Alignment: An Empirical Study of Small- and Medium-sized Enterprises in the Digital Age," *Journal of Information Technology*, vol. 31, no. 2, pp. 185–206, Jun. 2016, doi: 10.1057/jit.2016.10.
- [57]. S. P. Goggins and G. Valetto, "Assessing the Structural Fluidity of Virtual Organizations and Its Effects," *Socioinformatics - The Social Impact of Interactions between Humans and IT*, pp. 121–137, 2014, doi: 10.1007/978-3-319-09378-9_8.
- [58]. N. V. Toyman and Y. Çakırel, "Structure and Strategy in Virtual Organizations: Strategies for Virtual Travel Organizations," *Digital Business Strategies in Blockchain Ecosystems*, pp. 401–421, Nov. 2019, doi: 10.1007/978-3-030-29739-8_19.
- [59]. Y. Kim, T. Y. Choi, T. Yan, and K. Dooley, "Structural investigation of supply networks: A social network analysis approach," *Journal of Operations Management*, vol. 29, no. 3, pp. 194–211, Nov. 2010, doi: 10.1016/j.jom.2010.11.001.
- [60]. S. S. Xiao, I. Jeong, J. J. Moon, C. C. Chung, and J. Chung, "Internationalization and Performance of Firms in China: Moderating Effects of Governance Structure and the Degree of Centralized Control," *Journal of International Management*, vol. 19, no. 2, pp. 118–137, Jun. 2013, doi: 10.1016/j.intman.2012.12.003.
- [61]. M. Schilling, A. Melnik, F. W. Ohl, H. J. Ritter, and B. Hammer, "Decentralized control and local information for robust and adaptive decentralized Deep Reinforcement Learning," *Neural Networks*, vol. 144, pp. 699–725, Dec. 2021, doi: 10.1016/j.neunet.2021.09.017.
- [62]. D. A. Batallas and A. A. Yassine, "Information Leaders in Product Development Organizational Networks: Social Network Analysis of the Design Structure Matrix," *IEEE Transactions on Engineering Management*, vol. 53, no. 4, pp. 570–582, Nov. 2006, doi: 10.1109/tem.2006.883706.
- [63]. R. Ureña, G. Kou, Y. Dong, F. Chiclana, and E. Herrera-Viedma, "A review on trust propagation and opinion dynamics in social networks and group decision making frameworks," *Information Sciences*, vol. 478, pp. 461–475, Apr. 2019, doi: 10.1016/j.ins.2018.11.037.
- [64]. Q. Chen, T.-T. Wu, and M. Fang, "Detecting local community structures in complex networks based on local degree central nodes," *Physica A: Statistical Mechanics and its Applications*, vol. 392, no. 3, pp. 529–537, Feb. 2013, doi: 10.1016/j.physa.2012.09.012.
- [65]. A. Youssef, Y. Crouzet, A. de Bonneval, J. Arlat, J.-J. Aubert, and P. Brot, "Communication Integrity in Networks for Critical Control Systems," 2006 Sixth European Dependable Computing Conference, pp. 23–34, Oct. 2006, doi: 10.1109/edcc.2006.5.
- [66]. M. J. Khabbaz, C. M. Assi, and W. F. Fawaz, "Disruption-Tolerant Networking: A Comprehensive Survey on Recent Developments and Persisting Challenges," *IEEE Communications Surveys & Tutorials*, vol. 14, no. 2, pp. 607–640, 2012, doi: 10.1109/surv.2011.041911.00093.
- [67]. V. Gilsing and B. Nooteboom, "Density and strength of ties in innovation networks: an analysis of multimedia and biotechnology," *European Management Review*, vol. 2, no. 3, pp. 179–197, Dec. 2005, doi: 10.1057/palgrave.emr.1500041.
- [68]. J.-H. Cho, A. Swami, and I.-R. Chen, "A Survey on Trust Management for Mobile Ad Hoc Networks," *IEEE Communications Surveys & Tutorials*, vol. 13, no. 4, pp. 562–583, 2011, doi: 10.1109/surv.2011.092110.00088.
- [69]. F. Buick, J. O'Flynn, and E. Malbon, "Boundary Challenges and the Work of Boundary Spanners," *Reimagining the Future Public Service Workforce*, pp. 21–38, Sep. 2018, doi: 10.1007/978-981-13-1480-3_2.
- [70]. B. Oyewo, X. V. Vo, and T. Akinsanmi, "Strategy-related factors moderating the fit between management accounting practice sophistication and organisational effectiveness: the Global Management Accounting Principles (GMAP) perspective," *Spanish Journal of Finance and Accounting / Revista Española de Financiación y Contabilidad*, vol. 50, no. 2, pp. 187–223, Jul. 2020, doi: 10.1080/02102412.2020.1774857.

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