

The Pattern of Inter-Organizational Level of Connectivity, Formal Versus Informal Ties

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ABSTRACT

Inter-organizational network exists in many forms. Yet managing them has taken rather a monotonous approach. Using the social network analysis methodology, this study embarks on the objective in elucidating the structure of network depending on the different type of inter-organizational relations. The different pattern of embeddedness in the different type of inter-organizational relationship raise the question of how should we treat the different type of inter-organizational relationships and the pattern of embeddedness. Such questions are important as firms invest heavily in developing and maintaining their network of inter-organizational relationships. , this research will explore what is the structure of the inter-organizational relationships network may look like both in formal and informal network relationship. We seek to determine the different in term of density of connectivity among connected firms as this will indirectly indicate the degree of investment that firm commit to manage the different type of inter-organizational network structure. Findings of this study indicated that firms' degree of involvement differs in the different type of inter-organizational relationships that they are embedded in. Implication of the findings highlights the importance of network management base on type of inter-organizational relations and selective resource allocations management for inter-organizational network. Future research areas are also discussed.

Keywords: *Organizational communication, social network analysis, supply network, networking.*

INTRODUCTION

Managing the complex inter-organizational network can be a difficult task for managers of the inter-organizational network. Structurally, inter-organizational network is virtually formed by the connectivity or links between firms where the integration progressively forms the ultimate structure, which is the inter-organizational network itself (Beamon, 1999; Choi, 2008, Osman, 2015). The relationship is sometimes known in the literature as the buyer-supplier relationship (Beamon, 1999). According to Choi and Kim (2010), a buyer–supplier relationship represents a dyad, or two nodes and one link, in network terms. Each node can be conceptualized as an actor performing activities for generating value Choi (2008). The firms need resources from its supplier organization, and the supplier needs contracts and payments from the buyer. On top of that the firms also interact with each other to share information regarding market opportunities and new threats (Choi, 2008, Osman et. al. 2015). As a consequence, these phenomena create a link and form a dyad or a buyer–supplier relationship. Because a firm in the inter-organizational network often has links to other firms, the firm is then impliedly linked to the new indirectly connected organizations. Similarly, with the supplier organization, this

will also bring to the dyad their links with other organizations either directly or indirectly (Lamming et al., 2000). Conclusively, a buyer–supplier relationship is not only a dyad. It is also part of a network that has come to bear on individual nodes to the relationship through each other’s extended business relationships. This form of inter-firm relations or connectivity created the complexity in the inter-organizational network structure (Kim and Choi, 2015).

Managing the inter-firm relationship is even more complex as many seek the best approach towards it (Osman, 2016). The traditional reductionist arguments state that firms opted for the removal from the complex inter-organizational network of partners who are not meeting the performance requirements of the inter-organizational network in an attempt to manage the complexity arising from extensive inter-firm relationships (Choi and Kim, 2008).

On the other hand, in inter-organizational studies, the concern with management of inter-relationships has shifted the perspective of inter-organizational network management from the reductionist perspective to rational system perspective and to the open-system perspective, and more recently into the network form of organizations (Osman, 2013). The prevailing assumption behind the adoption of these more subtle approaches is that, the network is richer (Powell, 1996) due to the involvement of the parties in those different types of inter-organizational relationships both direct and indirectly connected firms (Uzzi and Gillespie, 2002). What this argument means is that, each and every member of the network holds a position in the network that is rich in ‘resources’ that only the firm can provide via its embeddedness level in the network structure. Yet, we still see core players in network structure rigorously manage its network through the reductionist school of thought approach (Stasenko et. al, 2016).

Thus in this research we argue and suggested that simply removing underperforming firms may not be the best way, as firms may remove partners who are resourceful or more influential, but these characteristics are not visible through good accounting measures. The different pattern of embeddedness in the different type of inter-organizational relationship raise the question of how should we treat the different type of inter-organizational relationships and the pattern of embeddedness. Such questions are important as firms invest heavily in developing and maintaining their network of inter-organizational relationships.

In this vein, Choi et.al (2016) posited that approaches that value and appreciate these complex inter-firm relations may be better alternatives as firms have been found to benefit through relations with other firms in a network structure. Thus the objective of this research is to elucidate the different structure of embeddedness that firms may have in the different network relationship that the firm are embedded in. This is important as firms invest strategically in network management as network brings tangible and intangible value to the organizations. Consequently the research questions of this study will be:

What is the pattern of connectivity of firms embedded in the different type of network relationship?

To answer the questions this research will adopt a social network analysis approach. Through this research methodology, this research will explore what is the structure of the inter-organizational relationships network may look like both in formal and informal network relationship. We seek to determine the different in term of density of connectivity among

connected firms as this will indirectly indicate the degree of investment that firm commit to manage the different type of inter-organizational network structure.

LITERATURE REVIEW OR RESEARCH BACKGROUND

The embeddedness theory argues that inter-firm relations can be in the form of formal commercial transaction activities, such as contractual relations or web of informal social exchanges, including information-sharing and referral activities (Poppo and Zenger, 2002; Borgatti and Li, 2010). These two types of inter-firm relations can be either complementary or substitutes of the other (Osman 2015).

For example, studies that attempted to map the actual map of an upstream inter-organizational network structure was conducted by Choi and Krause (2006), as well as a study by Li and Choi (2010) and Osman (2013). What developed from this research was a complex inter-organizational network map of the flow of materials from the upstream suppliers to the focal firm. However, Lin and Choi (2010) and Osman (2015) stressed that these flow only represents the material flow among firms in the upstream inter-organizational network structure. In actual fact, according to the Osman (2013), inter-firm relations are embedded in formal commercial transactions and the web informal social exchanges. Other relations such as information-sharing activities may occur in the upstream inter-organizational network. For example, in a typical supplier-supplier or firm's relationship, information such as: demand forecast, production developments, competition running capacity and other context rich data may be exchanged in a cooperative supplier-supplier or firm's relationship (Choi et al., 2016). More importantly, the authors stressed the importance of understanding the positions of firms in the network structure as means of managing the complex network more prudently.

Complexity and Inter-Organizational Relationship Management

Hall et al. (1967) refer to complexity as being the different components that together make a whole. Similarly, Blau and Schoenherr Perrow (1971), Mileti et al. (1977), Bak and Paczuski (1997) and Deshmukh et al., (1998) concluded that complexity is the result of the patterns of interactions among components and the strength of the respective interactions. Perrow (1973) characterized complexity as being the number of components, components' attributes and mode of connections between components in a system. Rehtin's (2004) view of complexity is similar to that of Perrow (1973). Rehtin (2004) views complexity in a system as the interconnected parts in the system that are interdependent of each other in performing their functions. There are three important elements regarding the respective descriptions by Perrow (1973) and Rehtin (2004) of the complexity: i.e. many parts, interconnectedness and the interdependency of the parts. On a similar note, Sussman (2007) defines complexity in a system as being complex in instances where the system consists of a group of related units and the nature of the relationships is not fully understood.

Overall, it can be argued that the complexity in an inter-organizational network arises from the fragmented yet extensive inter-firm relations between the varied firms in the network structure (Choi and Krause, 2006). These descriptions of complexity would justify the argument that the network is also complex, and the inter-firm relations represent the inter connectivity

between the elements in the system (Kim, 2016). Using this lens, the researcher argue that an understanding of how the inter-organizational structure would emerged in the different types of network relations demands better understanding for the sake of effective management of the inter-organizational network relationships.

Inter-Organizational Involvement and Network Structure

Network formations have internal and external drivers (Kim, 2016). Firms' embeddedness or involvement in network relationships can be driven by self-interest and commitments (internal) such as the acquisition of more resources and meeting private objectives. Even though organizations build ties with others in the network voluntarily to obtain competitive advantages and resource sharing, ties also emerge through the interjection of forces external to the network. Industry leaders in business sectors and government agencies have been found to have introduced collaboration among other organizations in the network when there is a concern on equal sharing of costs and benefits among organizations in the network (Provan, 1993; Provan and Kenis, 2008). Consequently, the internal and external drivers create the two type of commonly found network structure which is the formal and informal network. The literature indicated two streams of research that studies how the inter-organizational network ties influence the management of the inter-organizational network. The first stream of research is in the domain of marketing and inter-organizational network management. This literature stream has studied the embeddedness in the buyer supplier relationship focusing on the organization as the unit of analysis, relationship quality, duration and type and has indicated that these attributes are success factors in the buyer supplier alliances (Bozarth et al., 2009; Claro, 2004; Mentzer et al., 2001). Even though this stream of research generally centers on the relationship attributes in dyadic ties, this stream of research was successful in determining several essential relational concepts that are generalizable to the overall inter-organizational network. Unfortunately, the determinants or the impetus of the involvement in the network of multiple buyer-supplier organizations have rarely been researched in the literature (Autry and Griffis, 2008).

The second stream of literature addresses the question of the best fit. This line of study attempts to determine the best structure or configuration of the inter-organizational network to meet the challenge of market. This stream of literature is primarily concerned with issues such as inclusion or exclusion of buyers or suppliers, mapping the structure of the inter-organizational network, and how clusters of the buyer-supplier relationships should be managed (Cooper, Lambert and Pagh, 1997; Gilsing and Nooteboom, 2005; Powell, Koput and Smith-Doerr, 1996; Shan, Walker and Kogut, 1994, Kim, 2016). Nevertheless, to our knowledge, there is no known best configuration of buyer supplier organizations operating within the network. This issue is further complicated by the fact that the relative success of network structural configuration is predominantly related to the relational context of the buyer supplier organizations interrelatedness (Autry and Griffis, 2008; Choi and Kim, 2008). These streams of literature provide a fundamental justification in their explanation of dynamics of inter-organizational network structure. However, the literature falls short of addressing the importance of ascertaining the extent to which the involvement or embeddedness of these buyer-supplier organizations relates to the type of relationships. In addition, the themes ignore

the interactive elements of the connectivity, whereby organizations obtain information from this connectivity. It is important to note that, although the buyer supplier relationship is essentially a dyadic tie between a buyer and a supplier, the outcomes and processes associated with the ties can be linked to the social network structure within which the buyer-supplier organizations are embedded in.

THEORETICAL FRAMEWORK

The relational capital metaphor is that firms that do in a superior way are in a way are to a greater degree more connected than others. In this condition, firms are dependent on exchange with their joined partners. Thus, occupying a certain position the structure of these exchanges is by itself an invaluable asset to the particular firms. The impact of being linked other firms in the networks includes information benefits, social solidarity, influence and control. The information benefits of the timeliness and trustworthiness (Nahapiet and Ghoshal, 1998b) of the information provide by other members in the network. Social solidarity arise from mutual trust and commitment among firms in the network (Burt, 1995; 2004). Influence and control are the result of actor's ability to influence others and the ability to be free of other's influence (Coleman, 1988). In the management and organizational literature, these benefits are acknowledged as benefits to the organizations.

There are three types of flows in a network of interrelated actors who include the information flows, asset flows and status flows (Galaskiewicz and Marsden, 1978). Oh, Chung and Labianca (2004) argue that resources of the actors that actors or ego is connected top also constitute relational capital. For example, Stuart (1999) found that biotech firms with strategic alliance go to IPO faster and earn higher valuations than firms that lack such ties. In social network study, researchers made several important premises regarding the actors, the ties and the network structure. Firstly, with regard to the actors, social network analysts posit that actors are interdependent with each other. The interdependency between the actors resulted from the ties that tie two or more actors together. Secondly, social network researchers posit that ties are conduits that facilitate the transfers and exchanges of resources such as information, money or materials between actors in the network. For instance, in inter-organizational study, Krause (2004) study how network ties in the flow of flow of money between the Tobacco Prevention Organization in the US influence the prestige degree of a particular organization. While Kim et al. (2011) confirmed ties between organizations in the inter-organizational network can be in the form of incoming raw materials or outgoing finished goods. Third, social network researchers also posit that the resulting network structure can act as constraints or opportunity for the members' actions and decisions in the network. As degree of inter connectivity between actors (i.e. individuals or organizations) are different from one another, and actor can have a very dense (connected to all other's actors) network structure or an actor can as well be an isolate (not connected to any actor in the network). A dense network structure can be a source of competitive advantage to an actor because the dense ties can furnish the actor with information from multiple sources.

In this study, the researcher argues that contract ties, information-sharing ties, referral made ties and referral received ties constitute networks among firms in the inter-organizational network structure. The researcher further explains the important characteristics of these and

clarifies how and why these ties or inter-firm relations constitute the networks. First, inter-firm relations such as: contract ties, information-sharing ties, referral made ties, and referral received ties are conduits of information (Srividasan, 1999). Ahuja (2000) stated that inter-firm relations could also function as the communication channels between firms and their partners. For instance, it was found by McEvily and Zaheer (1999) that relevant advice obtained by managers from their colleagues in other firms is instrumental in developing the capabilities and innovation of the respective firms.

In this study, the researcher also argues that contract ties, information-sharing ties, referral made ties and referral received ties constitute networks among firms in the centralized upstream inter-organizational network structure. Wasserman and Faust (1994) stated that a network was made up of a finite set of actors and relations. The authors added that the relations between the actors defined the actors of the network. In the following networks, namely: contract tie, information-sharing tie, referral made tie and referral received tie; actors are the firms. Similarly, the relations are, specifically: contract, information-sharing, referral made, and referral received, all of which exist in the upstream inter-organizational network. Knoke (1999) proposed classifying network ties through increasing formality of the ties. Poppo and Zenger (2002) and Osman (2013) found that governance of inter-firm relationships involves formal and informal coordination. Under formal coordination or inter-firm relations, Cousins et al. (2001) argue that long-term resource dependencies between firms or organizations are forged to ensure future commitments and cooperation. Examples of this formal coordination include inter-firm relations such as contract ties and joint planning programs (Poppo and Zenger, 2002). An important characteristic of the formal inter-firm relation is the existence of a hierarchical or a top-down approach to the governance of the inter-firm network. Through the hierarchical or top-down approach governance benefits such as administration, and control are realized (Powell, 1990). On the other hand, Cousins et al. (2001) argue that informal coordination relates to inter-firm relations of communication that emerge from informal social relationships. Thus, inter-firm relationships under the informal coordination are largely voluntary and horizontal in nature. Based on this argument, clearly a firm's level of embeddedness in a network would involve a continuum of inter-firm relations from formal to informal coordination. This may include network ties such as: contract ties, information-sharing ties, referral made ties, and referral received ties. The embeddedness theory also predicts that trading transactions are an embedded web of social exchanges. Osman et. al. (2015) have identified commercial transactions to include formal contractual relationships; while the web of social exchanges includes informal inter-firm relations such as information-sharing. These indicate both formal and informal inter-firm relations of the centralized upstream inter-organizational network.

Similar to the embeddedness of firms in interlocking directorates (Mizruchi, 1996) and managerial ties (Ingram and Roberts, 2000), the embeddedness of firms in the contractual ties' network, information-sharing tie network, referral made tie network, and referral received tie network is a cross-level phenomenon (House et al., 1995). In order to comprehend the effects of these networks on the firm's level variables, the mechanism demonstrating how these networks affect the firms must be specified. To obtain a much deeper understanding of how each of the firms are embedded in the different network structure, the researcher will analyze

the overall network structural pattern of embeddedness through a network structural measures index which indicates the network embeddedness or involvement of firms. The structural measures, k-core, provide the researcher with a holistic statistical perspective of network embeddedness and help to illuminate the embeddedness patterns of firms with more accuracy and in a more informative fashion (Wasserman and Faust, 1994; Scott, 2000). In social network analysis, k-core is a subset of all the nodes in a network such that each node is linked to at least some other k nodes in the same subset. A k-core is a highly-interlinked collection of nodes within a larger network. Comparisons of k-cores of a network for different levels of k also provide some insight into the strength and connectedness of firms in the inter-organizational network structure (Mueller, Buergelt and Seidel-Lass, 2007). The visual analysis indicate that the lower the k-cores in the network structure, the stronger the connectedness of the firms (i.e. the involvement or embeddedness of firms) in the inter-organizational network structure.

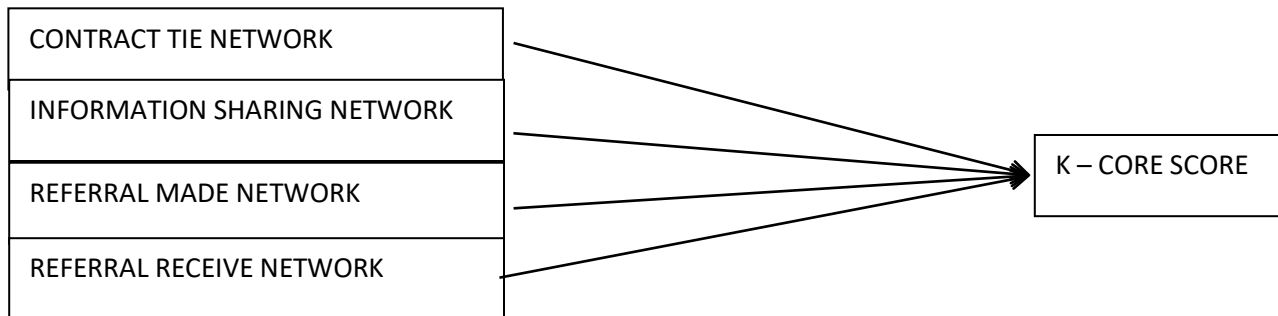


Figure 1: Research framework

METHODOLOGY

This research follows the exploratory and statistical social network analysis approach found in literature studies in order to determine how firms position itself in the inter-organizational network through its k-core structure. In this section, the researcher briefly discusses and justifies the adoption of the SNA methodology.

Structuring of network of relations has an important implication for actors of the various networks (Knocke and Yang, 1998). Given a collection of actors, a social network analysis can be used to study the structural variables measured on actors in the respective network. These structures involve the pattern of ties between the actors. A network analyst would seek to model these ties to depict the structure of a group. One could then investigate the impact of these structures on the functioning of the network or the influence of these structures on actors embedded within these network structures (Hanneman and Riddle, 2005). Borgatti and Li (2009) stated that the social network analysis concepts were particularly suitable to study how the patterns of inter-organizational relationship in an inter-organizational network translate to competitive advantage. This can be achieved through management of the hard ties and soft ties in the inter-organizational network. Furthermore, according to Borgatti and Li (2009), adoption of the social network analysis to the study of the inter-organizational network

will allow a better understanding of the operations of the inter-organizational networks, both at the individual level and the network level. This determines the importance of the organizations, given their position in the network and how the network structure affects individual organizations and the network performance as a whole. Consequently, this study adopted the social network analysis method strategy for data collection, analysis and reporting of results, as this is the most appropriate means for arriving at valid results and testing the hypotheses set forth in this study (Marouf, 2011).

For the purposes of this study, an inter-organizational network of a small maritime industry seemed to be an ideal setting. An inter-organizational network in the maritime industry is a material-intensive enterprise. Much of the activity is highly dynamic and is widely dispersed throughout the network. The flow of materials and information is transferred through interactions among different firms. The focal research site of this study is located in the Peninsular Malaysian cluster. The network, labeled here as APMMHQ-1, is part of the inter-organizational network. APMMHQ-1 is a company in the Malaysian shipbuilding industry involved in ship repairs, maritime, engineering and related service provider matters.

APMMHQ-1's inter-organizational network was considered to be one of the best supply systems in the region through its Integrated Logistic Support (ILS) programs. Top level management was approached for possible participation in the study. After several communications about the goal of this study and the potentials' benefits for the APMMHQ-1 inter-organizational network, positive commitments were received from the top management to participate in and grant participation for this study. Following this, to identify the population of this study (i.e. the firms in the centralized upstream supply network of APMMHQ-1 for product RHIB), this researcher followed the guidelines of Diani (2002) and Krause, Mueller and Luke (2004). The authors proposed that network researchers could begin setting up the research boundary with a nominalist approach and follow this up with a realist approach.

Thus, the researcher began by compiling a database of firms that are perceived to be part of the centralized upstream supply network for the product RHIB. This was achieved through consulting the Director of Logistics and three executives of APMMHQ-1 Logistics Department in Putrajaya, Malaysia, as well as the APMMHQ-1 archival records. In relation to the inclusion or exclusion of actors in the upstream supply network, the firms had to provide actual materials or services with regard to the supply of spares and parts within the centralized upstream supply network of APMMHQ-1 for the production of RHIB. Consistent with the realist criterion, firms were selected because of their involvement with the provision and supply of materials to all relevant areas of the APMMHQ-1 for the production of RHIB, not simply because they were already linked to other firms for the spares and parts. Once a list of related firms had been compiled, the list was shown to three senior logistics officers in the APMMHQ-1 Logistics Department. Their validation of the list was sought before embarking on the next step. Once validated, the researcher made a phone call to the firms. The objectives of the phone calls were to determine the key informants or respondents and to determine the suitability of the informant to answer the survey instrument. The introductory call was also made to determine the correct address of the firms so that the survey instrument could be sent correctly. Once this information was gathered, the researcher mailed cover letter and the research instrument to the identified firm. The researcher followed this up with a phone call to set up appropriate

phone communication dates to explain to the key respondent the objectives of the research and to clarify any unintended issues. The information obtained during these phone calls, and the returned survey forms assisted the researcher to determine the firms that did not participate in the APMHQ-1 upstream supply network for the production of RHIB. Based on this finding, the populations of the study were reduced. Each of the remaining firms would only be included based on the boundary specification criteria set established for the mixed nominalist and realist strategy that was adopted.

Firms that did not return the survey are still included as part of the network members, but are known as isolates of the network (Wasserman and Galaskiewicz, 1994). It should be noted that in bounded network studies, even members who decline to participate are included in the resulting network data and analysis as isolates, as their relationships are still assessed through the survey responses of their colleagues (Borgatti and Molina, 2003). For the purpose of data analysis, the process of visual analysis has been applied in many social network studies in an attempt to provide an overall structure outlook of the network in question (e.g. Krauss et al., 2004; Kindermann, 2007; Creswick and Westbrook, 2010). Visual analysis is useful for displaying relevant network data information. It provides a pictorial form of data as an early part of network analysis (Tufté and Weisè Moeller, 1997). Tufté and Weisè Moeller (1997) analyzed the visual analysis performed by Dr. John Snow, concerning the London cholera epidemic of 1854. The authors concluded that Dr. Snow mapped and identified the source of the cholera by mapping the area (in terms of interactions of patients) where deaths have been recorded. The map of the interactions placed most of the cholera victims around a central point near a well pump on Broad Street in central London. The interaction map served as proof that victims all used the water from the well and tested that it was the water that caused the epidemic. Using network maps or sociograms, social network analysis can explore the location of individual actors in the network. The location of these actors in the network (referring to: centrality (Freeman, 1979), clique (Coleman, 1988) and structural holes (Burt, 1994), in turn, have been found to provide firms with intangible resources as mentioned in a study (e.g. Ahuja, 2000). Hence, the researcher applied the visual analysis of the network maps as part of the exploratory network analysis to answer research question two of this study. More importantly, the result of the exploratory network analysis will set the background for the analysis of an individual firm's pattern of embeddedness. It is anticipated that this will help answer research question one of this study.

For this purpose, this study adopted a spring-embedding visualization method in the UCINET program whereby a network layout is computed using a force-directed algorithm. More specifically, the algorithm places nodes based on node repulsion and equal edge length bias. When so configured, the placement of nodes in the sociogram is based on forcing the nodes apart and tending to select placements that lead to equal edge lengths (i.e., equal length lines between nodes). This particular layout has the advantage of detecting network centrality patterning (Polites and Watson, 2008). For these routines, this thesis applied the network imaging software within the UCINET (Borgatti, Everett and Freeman, 2002) i.e. the NetDraw, which is equipped with sophisticated visualization techniques. Visual representation of inter-organizational networks can provide useful direction for researchers, and act as a starting point to develop subsequent quantitative analyses (Choi and Hong, 2002).

RESULTS AND DISCUSSION

The goal of the research was to determine the pattern of embeddedness of firms in the inter-organizational network structure in relation to the type of network ties being considered. The results of the analysis will help elucidate the structure of inter-organizational structure in the different pattern of inter-organizational relations, mainly formal and informal type of relations. The metaphorical structure of the APMMHQ-1 inter-organizational network for the product RHIB was first developed. Following Choi and Krause (2006), the inter-organizational network structure for the RHIB was developed based on the archival review and discussion that the researcher conducted with key informants from AMPHQ-1. These consisted of, namely: two tiers one firms and one tier two firms concerning the flow of materials from the upstream firms to the focal firm, i.e. APMMHQ-1 for the product RHIB. Based on the data collected, the following figure depicts the inter-organizational network structure of APMMHQ-1 for the supply of materials for the product RHIB. In figure 2, the firms are colored based on their positions in the inter-organizational network structure. APMMHQ-1 is the focal firm in this centralized inter-organizational network structure and its colour in red. Firms in tier one has a blue colour and consists of seven firms. Tier two firms are represented in green and consist of 16 firms. Finally, firms in tier three are purple in colour and consist of twelve firms.

Figure 2 represents the formal inter-organizational structure regarding the flow of materials. The structure in figure 2 indicates a hierarchical structure of the APMMHQ-1 inter-organizational network for the supply of materials and services for the product RHIB. Flow of materials for the production of the RHIB consists mainly of three tiers of suppliers having a total of 37 firms. The largest number of suppliers or firms in the inter-organizational network structure resides in tier two of the upstream inter-organizational network consisting of 17 firms. The logic behind this is that the firms in tier two are the firms that manufacture the raw materials from tier three firms into work in process (WIP) components or parts for the tier one supplier and, ultimately, the focal firm or manufacturer. This hierarchical structure is normally the result of the flow of resources in the APMMHQ-1 upstream inter-organizational network. In the following section, the researcher presents the network map of four network ties, i.e.: contract tie, information-sharing tie, referral made tie and referral received tie.

The Upstream Supply Network of AMPPHQ-1 for the Supply of Rigid Hull Inflatable Boat (RHIB)

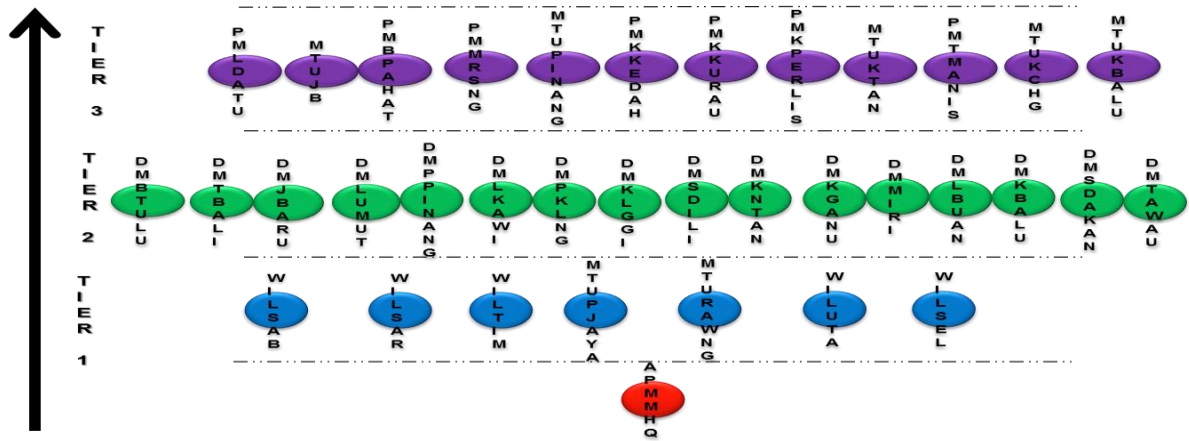


Figure 2: Inter-organizational network structure of APMMHQ-1 for the product RHIB
 Analysis of Network Structural Measures of Embeddedness: K-Core

In this section, the researcher discusses k-core analysis results. The k-core analysis results will indicate the true pattern of embeddedness or involvement of firms in respective inter-organizational relations. Through the application of sociogram, the k-core results will showcase which firms are closely knit together and which ones are not (in the different type of relations). A *k-core* is a subset of all the nodes in a network such that each node is linked to at least some other *k* nodes in the same subset. A *k-core* is a highly-interlinked collection of nodes within a larger network. Comparisons of *k-cores* of a network for different levels of *k* also provide some insight into the strength and connectedness of firms in the inter-organizational network, the lesser the k-cores or subsets in the network, the stronger is the connections among firms in the network structure (Mueller, Buergelt and Seidel-Lass, 2007).

Analysis of K-Core Value of Contractual Tie's Network

Figure 3 shows the *k-core* groups under the contractual tie network. A large number of the firms in the network fall into the *k-core* of nine followed by k-core eight, seven and six. In Figure 4, the subgroup, which includes: APMMHQ-1, MTUPJAYA-2, MTURAWNG-3, WILUTA-4, DMLKAWI-5, DMPPINANG-6, DMLUMUT-7, PMKKEDAH-8, PMKKURAU-9, PMKPERLIS-10, MTUPINANG-11, WILSEL-12, DMJBARU-13, DMPKLNG-14, DMKLGGI-15, PMMRSNG-17, PMBPAHAT-18, MTUJB-19, MTUKTAN-24, WILSAR-25, WILSAB-31, DMLBUAN-32, DMKBALU-33, DMSDAKAN-34, and PMLDATU-36 are the 9-core group. The subgroup which includes: DMSDILI-16, WILTIM-20, DMKCHNG-26, DMBTULU-27, DMMIRI-28, PMTMANIS-29, and MTUKCHG-30 is the 8-core group. The sub-group comprising: DMKNTAN-21, DMKGANU-22, DMTBALI-23, and DMTAWAU-35 are the 7-core group. Lastly, subgroup MTUKBALU-37 is the 6-core group. Overall, the formal contract tie network structure indicates that there are four *k-cores* in the contract tie. This means that in a contract tie, there are four sub-groups of highly-interlinked firms in the network structure. In the following section, the researcher discusses the pattern of embeddedness of sub-groups in the information-sharing tie network.

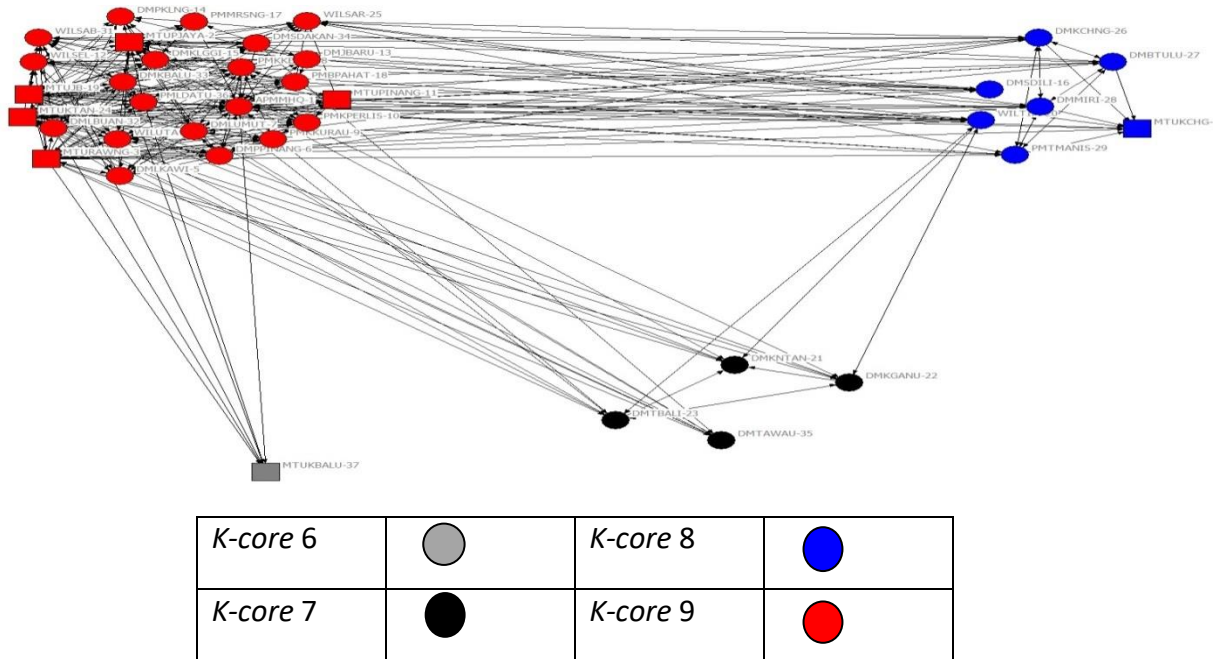


Figure 3: K-Core Diagram for Contractual Tie's Network

Analysis of K-Core of Information Sharing Ties

Figure 4 displays the data sets that indicate the *k-core* value for an information-sharing tie network. From the figure, we can see that there is only 2 *k-core* in the network, specifically: 9 *k-core* and 10 *k-core*. The majority of the organizations fall under the 10 *k-core* groups. In Figure 2, there are two different sub-groups in the network structure. The first subgroup includes: (DMKNTAN-21, DMKGANU-22, MTUKTAN-24, DMKCHNG-26, DMBTULU-27, DMMIRI-28, PMTMANIS-29, MTUKCHG-30, DMLBUAN-32, DMKBALU-33, DMSDAKAN-34, DMTAWAU-35, PMLDATU-36, and MTUKBALU-37) which form the 9 *k-core*. The second subgroup comprises: (APMMHQ-1, MTUPJAYA-2, MTURAWNG-3, WILUTA-4, DMLKAWI-5, DMPPINANG-6, DMLUMUT-7, PMKKEDAH-8, PMKKURAU-9, PMKPERLIS-10, MTUPINANG-11, WILSEL-12, DMJBARU-13, DMPKLN-14, DMKLGGI-15, DMSDILI-16, PMMRSNG-17, PMBPAHAT-18, MTUJB-19, WILTIM-20, DMTBALI-23, WILSAR-25, and WILSAB-31), which is the 10 *k-core*. These results indicate that, in the information-sharing tie network structure; there exist at most two sub-groups of highly inter-linked firms. What this means is that firms in the information-sharing network are more involved with each other, as represented by only two sub-groups of firms in the in Figure 4. The following section discusses the *k-core* for the referral made tie network structure.

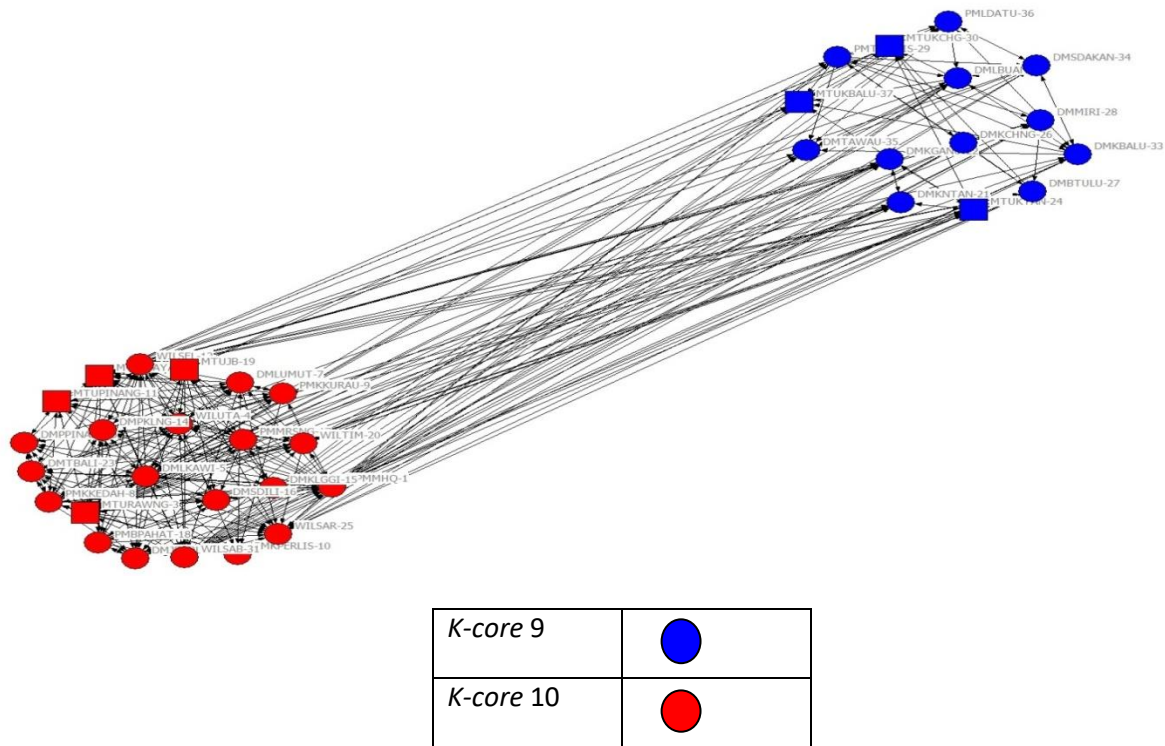


Figure 4: K-core diagram for information-sharing tie's network

Analysis of K-Core Value of Referral Made Tie Network.

In Figure 5, there are four *k-core* groups indicating the groups in the referral made network. Within the referral made network, the subgroups are, namely: 5 *k-core*, 6 *k-core*, 7 *k-core* and 8 *k-core*.

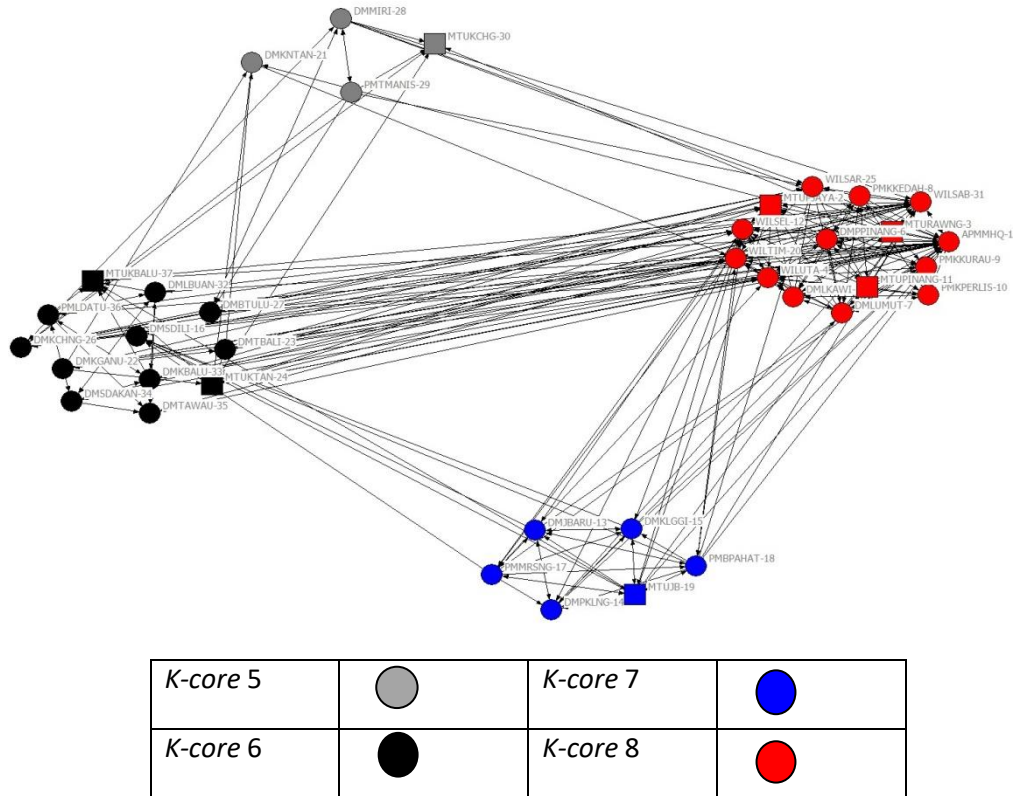


Figure 5: K-core diagram for referral made network.

The majority of the network subgroups fall under the 8 *k-core* and 6 *k-core*. This result indicates that, in the referral made tie network structure, the level of involvement or connectivity among firms in the referral made tie network are lower compared with those in the information-sharing tie network. The results confirm the coordination and continuum of relations, which place the referral activities in the middle between contract ties and information-sharing ties.

Analysis of K-Core for Referral Received Tie Network

Figure 6 presents the analysis result for *k-core* value of referral received tie network. Based on the figure, we can identify that there are only three *k-cores* in the network.

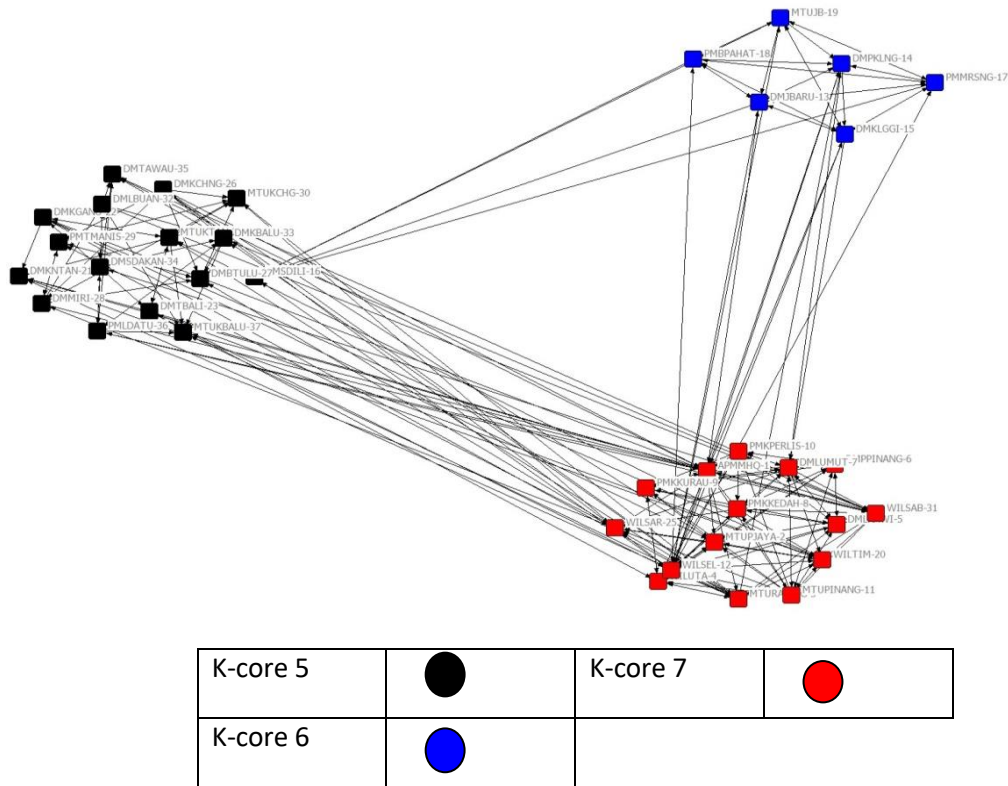


Figure 6: K-core diagram for referral received network.

Figure 6 displays the *k-core* network structure for the referral received tie network. The network structure indicates that the main *k-core* for the network is: 5 *k-core*, followed by 7 *k-core* and lastly 6 *k-core*. Structurally, the majority of the organizations are embedded in the less dense subgroups compared to the contractual and information-sharing ties network. Thus, compared with the contract tie network, information-sharing tie network, and the referral made tie network; the referral received tie network *k-core* results indicate that it is the second most connected network structure. This means that firms are more embedded in the referral received tie network and occupy second place right after the information-sharing tie network that has a *k-core* of two. To provide the holistic picture of the *k-core* pattern of the firms across all four ties, the following graphs (Figure 7) summarized the findings in a visual manner.

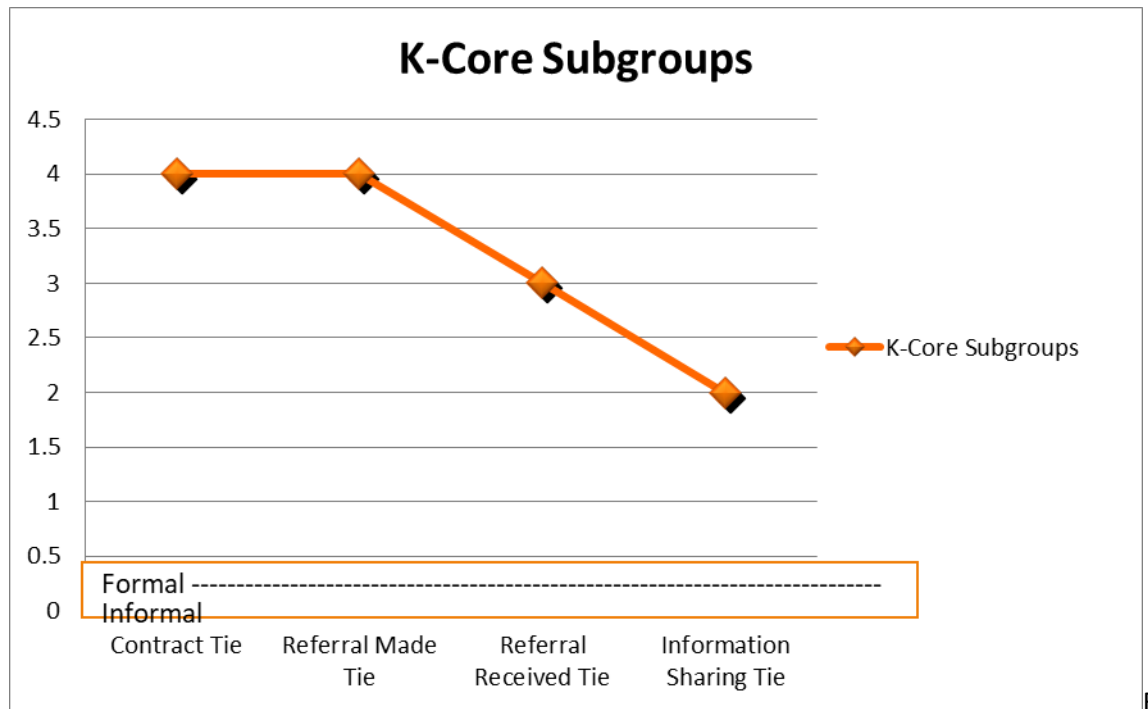


Figure 7: K-Core Subgroup Index

The *k-core* analysis finding indicates the pattern of connectivity in the four different types of ties. In Figure 7, the *k-core* value relates to informal ties, i.e. the information-sharing tie is less than in the formal ties. In the contractual ties, we found that the network is divided into four subgroups, which indicate lower connectivity and consequently, less embeddedness. In the informal sharing tie network, the firms are more connected as the network contains only two subgroups of *k-cores*. Structurally, based on the *k-core* analysis, we posit that the pattern of embeddedness of firms in the network does rely upon the type of ties being considered. Information-sharing ties, which are a less formal group of relationships, created a high level of network embeddedness wherein fewer subgroups exist. However, in more formal ties, the subgroups are more visible, thus decreasing the overall network connectivity. Thus, the overall pattern of embeddedness of firms based on the *k-core* value indicates that firms are more embedded in the ties with informal coordination mechanism compared to the network ties having formal coordination mechanism.

The goal of the exploratory network analysis was to determine the pattern of embeddedness of firms in the inter-organizational network structure in relation to the type of network ties being considered. Using the *k-core* index, the researcher mapped the overall pattern of involvement of a firm in four network ties on line graphs. To guide the analysis of the network maps, the researcher argued in favor of Cousins et al., (2006) and placed the four network ties on the continuum of formal to informal class of inter-firm relations. The distribution of the network structural measures of embeddedness show an interesting pattern. Using the exploratory network analysis, the researcher established that the embeddedness of firms in the inter-organizational network is related to the formal versus informal classification of network ties. Overall, relationship networks with high formality are less connected and less

dense in the network. The network plots and network structural measures indicate that, in the formally-integrated relationship, firms are less involved or embedded in the network structure. On the other hand, in a network based on informally-integrated relationships, the network shows a high pattern of interactions as indicated by the high score of network k-core index of embeddedness. Combining the results of the network maps and the statistical results of network structural measures of embeddedness, the network plots and network structural measures indicate that, in the informally integrated relationship, firms are more involved or embedded in the network structure. More specifically, two sets of findings emerged from the data analysis. These are described as follows.

First, the network structural measures indicated that firms that are embedded in informal ties (such as information-sharing ties) are more actively connected to each other than formal contractual ties. This could mean that informal relationships carry more weight than formal relationships. Our finding is consistent with Choi and Kim's (2008) work examining the relationships between a supplier's embeddedness in the supply network and the supplier's performance. Choi and Kim (2008) posited that firms are more embedded within their extended network through their informal social networks. Because of that, managers must pay higher attention to the pattern of embeddedness of these firms. By doing so, managers may do a better job of selecting partners for long-term relationships and may also find value in maintaining relationships with poorly performing firms who may potentially act as a conduit to other companies with technological and innovative resources.

The second set of findings elaborates on the tendency of the different types of firms to participate in distinctive relationships. Based on the description of the network plots, we posit the following: that in a formal inter-organizational relationship such as contractual ties, the most involved or embedded firms in the network are mostly the focal and first-tier firms. Hence, we could argue that the extent of the embeddedness of a firm in the network would appear to be contingent on the type of relationship network (formal versus informal). Thus, the finding from the exploratory network analysis shows that a firm's embeddedness in the network relates to the type of ties being considered. Firms are less embedded in the core structure of the formal tie network, such as contract ties, compared to informal network ties. These findings have a strong impact on the management of the resources devoted to inter-firm relationship development, which will be elaborated further in the discussion chapter. Overall, the results of the exploratory network analysis show that firms are more embedded in networks of informal relations than in a network of formal relations.

CONCLUSION

Overall, in answering research question one of this study, the visual analysis shows that the firm network embeddedness in the supply network is contingent upon the type of firms' relationship. The findings from the exploratory network analysis presented in the earlier sections described the interesting pattern and effects of firms' embeddedness. The findings also illustrated the contingent relationship between the firms' embeddedness and the network degree of formality in the network structure. This has a resultant impact upon knowledge and management of the network.

This study contributes to the literature by testing the implications of firms' embeddedness in formal and informal networks of inter-firm relations simultaneously. It also tests the interaction implications of the positions in the two classifications of inter-firm relations. To the best of the researcher's knowledge, research has not yet looked at the embeddedness effects of the firms in the two networks in the context of the inter-organizational network. Thus, this research makes the initial step into understanding of the impact of multiple inter-firm networks on the firms in the centralized network structure.

For future research, the researcher proposes that the framework of this study be investigated in other fields. The ship building industry context of the upstream supply chain, upon which this study has conducted an investigation, may characteristically differ from another industry and fields. As such, the researcher proposes that the design of this research be tested in the context of other industries or fields. The framework of this study can be tested in other industries, for example, to a more dynamic, fast cycle industry such as the electronics industry. The degree of uncertainty and required rate of innovation in the electronics industry may influence the pattern of strategic behaviour of embedded organizations and appropriate network configurations. Firms embedded in a rapidly changing network may achieve a competitive advantage through different forms of network embeddedness. This can result from firms in a lasting environment, such as the shipping industry (Rowley, Behrens and Krackhardt, 2000). In a volatile, rapidly-changing environment, the level of uncertainty will also be higher compared to that of a more stable industry. With this increased volatility and uncertainty, organizations are expected to take decisions that are based less on economic parameters but more on relationships and the resources at hand. Hence, ascertaining whether the findings of this study would also hold in a different industry would be an interesting undertaking and would add to the generalizability of this study.

In conclusion, by considering the overall implications of our study, we may conclude that complexity is not all bad. Managers need to consider their firm's existing embeddedness in order to exploit the competitive advantage of supply network inter-organizational relationships. Firms that fail to understand the underpinnings of these relationships stand to face more difficulties within the network itself. For this reason, managers that intend to obtain competitive advantages from the network must engage with other partners more effectively. No doubt, some firms are at an adequate standing, while others are struggling in some areas. The framework of this study can be applied by managers who are committed to engaging other network members.

BIODATA

Lokhman Hakim Osman is a former Lt Cdr of the Royal Malaysia Navy with passion and love for knowledge and challenges. He combines both elements to excel in the research field of supply chain management. His PhD titled "Impact of Firm Embeddedness in Upstream Supply network on Relational Capital Outcomes" was awarded in 2014 at Royal Melbourne Institute (Victoria, Australia). Dr Lokhman Hakim Osman also have special research interest in Network Analysis as he worked on his thesis titled Analytical network analysis that he is well-versed in includes, Pajek, NetDraw, SNA and PNet.

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