

NETWORK COMMUNICATION MODEL: PROPENSITY OF NETWORK INTER-CONNECTIVITY BASED ON TYPES OF NETWORK RELATIONS

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Abstract:

The supply chain has been described as a complex network of interrelated organizations transforming materials into finished goods and services. Supply network is complex as organizations are embedded in tiers of relationship and exchanges. Complexity resulting from the increase number of member organizations in the supply network has been known to complicate the supply network further, making the management of the supply chain a daunting task. In this study, the researcher investigated the degree of attention paid by firms in different types of network relations. Using Social Network Analysis, it was found that firms are more connected in informal network relationship that in a formal one. These findings are essential for resource management towards an effective and efficient supply chain management. Future research are discussed.

Keywords: Supply Chain Management; Network Studies; Inter-Organizational Relations; Social Capital; Supply Chain strategy.

1. Introduction.

Oliver and Weber (1982) are believed to be among the first scholars to use the term supply chain to describe the flow of resource and materials from the suppliers to the end users. In the early 1980 the focused of many scholarly works centred on understanding the integration of business processes throughout the supply chain (Ragatz, Handfield and Petersen, 2002; Vyas and Woodside, 1984; Zenger and Lawrence, 1989). Emphasis was given on the structure of the supply chain in order to deliver goods and services that meet the end users' needs.

Scholars then began to integrate different frameworks and views of SCM and, thereby, better define the domain of Supply Chain Management (SCM). As a result, several frameworks have been developed to guide research and

practice (Carbonara, Giannoccaro and Pontrandolfo, 2002; Kersten et al., 2006; Peck, 2005; Perona and Miragliotta, 2004; Piramuthu, 2005) SCM research has since evolved to encompass a combination of trends in the management literature, such as industrial markets, integrated materials' management, system integration, the "quality" revolution, management of relationships, and business process integration and management.

Despite the varying and progressive perspective of the supply chain, each of the notions of the supply chain management relies on terms such as coordination and integration and emphasises the harmonization of operation among organizations in the supply chain (Bowersox, Closs and Cooper, 2002). In addition, the focus of this early conceptualization of the supply chain focus on their cross-

functional business processes with the objective of providing value for the entire supply chain (Lambert and Cooper, 2000; Lambert, Cooper and Pagh, 1998)

These days, supply chain management (SCM) involves adapting to changes in a complicated and complex global network of organizations (Choi and Krause, 2006; Hoole, 2004; Li et al., 2010; Masson et al., 2007; Sivadasan et al., 2010; Sivadasan et al., 1999; Vickers and Kodarin, 2006; Zhou, 2005). Since the early 2000, scholarly work began to conceptualize supply chain as supply network to better illuminate the complexity of the organizations' inter connectivity (Harland et al., 2001; Lamming et al., 2000). A typical supply network consists of inter firm relationships that may connect numerous industries. As a result, supply chain management often requires consideration of a large number of factors from various dimensions and perspectives.

Managing the complex upstream supply network can be a difficult task for managers of the supply chain. The traditional reductionist arguments state that firms opted for the removal from the complex upstream supply chain of partners who are not meeting the performance requirements of the supply chain in an attempt to manage the complexity arising from extensive inter-firm relationships (Choi and Kim, 2008).

However, recent arguments suggest that simply removing these 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.

Thus this research embark on goal to better understand the actual

structure of the supply chain as this will eventually help operationalization of resources.

2. Literature Review

2.1 Antecedents of Supply Network Structure. It is important to note that the supply chain is no longer a chain. It is a network of inter-connected firms. Oliver and Weber (1982) are believed to be among the first scholars to use the term supply chain to describe the flow of resource and materials from the suppliers to the end users. In the early 1980 the focused of many scholarly works centred on understanding the integration of business processes throughout the supply chain (Ragatz, Handfield and Petersen, 2002; Vyas and Woodside, 1984; Zenger and Lawrence, 1989). Emphasis was given on the structure of the supply chain in order to deliver goods and services that meet the end users' needs. Scholars then began to integrate different frameworks and views of SCM and, thereby, better define the domain of Supply Chain Management (SCM). As a result, several frameworks have been developed to guide research and practice (Carbonara, Giannoccaro and Pontrandolfo, 2002; Kersten et al., 2006; Peck, 2005; Perona and Miragliotta, 2004; Piramuthu, 2005) SCM research has since evolved to encompass a combination of trends in the management literature, such as industrial markets, integrated materials' management, system integration, the "quality" revolution, management of relationships, and business process integration and management.

Over the years, various structures of the supply chain have evolved. One important finding of Womack (1990) is that, in a supply chain, the exchanges between the firms not only concern the

formal exchanges of materials from the upstream suppliers to the downstream customers. Most importantly, it also involves informal forms of relations such as other commercial transactions, including information-sharing and referral activities, which create a significant competitive advantage to the firms embedded in such relationship structures (Lazzarini, 2000; Borgatti and Lie, 2010). Choi and Krause (2001) study the flow of materials in three automobile manufacturers in North America. The authors mapped the network of flow of parts and materials for the assembly of the center console for several models. Base on the mapping of the network, it shows that the flows of materials are not linear as commonly perceived. Furthermore, in a supply network of the center console parts and materials, it could be assumed that the other organizations or suppliers in the supply network are connected to other organizations through some indirect connections. This indirect connectivity could mean that organizations in the supply network are communicating with each other without the knowledge of the other organizations or suppliers.

This seminal work of Choi and Krause (2001) has led to other further analysis. Lazzarini (2002) study tried to visualize the adoption of the social network concepts for the supply network study using what is termed net chain analysis. The authors conclude that a supply network consists of a number of hierarchical layers, and each layer contains many other firms that are connected to other organizations in the network either through horizontal connections or vertical connections. Kim (2001) adopted the structural holes' concepts (structural holes relate to how an organization in a network can be connected or tie to other organizations

in the network through indirect connections) to explain the flow of information in the supply network. Kim (2011) conceptualized several supply network concepts such as material supply using social network elements such as in-degree centrality to explain how materials flow from the upstream suppliers to the focal organizations in the supply network.

Despite the varying and progressive perspective of the supply chain, each of the notions of the supply chain management relies on terms such as coordination and integration and emphasises the harmonization of operation among organizations in the supply chain (Bowersox, Closs and Cooper, 2002). In addition, the focus of this early conceptualization of the supply chain focus on their cross-functional business processes with the objective of providing value for the entire supply chain (Lambert and Cooper, 2000; Lambert, Cooper and Pagh, 1998). Figure 1 represents a supply network structure of multi-tiered entities involving the formal commercial transaction and informal web of social exchanges in the supply network mimicking the true nature of a supply chain model. In Figure 1, firms in the supply chain are pictured interacting with each other in the supply chain despite the distinct formal role of the firms such as: the raw material suppliers, distribution agencies or even the focal firms in the supply chain. Thus, it is argued that the upstream supply network now contains a mix of more formal and informal inter-firm relationships, thereby creating a much more complex network structure (Choi and Kim, 2008). This inevitably creates a complex structure of relationships between the entities in the supply chain. It also indicates that the supply chain has become a more complex

network because of the activities and exchanges that have increased over the years.

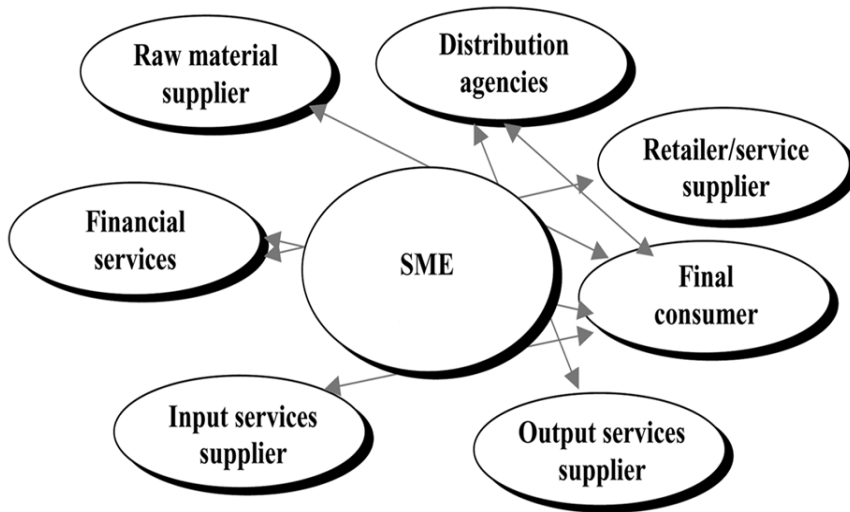


Figure 1. Supply Network
 Source: Ritchie and Brindley (2000)

For example, one study that attempted to map the actual map of an upstream supply network structure was conducted by Choi and Krause (2006), as well as a study by Li and Choi (2010). In 2006, Choi and Krause (2006) set off on a research project to map the actual form of a supply network structure for a component in Honda Acura in the North America manufacturing facility. The network data from this initial study was later transformed (using the Social Network Analysis tool i.e. UCINET) by Li and Choi (2010) to map the actual interaction pattern of suppliers. More specifically, the authors mapped out a full upstream supply chain structure for a simple centre console assembly for the Honda Acura model. What developed from the research was a complex upstream supply network map of the flow of materials from the upstream suppliers to the focal firm.

Choi and Kim (2008) have also pointed out the need to define the context of the buyer-supplier relationships rather than the interaction process per se. Choi and Kim (2008) draw on balance theory to stress the need for supply chain managers to adopt a strategy that pictures the firms as being involved or embedded in a larger network structure rather than existing in isolation. The authors argue that such strategy helps create a more accurate response to the market environment. Consequently, it is warranted to argue that the actions of entities in buyer-supplier relationships can only be fully elucidated in terms of the positions of these buyer-supplier organizations in the network relationships and that the position represents different impact upon the firms.

2.2 Supply Network Embeddedness. The supply network is an amalgamation of relationships or

activities between firms (Croxtton et al., 2001; Lambert and Cooper, 2000). Structurally, supply chain is virtually formed by the connectivity or links between firms where the integration progressively forms the ultimate structure, which is the supply network itself. According to Choi and Kim (2008), 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 the purpose of generating value (Carter, Ellram and Tate, 2007). The firms need resources from its supplier organization, and the supplier needs contracts and payments from the buyer. On top of that the firms interact to share information regarding market opportunities and new threats (Cousins et al., 2006). As a consequence, these phenomena create a link and form a dyad or a buyer–supplier relationship. 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. Thus, firms in the supply network are embedded in these different types of buyer-supplier relationships or simply, the supply network ties.

Embeddedness has been extensively discussed and documented in the field of economic sociology (Baum and Dutton, 1996). Sociologists have promptly indicated that the different social structure architectures in exchange relationships shape the flow of resource and subsequently, the embeddedness structure (e.g Coleman, 1988; Freeman, 1979). These distinct architectures in turn generate both constraints and opportunity for the tied organizations and can implicate the organizational performance and behaviour. Based on this viewpoint, we

argue that much of the study of buyer supplier relationship in the supply chain characterized an under-socialized account of the buyer supplier organizations behaviour or actions.

Within a supply network, the buyer-supplier relationship may take several forms such as contractual ties, or market transactions to informal information sharing ties (Carter, Ellram and Tate, 2007; Galaskiewicz, 2011; Kim et al., 2010; Mueller, Buergelt and Seidel-Lass, 2007). Slack, Chamber and Johnston (1995) identified these ties based on five types of organizing relationships, which include short term trade, semi and long term trade, coordinated-profit sharing, long term alliance, and joint venture. According to the authors, short-term trade refers to a formal single transaction after which the relationship ends. Semi and long-term trade agreements refer to the trade agreements without formal contracts that legally bind the organizations. Van der Vorst and Beulens (2002) view the supply chain as lying between fully vertically integrated systems and those in which the member organizations are totally independent of each other. In our opinion, the buyer supplier relationship in the supply network may take on many forms as discussed above, bounded by one extreme by formal supply network ties and at the other extreme by the informal supply network ties creating a network of interrelated and interdependent firms (Borgatti and Li 2010). The literature also indicated a stream of research that addresses the question of the best fit for management of the supply chain. This line of study attempts to determine the best structure or configuration of the supply 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 supply chain, and how clusters of the buyer-supplier relationships should be managed (Cooper, Lambert and Pagh, 1997; Gilsing and Nootboom, 2005; Powell, Koput and Smith-Doerr, 1996; Shan, Walker and Kogut, 1994). 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).

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 network structure and relationships. Furthermore, the focus on the organizations or the partnership as the unit of analysis and the external environment are too atomistic (Cousins et al., 2006). When evaluating potential course of actions, such assumption lacks a certain variable which equally important: the actions of other organizations or the relationships which the buyer supplier organizations are embedded in (Brookes and Singh, 2008). 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. Thus, the research question for this study is:

RQ: How does the embeddedness of firms relates to various supply network relationships?

3. Research Methodology

According to Wasserman and Faust (1994), the traditional statistical method is not adept with regard to the measurement of relations. This is because the standard statistical method disavows the existence of relations between entities in a network which is itself the center of network research (Lusher, 2000). Because the focus of this study is not only concentrated on attributes of firms but also on the relations between firms, this study has consequently, adopted the social network analysis (SNA) methodology strategy for data collection and data analysis by which to obtain valid results for this study.

Social network analysis is a research method which has its origins in the field of sociology, anthropology and politics (Scott, 1998; Borgatti and Li, 2010). SNA focuses on the relationships or ties between network entities, not just the attributes of the network entities (Wasserman and Faust, 1994). According to SNA scholars, a network is made up of actors who could be either individuals or organizations, which are interconnected to each other through the different kind of social interactions (Scott, 2000; Hanneman and Riddle, 2005). The interactions can be in the form of formal ties or informal ties such as contract ties, information sharing ties and referral ties (Borgatti and Li, 2010). The objective of a social network analysis is not to determine the attributes of the actors that impact upon the network, but rather on how the inter

connectivity between the network actors influences network performance (Mueller, 2000).

Hence, social network analysis allows the researcher to investigate how firms are embedded in the centralized upstream supply network structure thus elucidate the true structure of supply network. A network of firms operating in an upstream supply network of a small maritime industry company formed the population of this study, i.e. the APMMHQ-1 (pseudonym provided for anonymity). The APMMHQ-1 is a manufacturing company in the Malaysian shipbuilding industry involved in ship repairs, maritime works and engineering. In network studies, all actors who are located within a pre-determined boundary are included for analysis. Consequently, unlike the conventional sampling strategy, social network analysis seeks to include all the actors in the network under consideration (Hanneman and Riddle, 2005). The sample of this study includes 37 firms involved in the production of Rigid Hull Inflatable Boats (RHIB) for APMMHQ-1. Through a network survey, data was collected from a total of 36 out of 37 firms in the APMMHQ-1 upstream supply network with an overall response rate of over 90 per cent. Network data was analysed using network analytic techniques, namely: exploratory network analysis. Exploratory network analysis was applied to explore patterns of interactions among firms, which used to interpret the overall pattern of embeddedness of firms in the APMMHQ-1 upstream supply network. This analysis applied the spring embedding algorithm using social network software packages, i.e. UCINET (Borgatti, Everett and Freeman, 2002), NetDraw, Mage and

Pajek (Nooy, Mrvar and Batagelj, 2005).

3.1 Development of Network Sociograms. In this study, network sociograms were developed using the NetDraw and the Mage software packages. Although NetDraw and Mage were used to create the final output (i.e. the network sociograms), two other software packages were used in the early stages of the visual analysis, i.e. Excel and UCINET® (Borgatti, Everett and Freeman, 2002). Microsoft Excel was used to enter the binary data from the network survey and UCINET® converted the Excel worksheets into a readable format for the NetDraw program before converting it into sociograms. In the following section, the researcher briefly describes the entering and uploading processes performed via the three different applications (Excel, UCINET® and NetDraw).

Development of the relevant sociograms or network maps requires two types of network data to be collected from the network survey. The network data are the node data (or the firm attributes data) and the tie data. In the following sections, the researcher describes how these network data were processed and entered into the relevant program to perform the exploratory network analysis.

3.2 Entering the Node data (Firm attributes)

First, for each of the network ties (i.e. contractual ties, information-sharing ties, referral made ties, referral received ties) the researcher created two Excel worksheets (NODE-DATA and TIE-DATA worksheets). For example, for the contract tie networks, a CONTRACT TIE NODE-DATA worksheet and a CONTRACT, TIE-DATA worksheets are created. The NODE-DATA worksheet was used to

enter the node data or the firm attribute such as organization size, age, and so on. The first column header of the Excel worksheet contained the ID or the label for the research sample, namely, the 37 firms in the APMMHQ-1 upstream supply network for RHIB equipment and materials. In the subsequent columns of this worksheet, we record relevant information about the firms, such as the size, age of, address or location of the organizations, and the sectoral affiliation respectively.

3.3 Entering the tie data. The tie data worksheet is used to enter the tie data which are the binary data representing the existence (or non-existence) of ties between the firms. To do this, the researcher headed the first two columns in the tie worksheet as FROM and TO. In the first cell of the FROM column, the researcher copied the first organization ID in the node data worksheet and pasted it into the first cell. The researcher then copied the full list of the IDs from the NODE-DATA worksheet and pasted the list into the TO column of the tie worksheet. A third column was added, named the TIE STRENGTH column. The researcher entered zero (0) in the initial reflexive tie and '0' or '1'; where "1" indicates the existence of relations between two firms and "0" indicates no relation between two firms from the tie data from the network questionnaire for the subsequent cells. Next, in the TIE-DATA worksheet, the researcher used the fill down function in Excel to fill in the IDs for every row of the FROM column. This step made each row of the FROM column a fully defined item from the tie data. All steps mentioned were performed to generate the matrix for each of the four ties in the network questionnaire (appendix nine). In the following section, the researcher

describes the uploading of the network tie data and the firms' attribute data into the UCINET to perform the exploratory network analysis.

3.4 Loading Data to UCINET®.

Once the node data and tie data was recorded in Excel, the next step involved uploading the worksheets into the SNA software, i.e. the UCINET®. In the UCINET® software, the following steps were performed. The researcher used 'Data'□'Import via spreadsheet'□'DL type formats' command to upload the Excel worksheets into the UCINET® program. When a dialogue box opened, the researcher used the 'File'□'Open Excel file' command to direct the software to the Excel program that contained the ties and node data. The researcher located the Excel worksheet and selected the NODE DATA or the TIE DATA worksheet of each tie. When the NODE DATA worksheet was selected, the researcher selected the Full Matrix format and checked the column header in the UCINET® dialogue box. The researcher then used 'File'□'Save UCINET® dataset' command and named the new file after the type of node attribute uploaded. Similar steps were performed in order to upload the TIE DATA worksheets into the UCINET® program. However, instead of the 'Full Matrix' format, the 'Edgelist (1 mode)' format was selected in the corresponding dialogue box. To cross check the uploaded NODE DATA and TIE DATA worksheets, the researcher used 'Data'□'Display' to see how UCINET® has stored the data.

3.5 Creating Network Sociograms using NetDraw. Once the NODE DATA and TIE DATA worksheets were stored in the DL format of the UCINET® program, the researcher then loaded the NetDraw program to create the sociogram for

each of the ties in the study. In NetDraw, the researcher used 'File' □ 'Open' □ 'Ucinet Dataset' □ 'Network' to open the CONTRACTUAL TIE DATA for contractual tie network. In the subsequent dialogue box, the researcher browsed the UCINET file contract tie data and clicked the file. This step is performed to create the network structure of the sociogram. To upload the NODE DATA, the following steps require selecting the contract tie NODE DATA of the UCINET® files. Once the contract TIE DATA and contract tie NODE DATA files were uploaded in NetDraw program, the program generated the network sociogram based on the entered binary data sets. The above processes were

repeated for all other network ties. The outcomes are discussed next.

4. Results

4.1 Visual Analysis of the Map of APMMHQ-1 Upstream Supply Network for Product RHIB. For comparative purposes, the metaphorical structure of the APMMHQ-1 upstream supply network for the product RHIB was first developed. Following Choi and Krausse (2006), the upstream supply network structure for the RHIB was developed based on the archival review and discussion that the researcher conducted with key informants from AMPPHQ-1.

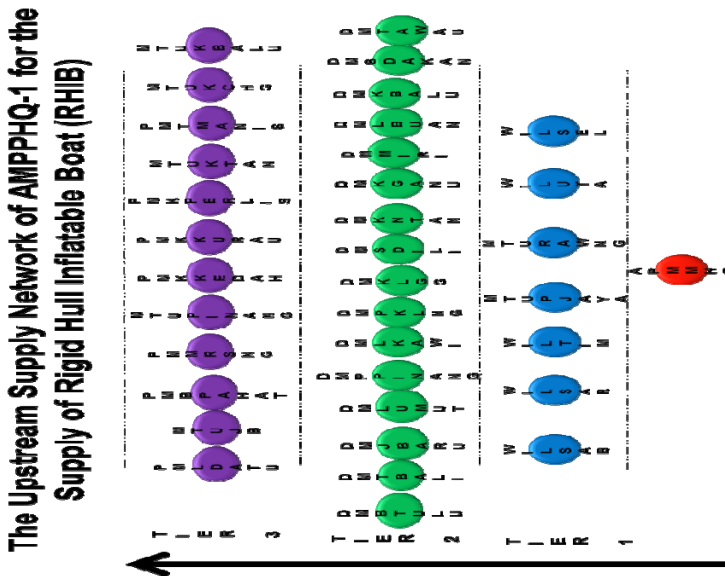


Figure 2. Upstream Supply Network Structure of APMMHQ-1 for the Product RHIB

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 upstream supply network structure of APMMHQ-1 for the supply of materials for the product RHIB. In Figure 2, the firms are coloured based on their positions in the upstream supply network structure.

APMMHQ-1 is the focal firm in this centralized upstream supply 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. The structure in Figure2 indicates a hierarchical structure of the APMMHQ-1 upstream supply 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 upstream

supply network structure resides in tier two of the upstream supply chain 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 supply chain network.

4.2 Analysis of Network

Centralization. Figure 3 documents the centralization score of the four supply ties.

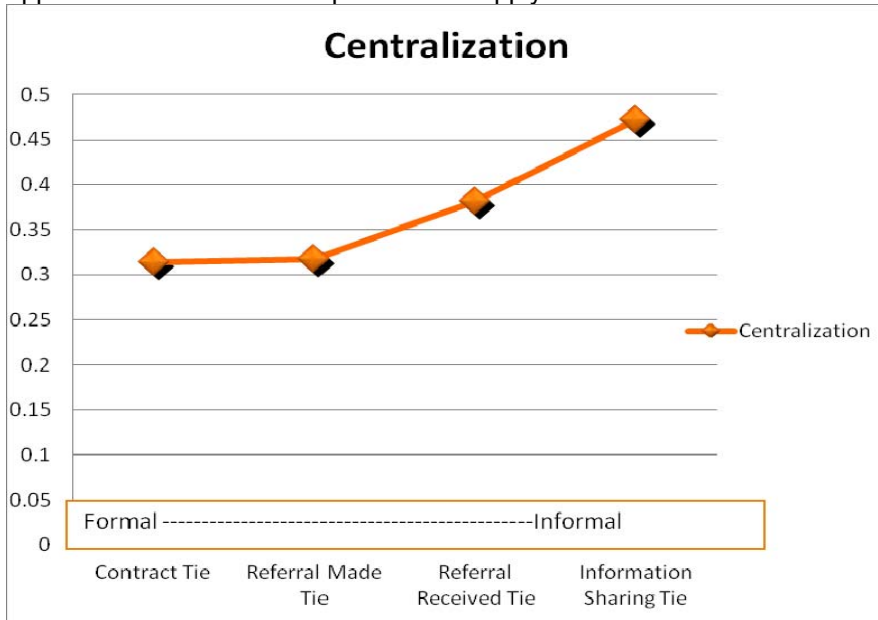


Figure 3. Centralization Index

The centralization index of contractual ties is 0.3142; the referral made tie is 0.3174, and the referral received tie is 0.3821. The centralization score for information-sharing is 0.4724. This score suggests that formal ties or firm relationships, such as contract ties, are less

centralized than a lesser continuum of the buyer relationships.

The information-sharing network centers on the focal organizations. This could be due to the fact that, in a supply network, the focal firms dictate the flow of resources within the network. Because of that, other firms seek information directly or indirectly from

the focal firms in the form of orders and supply on a constant basis. These make the focal organizations the centre of information sources and provide them with a powerful positional advantage. The distribution of the network centralization shows that firms are more centralized in the information-sharing ties. The referral ties have the middle score while the contract ties have the lowest score. This pattern

suggests the following: firms are more involved in network relations that are based on informal coordination mechanisms than in a formal one.

In the following section, the researcher presents the results of network structural measures of embeddedness density.

4.3 Analysis of Network Density.

Figure 4 shows the density score for the contractual tie network.

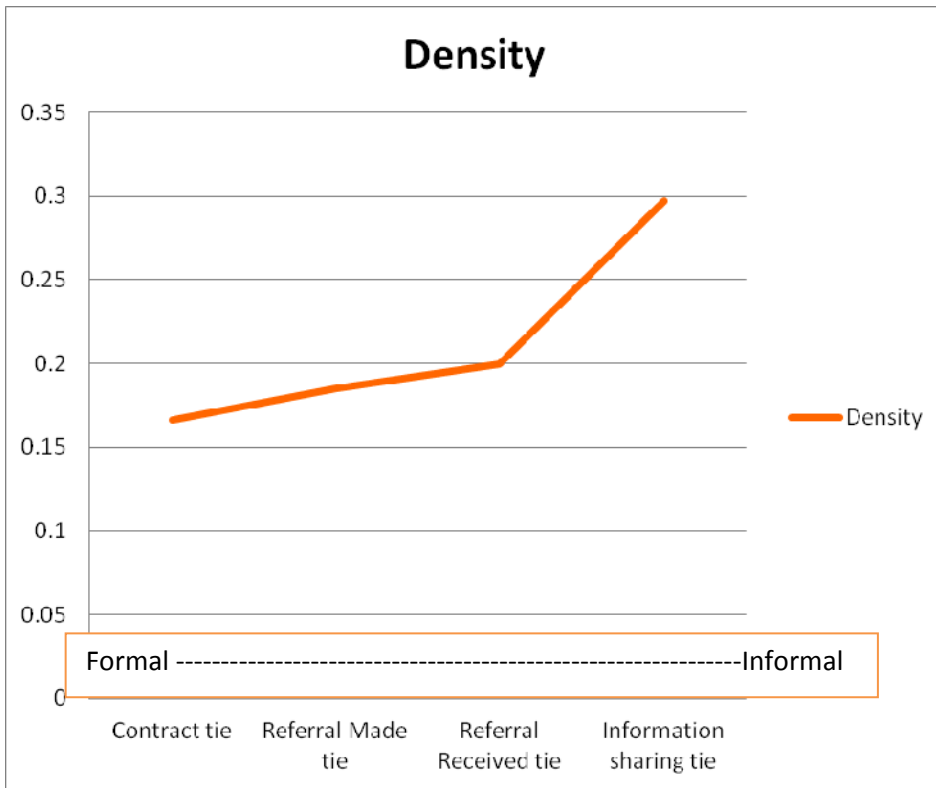


Figure 4. Network Density Index

The density of the whole network of contractual ties is recorded as being 0.1660. This means that 17% of all possible ties between the firms are present in the contractual tie's network. The density network of information-sharing ties is recorded as 0.297. This indicates that 30% of all possible ties between the firms are present in the

information-sharing tie's network. The density of referral received ties network is recorded at 0.200. This means that 20% of all possible ties between the firms in the network are present. It is an indication that firms are less embedded in the referral network structure. The network for referrals received has a density score of 0.185.

This indicates that 18.5% of all possible ties between the firms in the network are present. Holistically, this is an indication that firms are embedded to a lesser degree in the referral received tie network. Overall, the results of the network structural measures of embeddedness density show that firms are more connected in informal relationships than in formal relations.

This conclusion is consistent with findings from studies in other fields of inter-firm relations (Cousins et al., 2006; Oh and Labianca, 2004). It is argued that fewer formal interactions took place rather frequently among organizations, and the information gathered from the informal ties is more fluent than formal ties. Hence, organizations more often than not involve themselves with informal ties or activities with multiple types of organizations rather than in formal administrative activities based on contracts or transmittal of money.

In the following section, the researcher discusses the results of exploratory network analysis of network structural measure geo-desic distance.

4.4 Analysis of Network Geodesic Distance.

The cohesiveness of the different networks is also examined by calculating the distance between firms of the networks and the number of ties between them. The geodesic distance refers to the shortest path between the firms and measures the extent of connection in the network (Knoke and Kuklinski, 1982). Understanding the geodesic distance between firms in the network allows the researcher to determine the level of connectivity among firms. Consequently, it also gives general descriptions of the embeddedness level of firms in each of the network ties.

Figure 5 displays the geodesic distance score in a graphical manner.

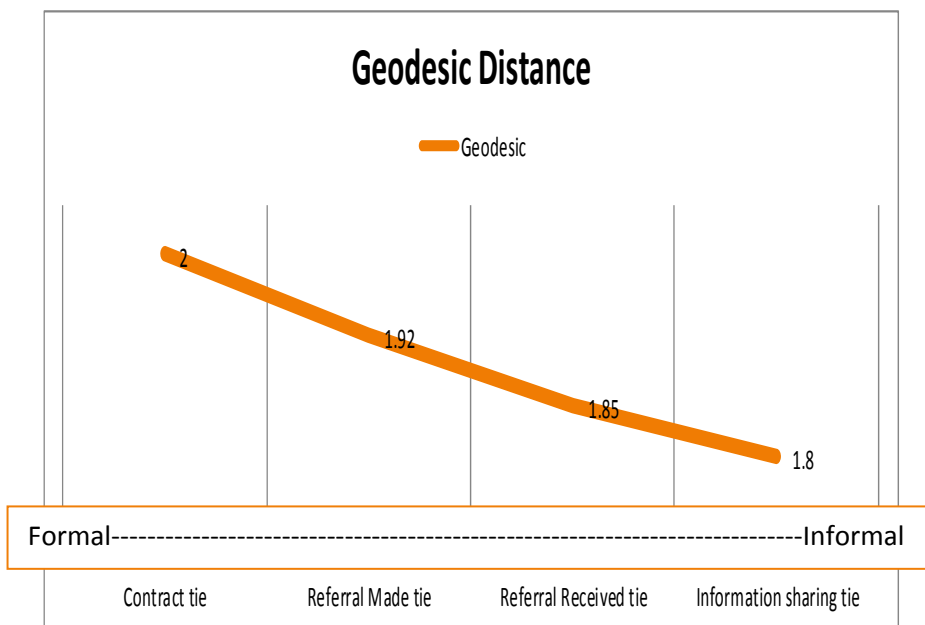


Figure 5. Geo-Desic Distance Index

The average geodesic distance between the firms in the contractual tie network is 2.0. This indicates that, on average, each organization is only two steps on the path away from other organizations in the network. This means that the contractual tie is an important tie to each of the firms in the APMMHQ-1 upstream supply network, as the majority of the firms tend to stay close to each other in the network with an average of two geodesic distance values between two embedded firms. The closeness between firms in the formal contractual tie may be due to the value of the ties to the overall management of the contracts that exist between the connected firms.

The average geodesic distance between firms in the information-sharing tie network is 1.8. The network structure indicates that in the information-sharing tie, firms are closely connected to each other. Firms are closely connected to each other in information-sharing ties due to the informal nature of the information-sharing tie. The average geodesic distance between the firms in the referral made tie network is 1.92. In theory, the 1.92 geodesic distance score means that firms in the network would have to go through approximately 1.92 ties of actors in the network in order to gain access to certain resources. The geo-desic distance in a referral received tie is 1.85.

The analysis of the geo-desic distance indicates the overall literal distance between firms in the network structure through the length average length of ties between firms in the network. The longer the length of ties indicates the larger the distance between two firms to connect with each other in the network structure. As such,

when comparing a geo-desic distance of 2 in the contract tie and a geo-desic distance of 1.8 in the information-sharing tie, it can be concluded that firms are closer or more connected to each other in the information-sharing tie than in the contract tie. This is because it took a lesser path to the next firm in the information-sharing than in the contract tie.

Figure 5 indicates that, in the more formal ties such as the contract tie; firms are closer to each other than in the informal network structure. Clearly, the geodesic distance statistics indicate that firms are more closely embedded in the informal tie's network than in the formal tie network.

4.5 Analysis of Clustering Coefficient Index Score

The clustering coefficient is the extent to which any two organizations in the network are connected to the same organizations, as well as being also directly connected to each other (Hanneman and Riddle, 2005). In other words, the clustering coefficient score indicates the degree to which inter-clique interactions may exist in a particular network. A higher cluster coefficient score may indicate more activities between different sets of cliques. Hence, interactions in this network are expected to be higher. Consequently, attention is given to the level of embeddeness. As indicated in Figure 6, in the formal relation, the clustering coefficient index is recorded as a score of 0.461. The informal, information-sharing relationship recorded a clustering coefficient score of 0.572, and a score of 0.487 for the referral made tie respectively.

What the score indicates is that more collaborative activities or inter-clique interactions occur in the informal network compared to a formal network.

Thus, this is another indication that firms are more embedded in a firm's informal relationship network than in the formal one.

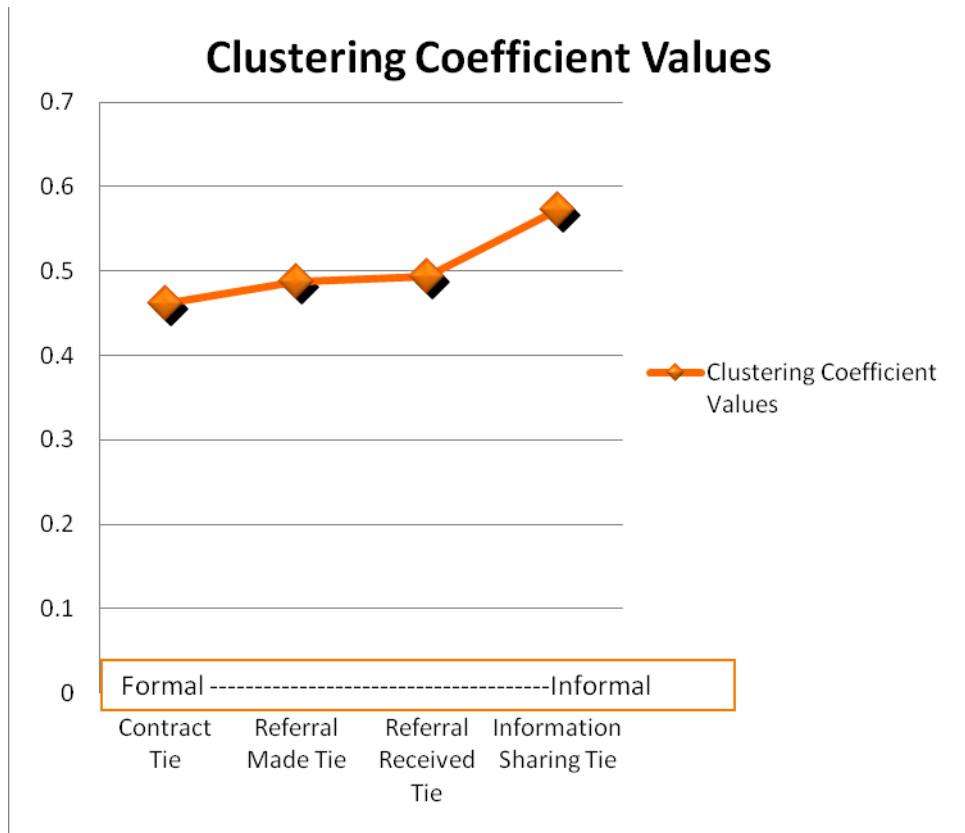


Figure 6. Clustering Coefficient Index

5. Discussion of Exploratory Analysis

The goal of the exploratory network analysis was to determine the pattern of embeddedness of firms in the upstream supply network structure in relation to the type of network ties being considered.

Using six indexes of social network analysis, 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 centralized upstream supply network is related to the formal versus informal classification of network ties. Overall, relationship networks with high formality are less centralized, less dense and less connected 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 structural measures 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 supply 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 upstream supply 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. The results of the exploratory network analysis are used in the following chapter to determine the impact of firms' individual embeddedness levels in the upstream supply network structure on its level of relational capital outcomes.

6. Conclusion and Future Research

In summary, while answering research question of this study, the researcher found that, in the context of the upstream supply network structure, firms' embeddedness or involvement is contingent upon the type of network relations. Clearly, the exploratory

network analysis has given a strong indication that, in the centralized upstream supply network structure, more attention and resources (as forming new alliances requires time and even money) of the embedded firms are dedicated to informal networks of relations than to the formal ones.

Through the utilization of exploratory network of the four firms' relationships, i.e.: contract ties, information-sharing, reference and made reference received tie; it is clear that the network embeddedness of firms in the supply network is related to the nature of the type of ties or firm relationships that are being considered. The findings of the exploratory network analysis indicated that, in a more formal form of firms' relationships; such as the contract tie, the firms are less embedded in the network structure. However, in the less formal ties or firm relationships (such as the information-sharing ties), firms are more embedded in their network structure as indicated by the dense number of ties. More importantly, because the definition of embeddedness relates to the degree of involvement of firms in the firm's relationship, this finding suggests that firms are less involved within the network of formal ties compared to the informal inter-firm relations.

The significant of this study is twofold. Through our findings, this study found similar conditions in the upstream

supply network, where firms are embedded in contract ties, information-sharing, referral made and referral received ties respectively. In addition, this study also went a step further by classifying these inter-firm relations into the formal and informal nature of its coordinations. The results indicate that, in the upstream supply chain, firms having inter-firm relationships are more embedded in the informal network of inter-firm relationships than in the formal inter-firm relations (Uzzi, 1997). Although this finding contradicts the work of Granovetter (1985) (which argues that the strength of tie's influences actor embeddedness in networks), our finding is in line with the work of Uzzi (1997) who found that in inter-firm networks, firms are embedded in arms-length (formal relations) type of ties and embedded ties (informal relations).

For future research, we propose that the connectivity of firms in the supply network structure to be investigated in other types of relationships. These provide deeper and specific measures for the different and specific scenarios. We also suggest interested researcher to develop specific measures for the distinctive formal and informal supply network relationships. Focus and dedicated measures will inadvertently produce a more effective and efficient supply networks.

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