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ORIGINAL PAPER

ASSESSING SUPPLY NETWORK COMPLEXITY IN MARITIME INDUSTRY IN MALAYSIA: INTER-FIRMS' RELATIONS DRIVES PATTERN OF SUPPLY NETWORK STRUCTURE

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ABSTRACT. **Background:** Complexity has been an interesting research area for academics and businesses practices due to its relevance in determining the best practices and impacts to the supply network. The contribution of this research extend to the literature and put forward solutions for the industry since previous studies are neglecting whole network relations, which is highlighted as source of supply network complexity (SNC). Specifically, this research extends to enriching the literature and recommending solutions to the industry players since previous studies are neglecting important Inter Firm Relation (IFR) elements, formal inter-firm relation (FIFR) and informal inter-firm relations (IIFR), which are highlighted as a pertinent factor in this research. In this study, the Social Network Analysis (SNA) method was adopted to develop valid attribute for the measurement process and the embeddedness theory was used to evaluate the interrelationships among the proposed attributes. This study found that FIFR and IIFR have different effects towards the formation of SNS and consequently towards SNC. Finally, theoretical and industrial implications are also discussed.
Methods: Traditional statistical tools focus on attributes of phenomenon as determinants for occurrence of economic payoff. Thus, traditional statistical analysis is not suitable to measure the impact of relations or connections among member of network contributing to network complexity. For the purpose of this research, the Social Network Analysis methodology was adopted to collect, analyse and interpret network data. Network survey was conducted to collect relational data among members of maritime industry supply network. Network data was analysed and interpreted using specialized social network program i.e. UCINET and NETDRAW. Statistical network measures such as centralization and density was applied to determine the relations between network complexity and network relations.
Results: The findings of this study indicate that Inter Firm Relation (IFR), formal inter-firm relation (FIFR) and informal inter-firm relations (IIFR), which are highlighted as a pertinent factor in this research, have different effects towards the formation of SNS and consequently towards SNC.
Conclusion: The results of the statistical network analysis indicate that, network complexity exist in different forms and structure, depending on the type of relations that formed the network in the first place. Consequently, what these mean are, managing network requires different types of resource and strategy as the level of the network complexity are different at different states of connectivity.

Key words: network analysis, information sharing, supply network, complexity.

INTRODUCTION

Supply network complexity (SNC) has been a major concern worldwide [Nair, Blome, Choi, Lee, 2018]. It is the complexity that naturally arises from the fragmented, yet extensive inter-firm relationships (IFR) existing between firms in the supply network.

However, the complexity of the supply network structure (SNS) is increasingly becoming more difficult to understand due to the unique type of IFR that the firms are embedded in [Nair, Blome, Choi, Lee, 2018].

Furthermore, not all firms in the SNS are engage in relational-based behavior [Ceyhan,

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Dogan, Yildiz, Barca, 2018]. Evidently, numerous decisions and actions in an SNS were performed based on attributes of firms' analysis compared to degree of IFR [Mohd Adnan, Valliappan, 2019]. This is due to the facts that attributes are more visible and easily evaluated compare to IFR. Inter-firms' relation were argued to be more tacit and subtle in nature. Attributes of firms in the SNS can exist between firms because of limit, culture, geological area and long stretches of activity and size and physical elements.

As much as firms' attributes are responsible for producing prudent and effective decisions making, it is also detrimental for firms to elucidate another important element responsible for economic payoff i.e. IFR. [Chakkol, Finne, Raja, Johnson, 2018; Osman, 2018]. In previous studies, SNC is addressed as related to attributes of organizations that make the level of separation among organizations [Turner, Aitken, Bozarth, 2018]. The contention is that, as the quantity of firms inside the supply network (SN) builds, this thusly expands the administrative and operational necessities expected to deal with the distinctive attributes with different firms crosswise over numerous limits.

However, attributes are not the only reasons organizations are embedded in network. Aside from attributes of firms, the SNC also the results of degree of IFR within the supply network [Chakkol, Selviaridis, Finne, 2018]. Literature in the area of operation and supply chain management tended to IFR as ties among the firms from the system structure. IFR inside the SN may be inside the setting of trades or information trades, for example, showcase data or money related streams. What makes IFR more difficult to manage is the fact that IFR may exist in SNS as part of the formal network connections such as contractual obligations or informal network connections such as information sharing, but the knowledge of the existence only relevant to the connected few. Thus, supply network management requires an improved proposition when dealing with SNC. Therefore, there is a need to assess the IFR to improve understanding of SNC.

Because of the complexity of looking as IFR, only a few researches relate the subject of SNC with IFR as driving factors. Therefore, this research proposes elucidating IFR as one of the element to enhance management of SNC [Chakkol, Selviaridis, Finne, 2018].

The objective of this study is to assess the network relations that are related to IFR of maritime industry SNS in Malaysia. In recent years very few studies research into this topic in the Malaysia's market; for example, [Lyon, 2018] described the SNC as being hour glass shaped, with many different stakeholders at the supply and demand ends and a small number of trading companies in the middle. Most members of the SNS saw the numerous and various partners of the SN as representing a significant obstruction to the usage of duties by clouding recognisability and ruining commitment with clients or providers. Meanwhile this research analyses SNC not from the attribute context of the SNS components but from the IFR context. The perspectives used in order to achieve this objective of the study are that of buyer-supplier organizations

This article is composed as pursues. Literature review section developed the framework of this study within the context of SNS and SNC alongside its network relatedness. This is followed by the research methodology sections that discuss the social network methodology and examination of network information relevant for this study. This is followed by the discussion of the outcomes and figures identified with the relations. Finally, the researcher discusses the study contribution both to theory and practice, research impacts and constraints.

LITERATURE REVIEW

To give better understanding dependent on a theoretical point, this segments surveys pertinent literature tending to SNC. The proposed techniques and measures are additionally surveyed.

Supply Network Complexity (SNC)

The definition of SNC is the multifaceted nature that emerges from the connectivity among the embedded components in the SNS towards accomplishing accord objectives. SNC has a wide perspective in understanding it [Hartman, 2016; Osman, 2017].

These portrayals of multifaceted nature would legitimize the contention that the SNS is likewise complex and the IFR speaks to the interconnectivity between the components in the system. These descriptions of complexity would justify the argument that the SNS is also complex and the IFR represents the interconnectivity between the elements in the network.

Chakkol, Finne, et al. [2018] allude to complexity in the network as how much network members interrelate. IFR between firms in the SN could be as physical merchandise trades or data trades advertise information or monetary streams [Hartman, 2016; Osman, 2017].

With regards to the SNS especially, Chakkol, Selviaridis, et al. [2018] and Chakkol, Finne, et al. [2018] have expressed that the SNS have been encountering expanded multifaceted nature through broad IFR. For instance, in the SNS of vehicle producers, a provider may supply parts to a maker, while this maker may simultaneously supply different parts to a similar provider organization. One charming actuality is that a considerable lot of these working relations among providers in the SNS frequently exist past the learning of the central firm.

A firm in the SNS may respect the IFR if the data traded advances better coordination of the SNS [Hamari, Sjöklint, Ukkonen, 2016]. Notwithstanding, it might be unwelcome if the IFR adds to spillage of data in the SN. Thus, an association's observations with respect to a decent accomplice may change unexpectedly. In this manner, IFR among firms in the stockpile system is a significant part of the SNC. The IFR in the SNS (regardless of whether the organizations contend or collaborate with each other) has been found to essentially affect upon the monetary exhibition of the central firm or producer [Kim, Yoon, Zo, 2015].

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Another stream of research shows that the development of a SNS makes an increasingly complex structure emerging from the IFR [Kim, Chen, Linderman, 2015]. What makes the SNS increasingly complex is that, until now, current examinations have just been concentrating on the formal materials stream sort of IFR among the organizations in the SNS. In any case, actually, there are different types of IFR which added to the general multifaceted nature in the SNS. This is on the grounds that, as shown by the embeddedness hypothesis and the investigations of researchers such Y. Kim et al. [2015], the conventional business exchanges in the SNS are inserted in a web of informal social exchanges [Chakkol, Finne, et al., 2018].

IFR adds to expanding unpredictability in the SNS, adding to the precursors of the SN. Kim, Chen, and Linderman [2015] have inferred that the IFR is one of the drivers of complexity in the SNS and more profound comprehension is expected to beat the complexity nature coming about because of these IFR. All the more explicitly, the diverse IFR between them makes the degree of complexity which demands effective administration techniques from supervisors. These various causes of complexity demand a reasonable clarification of the SNS for compelling and proficient administration of the SN.

In this way, understanding SNC means understanding the relations among players in the SNS. This research considers SNC as connections which are clarified through how the IFR emerges among firms in the SNS. With that in mind, there are featured IFR that are commonly in the literature that exist among the embedded organizations, for example, formal between firm relations (FIFR) and informal between firm connection (IFFR). Hence, this examination proposes to improve literature on SNC by analysing these IFR to pattern and its relation to level of SNC.

The propose method

There are various complexes IFR with regards to SNS, related to the effort of dealing with the SNC. For instance, Ibrahim, Elias, Saad, and Ramayah [2008] examined the attributes of SN on the effect on procedure advancement in a firm. Kirchoff, Tate, and Mollenkopf [2016] built up the material administration manages in a SNS. The customary reductionist contentions express that organizations may decide on the removal of accomplices who are not meeting the prerequisites of the network participation, specifically when trying to deal with the unpredictability emerging from broad IFR [Miemczyk, Howard, Johnsen, 2016]. Subsequently, this investigation means to survey the IFR that is identified with SNS of a maritime industry by utilizes Social Network Analysis (SNA) procedure to analyze the interrelationship among IFR and SNS, and to delineate causal sociogram to the proposed IFR.

Since the focal point of this research isn't just focused on attributes of firms yet additionally on the relations between firms, this investigation adopted the social network analysis (SNA) methodology by which to get legitimate outcomes for this research. SNA centers around the connections or ties between network members not simply the traits of the network members [Wasserman, Faust, 1994]. As per SNA researchers; a network is comprised of actors which could be people or firms which are interconnected to one another through various sort of social connections [Hanneman, Riddle, 2005]. The collaborations can be as hard ties or delicate ties [Borgatti, Li 2010]. The target of SNA isn't to decide the traits of the actors that effect upon the system, but instead on how the interconnectivity between the network actors' characters' impacts execution [Chakkol, Finne, et al., 2018; Kim, Chen, Linderman, 2015]. Subsequently, SNA enables the research to investigate how firm embeddedness in the SNA would impact the firms' social performance.

Particularly, embeddednesss theory [Granovetter, 1985] is used to conceptualize firms qualitative judgments to the equivocation in uncertainty, while SNA method is to develop and analyze the causal relationship structure of network relations to the structure of the network.

One of the challenges in network research is that of deciding the for the network boundary. An exact boundary will enable accurate determination of target population, just as allowing a compelling depiction of the populace under investigation. An off base boundary determination methodology may deliver wrong network estimations. The challenges related with defining up the correct boundary details in network requests cautious treatment of a specific methodology picked by the researcher. To defeat the deficiencies this investigation at first utilized the nominalist technique and after that enhanced the network with a pragmatist procedure [Diani, 2002].

The proposed measures

There has been an expanding literature on SNC in the previous decades. Numerous variables of SNC have likewise been looked into and examined. In spite of the measure of earlier research and the components considered, there is still new a requirement for new investigations to satisfy the total cognizance of SNC. Increasingly exhaustive investigations are as yet should have been performed with the goal that the consciousness of SNC can be elevated both in the scholarly world and industry. In this investigation the analyst features two components to help the research fundamental measurement. Moreover, the embeddedness theory contends that these

connections or IFR can be as formal business exchanges exercises, for example, legally binding relations or a trap of casual social trades, including data sharing and referral exercises [Papadonikolaki, Verbraeck, Wamelink, 2017]. These kinds of IFR can be either integral or substitutes of the other. Thus, an increasingly exact understanding of the SNC is required. Consequently, the measurement embraced for this investigation is to be Inter-Firm Relation (IFR). While the components are Formal Inter-Firm Relation for example legally binds relations (FIFR) and Informal Inter-Firm Relations for example data sharing relations (IFFR).

Fundamentally, SN is for all intents and purposes shaped by the network or connections between firms where the combination logically frames a definitive structure, which is simply the SNS. The relationship is additionally referred to in the literature as the IFR [Chakkol, Finne, et al., 2018; Chakkol, Selviaridis, et al., 2018]. An IFR speaks to a dyad, or two hubs and one connection, in network terms. Every hub can be conceptualized as an actor performing activities to produce value. The firm needs assets from its provider firm, and the provider needs agreements and instalments from the purchaser. Agreements make the SN's Formal Inter-Firm Relation (FIFR) [Chakkol, Finne, et al., 2018]. FIFR directly affects the SNC through ties availability. By formal authoritative relations, the central firms authorize formal relations through legally binding terms (FIFR) and guidelines upon other network members. Over that the FIFR, firms interface to share data with respect to advertise openings and new dangers [Cousins et al. 2006]. As an outcome, these create a connection and structure a dyad or the IFR. Since a firm frequently has connections to different firms, the firm brings to the dyad new by implication associated firms. So also with the provider firm, this will likewise carry to the dyad their connections with different firms either legitimately or in an indirectly way [Choi and Kim 2008]. Indisputably, a FIFR is a dyad; it is additionally part of a network.

Within an SN, the IFR may also take the form of informal information sharing ties (IIFR) [Carter, Ellram, Tate 2007; Galaskiewicz 2011a; Kim et al. 2010; Mueller, Buergelt, Seidel-Lass 2007]. Slack, Chamber and Johnston [1995] identified these ties base 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 firms. Most importantly, it also involves informal forms of relations (IFFR) such as other commercial transactions including information-sharing (IFFR) and referral activities, which create a significant competitive advantage to the firms embedded in such relationship structures.

SNC is a complex concept that can be explained with many dimensions. Prior studies have tried to explain the SNC and propose solutions through merely attribute dimensions. This study uses a different set of dimension and elements that can best answer the research objective.

METHODOLOGY

This section provides an overview of the industrial background and comprehensively presents the Social Network Analysis method.

Industrial Background

An interrelated firms working together in a SN of a maritime industry framed the number of population in this research. The focal firm in this study is the APMMHQ-1 (nom de plume for the motivations behind secrecy). The APMMHQ-1 is an assembling organization in the Malaysian shipbuilding industry engaged with ship fixes, sea works and building. Until this point, the organization has granted agreements to nearby merchants and providers totalling RM31 million for the improvement of little vessels in the locale.

A network of firms operating in a supply network of a small maritime industry company

formed the population of this study, i.e. the APMMHQ-1 (pseudonym rounded for the purposes of anonymity). The APMMHQ-1 is a manufacturing company in the Malaysian shipbuilding industry involved in ship repairs, maritime works and engineering. To date, the company has awarded contracts to local vendors and suppliers totalling RM31 million for the development of small vessels in the region.

As a maritime nation, Malaysia potential to be a maritime industry hub is vast. However, despite the supports and encouragements from the government, the industry still operates in limited scopes of productions. It has been argued that, such phenomenon happened because managing the complexity of the supply network has been a difficult task for managers. Currently, at different stages of the transformations process of the APMMHQ1, values are added to the processes. Thus, in its essence, this concept models the supply network as a linear series of value adding stages that transfer raw materials and services to the focal firm. They are then ultimately distributed to the downstream customers through the distribution agents and retailers. Consequently, the overarching linear model of the supply network has been adopted by many managers in the maritime industry in Malaysia.

Researchers placed that the linear perspective on the interconnected firm, one which is contended to be lacking, dismisses the normal manners by which IFR in the SNS are shaped and advanced [Hedvall, Jagstedt, Dubois, 2019]. In this manner, it is contended that the SN now contains a blend of progressively formal and informal IFR, along these lines making a substantially more perplexing network structure [Hedvall et al., 2019]. This unavoidably makes a perplexing structure of connections between the elements in the SNS. It likewise demonstrates that the SN has turned into a progressively complex network due to the exercises and trades that have expanded throughout the years.

The players of the industry did not acknowledge or value the relations with other supply network members. The focus of the industry has been driven towards obtaining fast contracts and maintenance works. Little has been invested into maintaining network relations both domestics and abroad. In the context of the IFR, it can be seen that related parties in the network of relationships encounter conflicts through goal incongruences and suspicions of assets abuse. Consequently, the researcher addressed the issue of IFR in the SNS by investigating the pattern of firm embeddedness through its network structural positions in the two types of IFR.

Social Network Analysis Method

Examination of the ramifications of these structures upon the embedded firms requires a technique that can break down the attributes of the actors, yet in addition the relations between the organizations that structure the structures. Wasserman and Faust [1994] contended that the standard statistical technique and investigation isn't proficient at estimating relations. One significant actuality behind this contention is that standard statistical investigations repudiate the presence of connections between firms in a network through the suspicion of freedom of perception. Be that as it may, the network approach, all the more explicitly the Social Network Analysis (SNA), centres around the relations among firms and the example of the relations and the ramifications of the connections. Organizing of network of relations has significant ramifications for actors of the different network. These structures include the example of ties. A network researcher would try to show these connections to delineate the structure of a gathering. One could then examine the effect of these structures on the working of the network or the impact of these structures on actors inserted inside these network structures. Exploratory network analysis was applied to investigate examples of collaborations among firms which used to decipher the general example of embeddedness of firms in the APMMHQ-1 SNS. This examination was performed utilizing social network software, for example UCINET, NetDraw, Mage and, Pajek [Borgatti, Everett, Freeman, 2002]. Following are the explanatory steps of SNA for this investigation.

Data Analysis

Step 1: Determine study population

The initial step of SNA is to decide the number of population to be studied. There are two inspecting units in this examination, specifically: the organizations that possess the APMMHQ-1 SNA for the item RHIB and the ties or connection between them. In network study, the strategy used to test relations is a piece of the study instrument. In this investigation the analyst applied the pragmatist and nominalist approach so as to decide the suitable study sample.

Step 2: Network data collection

Leading network researchers such Borgatti and Li [2009] declared the power of surveys to get network information on inter-firm relations such as: data transfer, resource transfer and joint activities. A survey is appropriate for this sort of study as a result of it permits the scientist to research the participants' subjective perceptions of interactions [Diani 2002].

The survey form consisted of closed-ended queries and open-ended questions. It begins by asking general queries and is followed by additional specific and inquiring questions. The network survey form was adopted from many network queries of previous network studies on IFR [Borgatti, Li, 2009; Borgatti, Jones, Everett, 1998; Cousins, Handfield, Lawson, Petersen, 2006; Krause, Handfield, Tyler, 2007].

One class of queries investigates the network ties between the corporations within the APMMHQ-1 network. During this section, the survey shows a table with the names of all the corporations listed within the initial column of the table. Supported this, the respondents were asked to point by a check on the table the list of corporations that they need been in communication with for every style of relationship listed within the last sixth months. These styles of ties are necessary so as to grasp each formal and informal relationship among. The kinds of ties investigated were, specifically: contracts, and information-sharing. The written agreement tie queries show however formally coupled one firm is with another within the upstream offer network. The survey instrument asked the key informants to point on the list the list of corporations with that they need formal service contracts concerning the provision of materials for the merchandise RHIB. The corporations may be in tier 2 provision materials to the tier one provider, successively provides the focal firm (i.e. APMMHQ-1) with the materials necessary for the assembly of RHIB [Provan, Kenis, 2008].

The information-sharing ties illustrate the norm of collaboration and cooperation between the organisation/unit that's declared in formal links or ties. Network information on information-sharing ties reveals collaboration in a network. Information-sharing was assessed within the network survey by asking key informants to point on the rosters that of the corporations listed below may need AN exchange of knowledge to accomplish their work.

Step 3: Degree of connectivity index

This study can analyse the degree of SNC obtained in two indexes. First, we'll offer the index score of network density. Density is outlined because the variety of connections a participant has, divided by the overall potential connections a participant might have. As an example, if there are twenty folks collaborating, every person might doubtless hook up with nineteen people. A density of 100 percent (19/19) is that the greatest density within the system. A density of fifty indicates there's just one of nineteen potential connections among the SNS.

Step 4: Pattern of connection index

The second index is that the centrality index. Centrality focuses on the behaviour of participants in network. It measures the extent to that network members interacts with others within the network. The additional a personal connects to others in an exceedingly network, the larger their centrality within the network. The measures also are associate degree indicator of patterns of interactions between actors reckoning on the sort of relationships.

They're applied to holistically describe interaction pattern in network with the various kind of relationship.

Step 5: Mapping the causal IFR diagram

Network measures will form a first half of the data analysis using the UCINET. A second analysis technique captures the other half of the study question. These structural measures are not exhaustive. However, they have been used rather extensively in social network analysis research which involves inter-individual studies. In the second analysis, we present the network plots of the different relationships focusing on both buyer-supplier firms. This analysis is done using NetDraw and Mage. The generated network plots will fully capture the research question as it will graphically indicate the extent of embeddedness of buyer-suppliers firms in the network base on the different type of relationships.

RESULTS AND DISCUSSION

This study collects SNC attributes from the literature to propose for the industrial solutions and theoretical contributions. A group of 37 managers representing the respective firms in a maritime industry supply network were approached. These firms were requested to confirm their ties or relations in evaluating the importance attributes that necessary for the SNC. The analysis result is presented in this section.

Density index score for proposed measured IFR

Density score is the ratio of the actual number of ties in the network (n) to the number of potential ties (2L/g*(g-1), where L and g are the number of ties present in the network and the number of actors (represented by nodes) in the network respectively [Hanneman, Riddle, 2005]. Density scores are presented on a score of 0 or 1. A higher density score indicates a greater degree of interaction among the members in the particular buyer supplier relationship. In Table 1, the first column represents the density scores of the ties or linkages. Because each tie in this study generated its own matrices, the density scores in Table 1 is the density score for each of the contractual ties and information sharing ties. Based on Table 1, we could see that among the IFR density, the information sharing ties (IIFR) has the highest density score of 0.2965. It is followed by contractual ties (FIFR) density with 0.1660. The density scores illustrate that there are more information sharing ties SNS than there is contractual tie linkages between the member firms.

Table 1. SNS Density Index Score

Type of Linkages	Density	IFR Continuum
Contractual	0.1660	FIFR
Information Sharing	0.2965	IIFR

This finding is consistent with findings from studies in other field of inter-firmal studies [Cousins, Handfield, Lawson, Petersen, 2006; Oh, Chung, Labianca, 2004]. It is argued that less formal interactions took place rather frequently among firms and information gathered from the informal ties is more fluent than informal ties. Furthermore, the norm to collaborate among firms minimizes the requirements for formal ties because informal collaboration reciprocity is the yardstick rather than exclusion. Hence firms more often than not involve themselves with informal ties or activities with multiple types of firms than in formal administrative activities based on contracts or transmittal of funds.

Centralization index score for proposed measured IFR

Centralization measures the extent to which a network is around one of few actors. The centralization score is between 0 and 1 with higher values indicating that there is a high degree of centralization in the network around a central actor or actors. Table 2 documented the centralization score of the linkage matrices. In Table 2, the centralization index of contractual ties is 0.31428. The centralization score for information sharing is 0.4724. This score suggests that FIFR such as contract ties are less centralized. It is common in a centrally managed system such as the SNS to

have the focal firms to closely monitor the activities within which the network makes up.

Table 1. SNS Centralization Score

IFR	Network Centralization	IFR Continuum
Contractual	0.3142	FIFR
Information Sharing	0.4724	IIFR

The information sharing matrix linkages centralization score is 0.4724. Although previous studies have found that in other contexts, such as health care firms, the information sharing centralization index displays a very low score, we found that in the context of the SNS the centralization index remains high. This could be due to the fact that, in SNS, 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 firms the centre of information sources and provide the focal firms with a powerful positional advantage.

Description of Network Plot

Network structural measures such as the centralization and density scores are primarily concerned with the pattern of the whole network interaction [Burton, 2010]. They indicate the cohesiveness of the network structure. It is an indication of how connected actors in a network are depending on the type of relationship being considered. In the case of the SNS understanding the pattern of connectivity based on the different types IFR is key to managing the SNC [Choi, Kim, 2008]. Although the network structural measure illustrates the whole network connectivity pattern, it lacks the ability to indicate the dominant type of players in a network. Through our review of the literature, such illustration can be accomplished through either an ego network study, whereby an analysis of each of actor in the network would have to be undertaken or through network plots of the different type of IFR. Because this study population is high, we opted for the latter.

Figure 2 displays the network plot for the information sharing relationship network.

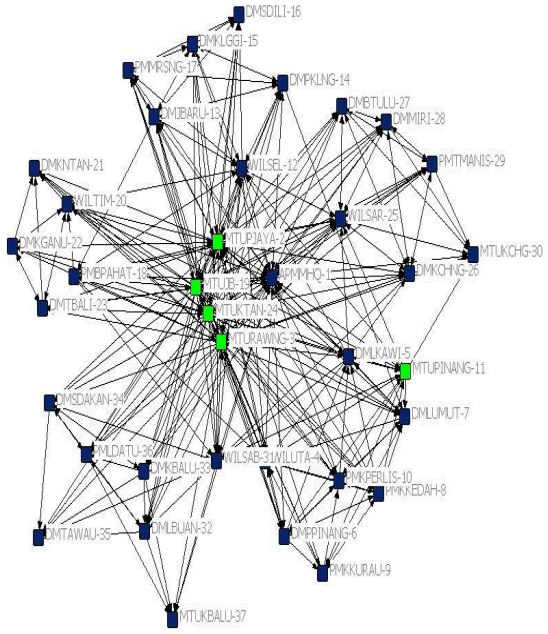
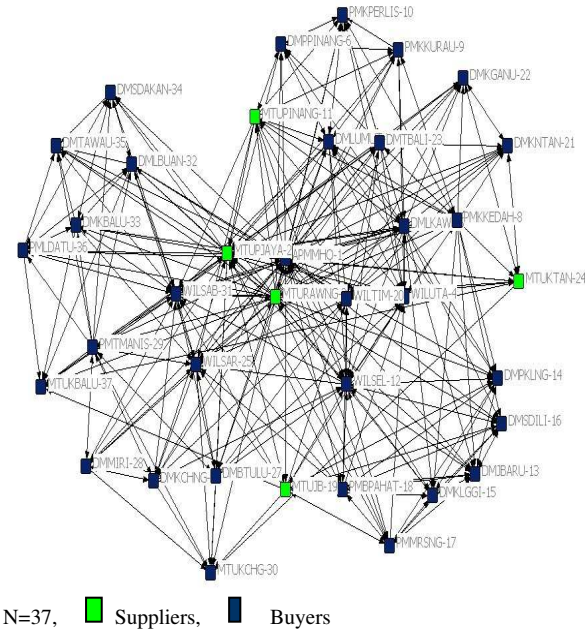


Fig. 1. Network Plot for Contractual Buyer Supplier Relationship

Network structural plots give an interesting approach in describing the structure and the embeddedness of the firms. It shows the extent of connectedness of an actor to other actors in the network through the number of lines. An actor that is more connected to another actor would have more lines connecting it to other actors. Hence, the high number of lines would place the actor in a central position in a network. The Ucinet software external to the whole network structural plot would locate an isolate or actor without any ties to other actors. However, in this preliminary report, we adhered to Kilduff and Tsai [2003] who stated that network plots are only useful to the degree that they complement and assist in answering theoretically motivated questions [Kilduff, Tsai, 2003]. In this study the network plots approach will be used for that purpose. Using NetDraw and Mage, we provide the

embeddedness description of firms in a SNS based on the different types of IFR.

In the network plot for the contractual relationship, the network is dominated by the supplier firms, which are coloured in green. Almost all firms have contracts directly with the MTU ISS firms or are indirectly connected through other mediator firms. For example MTURWANG-3 has 33 direct and indirect contractual ties with other member firms in the network. The second most firms with most contractual ties with other firms in the network are the MTUKTAN-24 and MTUJB-19, both with 32 ties. We could see clearly from this network plot that supplier firms are predominantly centrally located in the plot based on the high amount of ties. In this contractual buyer supplier relationship, suppliers are likely to be more involved and more embedded in the central location of the network. The network plot in Figure 1 indicates that in formal buyer supplier relationships, central roles are played by supplier firms. Contractual maintenance activities such as ordering and replenishment activities are actively monitored by supplier firms to ensure a timely supply of materials when needed by the users.



N=37, Suppliers, Buyers

Fig. 2. Network Plot for Information Sharing

Figure 2 is the network plot for the buyer supplier referral relationship network. Based on the diagram, we could see that there are linkages with every firm in the network. This network plot indicates a rather centralized structure of connectivity between member firms in the network.

Furthermore, in this network plot we could also identify that, unlike in a contractual network where the supplier firms are dominant; buyer firms such as APMMHQ-1 have become part of the core firms in the exchange or sharing of information activities. WILTIM-20 and WILSEL-12 have also more information sharing ties with other supplier and buyer firms. Supplier firms such as MTUJB-19 and MTUKTAN-24 have now settled in the periphery of the network structure. The network plot shows that central positions in information sharing buyer supplier networks are dominated more by buyer firms than supplier firms. Hence information sharing buyer supplier relationship of the network is more likely to be dominated by buyer firms than suppliers.

DISCUSSION

This section provides the theoretical insight to contribute to the existing literature and managerial implication for industries.

Theoretical implications

There are two aspects that are prioritized: Formal Inter-Firm Relation (Contract Relations) and Informal Inter-Firm Relation (Information Sharing Relation)

It was evident from the exploratory network analysis of the network maps that firm embeddedness in the SNS was related to the degree of formality of the IFR.

Informal Inter-Firm Relation (Information Sharing) shows to have the strongest effect toward the aspect of IFR and consequently SNC. In prior studies, IIFR plays an important role for obtaining opportunities or new innovations.

This study emphasizes that IIFR should be intensively managed by the firms embedded SNS to tackle SNS because IIFR shows strong effect on SNS and consequently SNC. IIFR approaches through information sharing activities may generate more collaboration and interactions with other members in the SNS. IIFR efforts should emphasize on information sharing activities. Therefore, the impact of IFR sticks more firmly with the members of the network and the resulting SNS. IFR also shows to have included FIFR. This could be because the basis on a SNS usually comes from the FIFR before the IIFR becomes abundance. What is means is that, many IFR in SNS is first forms because firms are embedded in the SNS through the contractual obligation of supply and distribution. Eventually, IIFR becomes more abundance as firms become more connected to other firms through other type of IFR including the IIFR. On the theoretical level, it can be said that, informal relations can be better mechanism for medium of communication in SNS. The more firms can embrace the importance of the IIFR, the more effective it may affect the management of the SNS and consequently the SNC.

Industrial Implications

The elements and dimensions explored provide insights for maritime industry SN management in Malaysia so they can help improve the quality of SN through a voluntary participation from the firms.

In the context of the maritime industry SMS, firms were found to be more embedded or involved in network relations that require less formal coordination approaches than in the network relations that were formally managed through terms and regulations. An example of this is the contract tie, as evidenced through the increased level of connectivity among firms. Network maps indicate that in formal relationships, such as contract ties, the extent of firms' embeddedness is lower. On the other hand, in informally integrated relationships, the results show a high level of embeddedness or involvement, as indicated by the high score of network structural measures of embeddedness.

The finding adds to the views that, at least in the APMMHQ-1 supply network, formal coordinative relations (such as the contract tie) only represent a small part of the actual interaction that exists in the SNS. It was also determined that the other (or maybe the larger) portion of the network economic actions is transmitted through a network of social relations.

Second, the finding of the exploratory network analysis also indicates that in the context of the supply network, firms are embedded through an integrated form of a network of formal and informal inter-firm relations. The existence of an integrated form of relations coincides with Chakkol, Selviaridis, & Finne (2018) who argued that an integrated structure of embedded ties (informal relations) and arms-length (formal relations) is the optimal form of integrated structure.

Consequently, this finding means the existence of a heterogeneous form of firms in the context of the supply network structure. As the firms are embedded in different types of network ties, such as the formal contractual tie network and informal information-sharing tie network, these different ties impact upon the embeddedness nature of the firm in the network. The reason for this is that, although the two ties are distinct, it is essentially an overlapping network structure which created a firm having a distinct characteristic to attend to both the formal and informal ties at the same time in the network. Essentially, we could refer to these firms as heterogeneous firms (of formal and informal characteristics) as they are both formally and informally embedded based on type of ties.

CONCLUSIVE REMARKS

Topics about SNC have not been often associated to the role of IFR. Earlier studies often link SNC with attributes of the firms embedded in the SNS. This study highlights the importance of how firms interact with other firms in the SNS. Therefore using the SNA method, these study asses a set of dimensions and elements to determine the importance of IFR for improving and understanding SNS in

maritime industry in Malaysia. These methods enable the researcher to transform relational data in the form of network matrix and produce reliable results for theoretical and industrial applications which have not been discovered in previous studies.

The findings of this study contributed to the context of the SNS, firms' embeddedness or involvement is contingent upon the type of network relations thus creating a new structure other than the traditional linear structure of the supply network. Clearly, the exploratory network analysis has given a strong indication that, in the SNS, 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.

Thus, overall, the researcher found that, in the context of the supply network structure, firms' embeddedness or involvement is contingent upon the type of network relations. Firms are more embedded in informal networks of relations than in formal ones thus creating a non-linear structure of the supply chain.

In conclusion, by considering the overall implications of our study, we may conclude that supply chain evolves. Managers need to consider their firm's existing embeddedness in order to exploit the competitive advantage of supply network inter-firm relationships. Firms that fail to understand the underpinnings of these relationships stand to face more difficulties within the network itself. For this reason, managers who 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.

LIMITATION OF THE RESEARCH

There are some limitations to this study. First, the limitation of this study is the context of this research. The sample of this study centres around the maritime supply network in Malaysia. Although this may reduce the generalization of the findings, this study is the first to adopt SNA for supply chain management research. Future research interest may adopt this research framework and apply it in other contexts of research. Second, this study is limited to the information sharing ties as the IIFR. Other IFFR that include referral relations may provide unique sets of findings. Future studies could use other types of IFR that include referral ties of in other form of industry. Further literature on SNC should be enriched depending on the specific relations that are has been used to be analysed in this study.

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KOMPLEKSOWOŚĆ ŁAŃCUCHA DOSTAW W PORTACH MORSKICH MALEZJI: WPŁYW RELACJI MIĘDZY FIRMAMI NA STRUKTURĘ ŁAŃCUCHA DOSTAW

STRESZCZENIE. **Wstęp:** Kompleksowość jest interesującym tematem badań naukowych w połączeniu z tematem stosowania dobrych praktyk oraz jego wpływu na funkcjonowanie łańcucha dostaw. Praca skupia się na obszarze przemysłu, gdyż jest on stosunkowo mało opracowany w ostatnio publikowanych pracach, gdzie są często pomijane aspekty zależności sieciowych, wpływających na kompleksowość łańcucha dostaw (SNC). W szczególności praca skupia się na elementach wewnętrznych relacji firmowych (IFR), formalnych relacjach wewnątrzfirmowych (FIRF) oraz nieformalnych relacjach wewnątrzfirmowych (IIFR), które są szczególnie potraktowane w prezentowanej pracy. W pracy zastosowano metodę analizy sieci socjalnych (SNA) w zmodyfikowanej formie dla oceny procesu oraz teorii zagnieżdżenia, które zostały użyte do oceny relacji wewnętrznych. W pracy stwierdzono, że FIFR i IIFR mają różny wpływ na formowanie SNS oraz w konsekwencji na kształt SNC. Poddano dyskusji również teoretyczne i przemysłowe implikacje.

Metody: Tradycyjne narzędzia statystyczne koncentrują się na wpływu czynników na ekonomiczny wynik. Dlatego też tradycyjna analiza statystyczna nie jest wystarczającą dla pomiaru wpływu relacji i powiązań między członkami sieci na kompleksowość tej sieci. W celu tej oceny, zastosowano metodologię SNA (Social Network Analysis), do zbierania, analizy i interpretacji danych. Dane zebrano na podstawie ankiety pomiędzy członkami łańcucha dostaw obszaru portów morskich. Zebrane dane zostały poddane analizie w specjalistycznym programie UCINET oraz NETDRAW. Do oceny relacji sieciowych oraz kompleksowości zostały użyte wskaźniki statystyczne takie jak centralizacja i gęstość.
Wyniki: Wyniki badań wskazały, że relacje wewnątrzfirmowe (IFR), formalne relacje wewnątrzfirmowe (FIRF) oraz nieformalne relacje wewnątrzfirmowe (IIFR), uwzględnione w pracy jako istotne, mają różny wpływ na kształtowanie się SNS oraz w konsekwencji na SNC.
Wnioski: Wyniki analizy statystycznej wskazują, że kompleksowość sieci występuje w różnej formie i strukturze, w zależności od typu relacji, kształtującej daną sieć. W konsekwencji, różnego rodzaju zasoby i strategie jak i poziom kompleksowości sieci są różne w różnych etapach połączeń.

Słowa kluczowe: analiza sieci, przekazywanie informacji, łańcuch dostaw, kompleksowość

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