

Abstract No:008-0533

Social Networks and Supply Chains

Naomi J. Brookes*
Amrik Singh
Aston Business School
Aston University
Birmingham
UK
B4 7ET

POMS 19th Annual Conference, La Jolla, California, U.S.A May 9th –May 12th 2008

ABSTRACT

Social networks have been used as constructs in social sciences since the 1950's. The social network perspective implies viewing systems in terms of relations between individual actors, where actors and actions are seen as interdependent rather than independent. The relational ties between actors allow the transfer of resources: physical or information based. Network structures are developed from combinations of these 'dyadic' relationships between two actors. Network models explain structures in terms of lasting patterns of relations between actors.

Despite the longevity of the 'social networks' perspective, the interrelation of social networks and supply chain management is a topic that has received limited attention from researchers. Given the significant role that social networks can play in resource transfer, understanding the ways that social networks support or impinge upon supply chain structures is of interest to the effective management of supply chains. This paper presents a tentative framework to explore the interaction of social networks at several levels-of-analysis with supply chain structures.

1.0 INTRODUCTION

This paper explores the utility of social network theory as a lens through which to explore constructs of supply chain structure. It begins by outlining social network theory and the uses to which it has been put in explaining management phenomena. It then examines the limited work to date that has been carried out in linking social network theory to supply chain structure. It calls upon literature from both operations management and marketing in undertaking this review. It concludes by proposing how social network theory can be employed at two levels of analysis (the organisational and the individual) to provide insights into developing supply chain structures.

2.0 SOCIAL NETWORK THEORY AND ITS APPLICATION TO MANAGEMENT PHENOMENA

The concept of 'social networks' is well established. Social networks have been used as constructs in social sciences since the 1950's (e.g. (Hayashi, 1957; Mouton, Blake, & Fruchter, 1955)). The features of the social network perspective have been summarized by Wasserman & Faust (1996). The social network perspective implies viewing systems in terms of relations between individual actors, where actors and actions are seen as interdependent rather than independent. The relational ties between actors allow the transfer of resources: physical or information based. Network structures are developed from combinations of these 'dyadic' relational ties between two actors. Network models explain structures in terms of lasting patterns of relations between actors. Combinations of relational ties can form 'paths' through the network by which non-adjacent actor nodes can communicate. The mathematical analysis of networks, either in the form of sociomatrices or topological networks, has formed the basis of a research perspective known as Social Network Analysis (SNA) that has been documented exhaustively by Wasserman and Faust (1996). Seminal

work in applying concepts of social networks to management issues was undertaken by Krackhardt & Hanson (1993), with a summation of that experience presented in the Harvard Business Review.

Social network theorists call upon a number of key constructs to describe and to analyse the social networks under their consideration (Wasserman & Faust, 1996). These include:

Centrality – centrality is a measure of the ‘importance’ of an actor node in the network. ‘Importance’ is either measured in terms of ‘degree’ centrality (the number of ties that an actor node has) or ‘betweenness’ centrality (the number of ‘shortest paths’ between network nodes that the actor node in question sits upon)

Relational tie characteristics – the ties between actor nodes can be characterised along a number of dimension. These are known as relational tie characteristics

Density – network density is calculated as the proportion of relational ties in a network to the total possible number of links between actor nodes in the network

Concepts of social network theory have a long-established usage in innovation research. In 1973, Granovetter’s seminal paper, *The Strength of Weak Ties*, argued that differing relational characteristic pertaining to the strength of relational ties enabled innovations to flow through a social network. The potential for social network concepts to impact upon product development, in particular global product development, has been recognized since the mid 1990's (Brookes, Morton, Grossman, Joesbury, & Varnes, 2007). A wide range of studies have all supported the proposition that the structure of a social network could affect product development performance. Many of these studies have either specifically focused on NPD teams directly or have considered related issues of group performance or knowledge sharing required for effective NPD team performance. (It should

be noted that the links between social capital, social networks and new product development are not always identified as beneficial.) In many cases the focus of investigation has been the ability of a social network structure to carry knowledge. The transfer of knowledge between individuals has been shown to be dependant on both the social network structure that an individual possesses and the relational nature of the ties within that network (Reagans & McEvily, 2003), (McEvily & Zaheer, 1999), (Cross & Cummings, 2004). For example, Hansen has shown that strong relationships facilitate complex information transfer, weaker quicker but can't transfer complex information (Hansen, 1999). Constant et al. have shown that weak ties carry technical advice (Constant, Sproull, & Kiesler, 1996).

In contrast to the use of social network theory in innovation and new product development research, the application of social network construct to the management of supply chains is not well developed. Lamming, Johnsen, Zheng, & Harland (2000) in articulating the construct of a 'supply network' do call upon the concept of a 'social network' but use it in a very narrow sense to describe a sub-set of networks based on personal parity and use examples of industrial clusters and some sub-contracting relationships. Their usage of the term 'social network' does not articulate or incorporate any of the concept normally associated with social network theory. A number of articles in the Marketing and Operations management bodies of research literature have begun to utilise relational tie constructs in describing supply chain structures. Wathne & Heide (2004) describe dyadic relationships in a garment manufacturing supply chain and the implications of these relational dyads on the approach to marketing in this context. Cousins, Handfield, Lawson, & Petersen (2006) conceptualize the relationships between buyer and suppliers as relational dyads and describe how relational 'capital' can be garnered and utilised across these dyadic relationships. Lazzarini, Chaddad, & Cook (2001) introduces the concept of 'netchain analysis.' A netchain is a set of networks comprised of horizontal ties between firms within a supply chain which are sequentially arranged based on vertical ties between firms in different layers. In developing the

'netchain' concept , they refer explicitly to both social network theory and supply chain structuring.

They state:

“Even though both SCA and NA stress the importance of interdependencies between multiple firms and how interorganisational relationships can be a source of competitive advantage, the integration of their core concepts and analytical tools is still to be done.”

Although, Lazarrini et al. (2001) do use some of the concepts of social network theory, they themselves acknowledge that the quantitative use of social network theory would be a highly useful extension of their work.

3.0) USING SOCIAL NETWORK THEORY IN A SUPPLY CHAIN CONTEXT

The first step in utilising social network theory in a supply chain context is to determine an appropriate 'unit of analysis'. As Tichy, Tushman, & Fombrun (1979) outline in their seminal paper, using social networks in an organisational context demands that the user identifies what social 'unit' each actor node in the network represents. A supply chain could incorporate a wide range of units of analysis:

- Between individual people
- Between organisational groupings (at different levels of granularity)
- Between whole organisations
- Between 'tiering' of organisations

The applications of social network theory presented in this paper focus on organisational social networks and on individual social networks. At an organisational level, this paper examines the

potential role of social networks in capturing and modelling the complexity of global supply chains. At an individual level, this paper explores how the social networks established between individuals can mitigate against supply chain risk.

3.1 Using Social Network Concepts to Model Holistic Complex Supply Chains

Existing approaches to modelling and designing global supply chains have been extensively reviewed by Meixell & Gargeya (2005). They have established an over-arching supply chain model that embraces the decisions inherent in the extant literature on global supply chain modelling and design. However Brookes and Lewis (2006) use an empirical case-study investigation in the aerospace industry to highlight the inadequacies of existing approaches to modelling supply chains. These included:

Multi-Tier Supply Chain Elements: Suppliers of materials featured at every tier in the supply chain . For example, all tiers of the aerospace supply chain (company, customer and supplier) were likely to use composite materials from a small defined group of suppliers. The appearance of the same organisation at every tier of the supply chain is difficult to explore using conventional supply chain models

Cross-Supply Chain Interactions: The featuring of a supplier in a competitor's supply chain needs to be captured in a model so that potential inimical effects can be identified and accommodated. Many current approaches to modelling supply chains fail to capture interactions between supply chains.

Reverse Flows in Supply Chains: The combination of global environmental legislation (e.g. the European Unions WEEE directive) and the move towards whole life-cycle care of products that servitisation demands has led to the need to capture bi-directional and complex flows within supply chains. For example, the aerospace industry is facing is the rise of independent 'Maintenance Repair and Overhaul' (MRO) independent contractors. Maintenance, Repair and Overhaul is an activity

traditionally performed by the aerospace OEM (original equipment manufacturer) after the product has entered into service with the customer. Involvement in MRO and the accompanying spares provision has played an important part in aerospace OEMs' profitability. The effect of complex bi-directional flows of materials on supply chain needs to be understood and current approaches do not incorporate this facility.

Given the drawbacks with existing approaches to modelling complex holistic supply chain networks, this paper now explores the potential for a social network approach to modelling to ameliorate the issues above. Social network models of a holistic supply chains would use actor nodes to represent separate organisations or significant organisational sub units. Relational ties between organisations could be used to represent flows of material, information, money or other transactional attributes that are transmitted across the supply chain. Combination of relational ties into a 'path' could represent a supply chain.

Through the simplicity of combination of multiple relational 'dyads', social network approaches can provide much of the functionality identified as required by Brookes and Lewis (2006):-

- Social network models allow actors to interact in a multiplicity of ways. Furthermore, they allow the model to distinguish between actor categories (for example, by ownership of organisation or by product/service type provided.) This allows the model to simultaneously capture different supply chains and the interactions between them.
- Social network models allow for a multiplicity of bi-directional relational ties that allow the model to capture the type of complex reverse flows associated with 'whole life cycle effects' on supply chains.

- Social network models allow relational ties to carry a wide range of information. Ties could be used to encapsulate ‘classical’ constructs such as average lead-time of the transaction but can also be used to capture more behavioural aspects such as levels of trust or perceived risk in a transaction.

A number of pre-existing automated tools are in wide usage to model social networks generally and should be able to be readily adapted for a supply chain context.

Additionally, the constructs used to analyse social networks involving centrality and density also can yield insight when applied to social network models of holistic complex supply chains:-

Centrality: Centrality can be used to identify vulnerabilities (and hence sites of highest potential risk) in supply chains. ‘Degree’ centrality in this context represents the number of supply chain interactions that an organization has. Simplistically, the greater the number of interactions, the higher the probability that disruption of the actor node organisation will cause widespread disruption of the whole supply chain. ‘Betweenness’ centrality indicates the distance between tiers of interaction. If an organisational node displays high level of betweenness centrality, it means that not only does that node have a high level of interaction but that those interactions are with very close tiers of the supply chain. This indicates an even more risky situation because there will be minimal lag or buffering along the particular supply chain paths in question to counteract the effects of any disruption at the actor node. Analysing the centrality of nodes in a supply chain social network provides a mechanism to identify the points of highest network vulnerability and risk.

Density: Density in the context of a social network model of a supply chain represents a quantitative measure of the level of complexity. Highly dense models indicate large numbers of

'multi-tier' interactions. Sparse models indicate relatively 'linear' supply chains where constructs of 'whole chain' ownership can have much greater validity and relevance.

Both density and centrality could be used to characterise typological archetypes of supply chain structures to provide a portfolio of contingent approaches to supply chain management.

3.2 Using Individual's Social Networks to Mitigate Against Supply Chain Risk

In this section of the paper, the unit-of-analysis of the network is the individual working in an organisation within a supply chain. This paper argues that there is a role for social network at an individual level to meliorate supply chain risk.

Supply risk is defined by Zsidisin (2003) as the probability of an incident associated with inbound supply from individual supplier failures or the supply market occurring, in which its outcomes result in the inability of the purchasing firm to meet customer demand or cause threats to customer life and safety. Chopra & Sodhi (2004) go on to argue that there are nine categories of risk: Disruptions, Delays, Systems, Forecast, Intellectual Property, Procurement, Receivables, Inventory, Capacity. This disruption can be mundane and short term or catastrophic and long term. Reviewing the literature on supply chain risk, (Chopra & Sodhi, 2004; Mohd Nishat, Banwet, & Ravi, 2006; Tomlin, 2006) identifies that there are a number of tactics that can be employed to reduce risk in a supply chain. These include:

- Increasing inventory
- Increasing capacity
- Acquiring redundant suppliers
- Increasing/improving communication

All of these solutions have some cost implications but increasing and improving communication has potentially the least cost implications. Reducing supply chain risk through improving the flow of information is an intuitively attractive proposition. Given the functionality of social networks in carrying information, then this paper postulates that individual's social networks could be harnessed to do this more effectively.

This proposition is supported on a case basis by the widely quoted supply chain disruption in Nokia and Ericsson (Chopra & Sodhi, 2004; Norrman, 2004). In this situation the same supplier risk (the burning down of a microchip factory) caused significant disruption to Ericsson, which lost \$400 million in sales, whilst Nokia used the social network of its employees to have access to much quicker notice of the disruption and therefore was able to act more quickly to mitigate against its effect.

The authors of this paper have encountered a similar situation in a case-study of supply chain disruption that they have been undertaking in the aerospace industry. A case study reviewed by the researchers of this paper in the aerospace industry found that when a company went bankrupt in the supply network of a small to medium sized manufacturer (SME), the SME was first alerted of the imminent bankruptcy through the social network of one of its employees. Thus, it was the dyadic relationship between two actors in the supply network which allowed the SME to mitigate the risk of disruption in the supply network through more rapid and effective information flow.

The explicit mapping, analysis and shaping of individuals' social networks have been undertaken with success in a new product development context in the aerospace industry (Brookes, Morton, Grossman, Joesbury, & Varnes, 2007). The experience of using these social network mapping and analysis techniques could be used in a supply chain context to capture relational ties between

individual node actors in different supply chain organisations. These interactions would not be confined to adjacent supply chain tiers but may exist along the entire supply chain thus giving much greater advance warning of potential risk. By identifying potentially productive relational ties between actors, conduits of rapid supply chain information flows could be identified. Where no such relational ties existed, their development could be encouraged. Thus, organisations could explicitly create and maintain social networks to propagate information flow in a way to substantially mitigate their exposure to supply chain risk.

4.0 CONCLUSIONS AND FURTHER WORK

This paper has highlighted the dearth of research in using social networks as a theoretical lens for supply chains and their management. In contrast to the existing levels of investigation, the paper has outlined a number of propositions at both an organisational and individual level that demonstrate the potential of social network theory to explore and intervene effectively in supply chains. These propositions now require empirical investigation to ascertain their utility in deepening the understanding of supply chain phenomena.

References:

- Brookes, N. J., Morton, S. C., Grossman, S., Joesbury, P., & Varnes, D. (2007). Analyzing Social Capital to Improve Product Development Team Performance: Action-Research Investigations in the Aerospace Industry With TRW and GKN. *Engineering Management, IEEE Transactions on*, 54(4), 814-830.
- Brookes, N.J., Lewis P.A. (2006) "Globalising the Supply Chain: A Case-Study in the Premium Aircraft Seating Business" *Moving Up The Value Chain: 13th International Annual EurOMA Conference*: University of Strathclyde, Glasgow, UK June 18-21, 2006

- Chopra, S., & Sodhi, M. S. (2004). Managing Risk To Avoid Supply-Chain Breakdown. *MIT Sloan Management Review*, 46(1), 53-62.
- Constant, D., Sproull, L., & Kiesler, S. (1996). The Kindness of Strangers: The Usefulness of Electronic Weak Ties for Technical Advice. *Organization Science*, 7(2), 119-135.
- Cousins, P. D., Handfield, R. B., Lawson, B., & Petersen, K. J. (2006). Creating supply chain relational capital: The impact of formal and informal socialization processes. *Journal of Operations Management*, 24(6), 851-863.
- Cross, R., & Cummings, J. N. (2004). Tie and network correlates of individual performance in knowledge-intensive work. *Academy of Management Journal*, 47(6), 928-937.
- Granovetter, M. S. (1973). The Strength of Weak Ties. *The American Journal of Sociology*, 78(6), 1360-1380.
- Hansen, M. T. (1999). The Search-Transfer Problem: The Role of Weak Ties in Sharing Knowledge across Organization Subunits. *Administrative Science Quarterly*, 44(1), 82-85.
- Hayashi, C. (1957). Note on Sampling from a Sociometric Pattern. *Annals of the Institute of Statistical Mathematics*, 9(1), 49-52.
- Krackhardt, D., & Hanson, J. R. (1993). Informal networks: the company behind the chart. *Harv Bus Rev*, 71(4), 104-111.
- Lamming, R., Johnsen, T., Zheng, J., & Harland, C. (2000). An initial classification of supply networks. *International Journal of Operations & Production Management*, 20(6), 675-691.
- Lazzarini, S. G., Chaddad, F. R., & Cook, M. L. (2001). Integrating supply chain and network analyses: the study of netchains. *Journal on Chain and Network Science*, 1(1), 7-22.
- McEvily, B., & Zaheer, A. (1999). Bridging ties: a source of firm heterogeneity in competitive capabilities. *Strategic Management Journal*, 20(12), 1133-1156.
- Meixell, M. J., & Gargeya, V. B. (2005). Global supply chain design: A literature review and critique. *Transportation Research Part E*, 41(6), 531-550.

- Mohd Nishat, F., Banwet, D. K., & Ravi, S. (2006). Supply chain risk mitigation: modeling the enablers. *Business Process Management Journal*, 12(4), 535.
- Mouton, J. S., Blake, R. R., & Fruchter, B. (1955). The Reliability of Sociometric Measures. *Sociometry*, 18(1), 7-48.
- Norrman, A. (2004). Ericsson's proactive supply chain risk management approach after a serious sub-supplier accident Andreas Norrman, Ulf Jansson The Authors. *International Journal of Physical Distribution & Logistics Management*, 34(5), 434-456.
- Reagans, R., & McEvily, B. (2003). Network Structure and Knowledge Transfer: The Effects of Cohesion and Range. *Administrative Science Quarterly*, 48(2), 240-267.
- Tichy, N. M., Tushman, M. L., & Fombrun, C. (1979). Social Network Analysis for Organizations. *The Academy of Management Review*, 4(4), 507-519.
- Tomlin, B. (2006). On the Value of Mitigation and Contingency Strategies for Managing Supply Chain Disruption Risks. *Management Science*, 52(5), 639.
- Wasserman, S., & Faust, K. (1996). *Social Network Analysis: Methods and Applications* (2nd ed.): Cambridge University Press.
- Wathne, K. H., & Heide, J. B. (2004). Relationship Governance in a Supply Chain Network. *Journal of Marketing*, 68(1), 73-89.
- Zsidisin, G. A. (2003). A grounded definition of supply risk. *Journal of Purchasing and Supply Management*, 9(5), 217-224.