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Managing triads in a military avionics service maintenance network in Taiwan

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Abstract

Purpose – The purpose of this paper is to investigate how different types of triad structures, and the management mechanisms adopted by the focal company, affect cooperative performance.

Design/methodology/approach – This paper uses a social network perspective to examine the triad management phenomenon in the military avionics maintenance context, which is closely associated with the field of operations management.

Findings – This paper demonstrates that different triad structures and management mechanisms influence perceived cooperative performance. Four main findings emerged: in a triad, a firm playing a bridging role perceives higher cooperative performance than when playing a peripheral role in the triad or being located in a fully connected triad. When a firm plays the bridging role in a triad, and has a high level of trust, this leads to higher perceived cooperative performance. When a firm plays a peripheral role in a triad, high levels of coordination mechanism combined with high levels of trust result in higher levels of perceived cooperative performance. In a fully linked triad, when the coordination mechanism is well developed, the level of trust is high, so that the resulting level of perceived cooperation is high.

Originality/value – This paper extends the knowledge of triad management by providing an in-depth study of a well-defined network setting with exceptionally high-level access to the most senior executives. In practice, this paper shows how to manage different triads.

Keywords Supply chain management, Aerospace industry, Maintenance programmes, Taiwan

Paper type Research paper

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Introduction

Strategic alliances and networks in the field of operations management are becoming more important (Giunipero *et al.*, 2006; Karlsson, 2003). The introduction of the term

"network" into the supply chain management (SCM) field (Pilkinton and Fitzgerald, 2006; Taylor and Taylor, 2009) has extended the SCM concept into more strategic fields (Mills *et al.*, 2004). In theory, networks and alliances are considered voluntary and cooperative inter-firm agreements, aimed at achieving competitive advantages for the partners (Zajac and Olsen, 1993; Gulati, 1998; Das and Teng, 2000). In practice, companies have formed various inter-organisational alliances in order to seek advantages in purchasing, R&D, design, production and distribution. In an era in which networks and alliances are prevailing in practice, managing strategic inter-firm linkages is a significant task and challenge for managers, particularly in the operations management field.

While much research has been devoted to SCM and the inter-firm supply network in operations management, less attention has been paid to managing structural positions in cooperative alliances and networks. On the one hand, in the strategic management field, research has focused on network structures and analysis at the intra-organisational level (Tsai, 2002), organisational level (Gulati and Gargiulo, 1999) and dyadic level (Gulati, 1995). On the other hand, in the operations management field, Mills *et al.* (2004) focused on a four-level framework for SCM (Harland, 1996): an internal chain at Level 1, a dyadic relationship at Level 2, external chain at Level 3 and network at Level 4. Despite this research, one level, the triadic relationship, has been largely ignored. A review of both the strategic management and operations management literature reveals that little work addresses the triadic level in the strategic network and supply network research.

According to Madhavan *et al.* (2004) "A triad is a set of three actors and the possible ties among them". Studying triads is becoming increasingly important for enhancing our understanding of networks as a whole, because the triad occupies an intermediate level in network analysis (Madhavan *et al.*, 2004) and represents a core structure at a high level (Wasserman and Faust, 1994). Despite Madhavan *et al.*'s (2004) emphasis on the importance of triad-level analysis, business networks research has not examined the issue of triad management. The complexity and diversity of triad structures suggest that this field requires future research.

From both practical and theoretical perspectives, the lack of empirical evidence on managing different triads in a network has limited the understanding of the supply network phenomenon. Therefore, we have applied the strategic management and social network perspectives to the operations management field. The objective is to explore how firms implement strategies, so as to manage structural positions within a strategic supply network, in order to survive in the military avionics maintenance industry. By investigating 13 triads in a given supply network in the Taiwan military avionics service maintenance industry, this research investigates how the focal company (FC) embedded in different triads adopts management mechanisms for generating improved cooperative performance. Accordingly, our research question is twofold:

(1) How do different triad structures within a supply network, affect cooperative performance?

(2) From the perspective of a FC, how do management mechanisms affect cooperative performance?

The study examines the research questions from the FC perspective. Within and across the triads, actors occupying different structural positions may use different management mechanisms and perceive different performance. In order to answer the

above research questions, two main streams of literature are examined. These are the triadic structures and management mechanisms in supply networks. As a result, three types of triads and two propositions are identified from literature. These triad types are then used as a basis for collecting and comparing data from 13 different triads across the 15 network actors. Then the results are analysed and discussed, and practical implications drawn. The paper contributes with two propositions and four main findings. Finally, it concludes by revisiting the original research questions and discussing the limitations and some possible directions for future research.

This research contributes to the field in three ways. First, it provides an empirical study of triads, which is important for an emerging field. Second, the respondents were all well-informed chief executives and directors; we are indebted to them for the level of access provided. Third, within a very specific context, we managed to cover the entire population.

Background

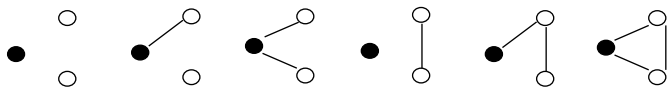
We commence by reviewing the literature, in order to understand the triadic structures and management mechanisms in supply networks.

Triads

As mentioned above, a triad comprises a set of three actors and the potential ties between them (Madhavan *et al.*, 2004). According to Wasserman and Faust (1994) and Gulati and Gargiulo (1999), a focal actor can be involved in six different triads with two other actors; specifically:

- *Triad 1.* All three actors are disconnected.
- *Triad 2.* Focal actor is connected to only one of the two other disconnected actors.
- *Triad 3.* Focal actor is connected to two other disconnected actors.
- *Triad 4.* Focal actor faces two other connected actors, but has no connection to either.
- *Triad 5.* Focal actor is connected to one of two other connected actors.
- *Triad 6.* All three actors are connected.

Figure 1 shows six triads. Triads 1 and 4 are defined as isolated roles; Triad 2 shows only one connection among three actors, so it is defined as a dyad, but not a triad. Therefore, only Triads 3, 5 and 6 represent triad structures of which Triad 6 represents a full connection. Triad 3 is typical of the central role, because the focal actor is located in a structural hole and forms a bridge between two other disconnected actors. In contrast, Triad 5 shows that the focal actor is in the peripheral position in the triad.



Notes: •, stands for focal actor; ○, stands for other actors

Figure 1.
Six types of triad

Triadic structural positions in supply networks

The *IJOPM* citation analysis reported by Pilkinton and Fitzgerald (2006) concluded that SCM evolved into a formal discipline around 1999. As part of this evolution, the SCM concept has changed, and thus the term "network" came into use. This extended the SCM concept into more strategic management (Mills *et al.*, 2004; Harland *et al.*, 2006) and other functional perspectives (Cigolini *et al.*, 2004). The strategic management perspective of supply networks focuses on the study of strategic alliances for a few selected actors within the same network. By following a selective approach, alliances are established only between those companies that recognise each other as potential strategic partners.

As supply networks broaden, the issue of strategic integration arises and the need for understanding the integration across organisations and functions (Harland *et al.*, 2006, p. 746). Harland *et al.* (1999) proposed the concept of "supply strategy" as a more holistic and multi-system level of supply. Triad-level analysis is critical, because the triad occupies an intermediate level in network analysis, which represents a valuable layer of meaning, since dyads are embedded in triads (Madhavan *et al.*, 2004).

In order to explore how firms manage their triadic structural positions in supply networks, we adopted network theory from strategic management and applied the triad concept to supply networks. The strategic network perspective suggests that firms with superior network structures such as central position (Wasserman and Faust, 1994) and structural holes (Burt, 1992), exert a significant impact on access to resource information, social capital brokerage and responses to the environment (Zaheer and Bell, 2005; Gulati *et al.*, 2000). Superior network structures have better:

- *Access to resources and information*: when firms with superior network structures, such as central positions, are able to access resources and information and better exploit them. Those firms show greater efficiency, and more effective coordination and performance than other network partners (Zaheer and Bell, 2005; Burt, 1992). Such firms develop their competitive capabilities and advantages faster and more easily, through a network of ties, than other actors in peripheral positions (Gynawali *et al.*, 2006).
- *Social capital of brokerage*: when firms have an advantage, based on their location in a social structure. Information arbitrage is the major advantage of those actors who bridge the structural holes (Burt, 2004). They are bridging two sides to become aware of interests and difficulties, transferring best practice, drawing analogies between two sides and creating synthesis, which creates the control advantage and bargaining power to control the flow by "playing them off against each other" through the selective transfer of information and other resources (Gynawali *et al.*, 2006).
- *Response to the environment*: when occupying a bridging position, which provides a vision of options otherwise unseen. Firms bridging structural holes have an advantage in detecting and developing rewarding opportunities (Burt, 2004), responding faster to external threats and opportunities (Zaheer and Bell, 2005), and are better able to discover potential exchange partners and allies.

Management mechanisms in supply networks

Supply networks need strategic management skills to plan, coordinate and review goal achievement, such as the management of supplier relationships and strategic thinking (Giunipero *et al.*, 2006). Effective network management is a source of competitive advantage and underpins corporate performance (Bititici *et al.*, 2004, 2005; Bales *et al.*, 2004). The management of inter-organisational relationships across a range of academic disciplines, such as transaction cost economics (TCE), the resource-based view (RBV) and social capital, is used to analyse, explain and formalise the supply activities of individual firms (Cousins *et al.*, 2006). We will expand on each of these in turn.

The TCE perspective on supply networks focuses on contract negotiation and partner coordination and monitoring, which are considered central elements of effective alliance management (Gulati and Singh, 1998). Based on the TCE perspective, coordination mechanisms are important for managing collaborative relationships (Danese *et al.*, 2006), agreements and bylaws in contracts help to define partners' commitments (Gulati, 1995), collaborative decision-making including collective responsibilities for outcomes (Coughlan *et al.*, 2003; Das and Teng, 2003; Jones *et al.*, 1997), and conflict resolution of disputes (Vereecke and Muylle, 2006; Jehn and Mannix, 2001).

The RBV on supply networks focuses on the commitment between partners to work together and to contribute their resources for maximizing value creation (Ireland *et al.*, 2002). Commitment and coordination functions such as setting up collaborative organisations, collecting and disseminating information, scheduling activities and determining demand allocations are important for managing collaborative relationships (Vereecke and Muylle, 2006). Resource allocation (Das and Teng, 2003) and distribution are essential in distributing profits and sharing responsibility among the network actors (Vereecke and Muylle, 2006; Bengtsson and Kock, 2000).

The social capital perspective on supply networks focuses on structural embeddedness, indicates that trust between social actors is necessary to gain full cooperation and for transferring resources and knowledge (Jones *et al.*, 1997). Trust facilitates consensus (Bengtsson and Kock, 2000) and reduces cultural differences, misunderstanding and opportunistic behaviour. In supply networks, high levels of trust, consensus building, communication and interaction contribute to the concept of collaboration as synergistic, unique and creative (Coughlan *et al.*, 2003).

These three different management perspectives concur that coordination and trust are key strategic management skills, which underpin supply network performance.

Managing triads in supply networks

Effective supply network cooperation, integration and management underpin successful supply network performance (Coughlan *et al.*, 2003). Vereecke and Muylle (2006) emphasise that supply network cooperation should be a win/win arrangement that increases business success for both parties. This research studies the structural position that a FC occupies in different triad structures and explores how the structural position influences cooperative performance. From the theoretical perspectives analysed above, we advance two propositions (as summarised in Figure 2):

P1. The types of triad structures affect cooperative performance.

P2. In different types of triad structures, different management mechanisms administered by the company affect cooperative performance.

Methodology

Research setting

Network boundaries have long been a critical concern for network research, as indicated by Provan and Sebastian (1998). The military avionics maintenance industry contains clearly defined supply networks. The prevailing phenomenon of triads within this industry constitutes a readily observable research setting. In Taiwan, the military avionics maintenance industry is characterised by high entry barriers that exclude small companies. This characteristic provides an ideal setting for identifying a clear network boundary and the triads within the network. In Taiwan, four major domestic companies, five foreign companies and six small domestic suppliers operate in the military avionics maintenance industry. The four major domestic companies are the Aerospace Industry Development Corporation, Air Asia, China Airlines and the Evergreen Aviation Technology Corp. of these four, the leading company participated in the investigation as the FC.

The FC, the Aerospace Industrial Development Corporation, previously known as the Aero Industry Development Center, was founded in 1969. In 1996, in order to help achieve national aerospace development objectives, the FC was reformed from a military establishment into a government-owned company under the jurisdiction of the Ministry of Economic Affairs. Through the government support of the past 40 years, the FC has become well-equipped with the expertise and capability dedicated to the aviation industry in aircraft system integration, aircraft development, parts manufacturing, aircraft assembly, testing, verification and maintenance. Currently, it employs 3,000 people with the ability to provide aircraft and components maintenance. In recent years, the market share of the FC has risen from 65 per cent to more than 80 per cent. Through the transition of privatisation, the FC is well positioned to support and foster the various national aerospace development policies.

Research approach

The theoretical issue of managing triads in supply networks is regarded as emergent or nascent. According to Edmondson and McManus (2007, p. 1161), nascent theory is that which has "received little research or formal theorising to date or else that represent new phenomena in the world". In order to achieve a methodological fit (Yin, 1999; Edmondson and McManus, 2007) between the state of previous research, research method, analysis and expected contribution, we adopted an exploratory case study strategy involving 15 network actors operating in 13 different triads (Eisenhardt, 1989; Yin, 1999; Hoskisson *et al.*, 1999; Voss *et al.*, 2002).

We covered the entire population by studying the FC and the other 14 network actors operating in the military avionics service maintenance industry in Taiwan. The total network actors are the FC, which is the dominant network actor, by virtue of holding more than 80 per cent of the market share, five foreign companies, three major

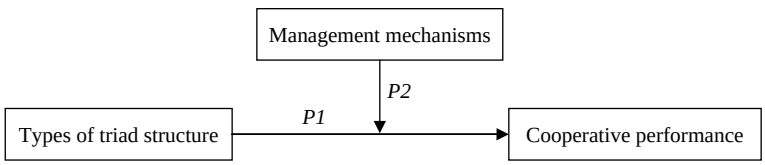


Figure 2.
Research framework

domestic companies and six domestic suppliers and agents. This is the first time this phenomenon has been researched in this context.

We selected the "triad-level" as the unit of analysis. In the Taiwanese military avionic service maintenance industry, the high-entry barriers shape the entire industry, making it relatively small, which enables a clear and easy identification of the supply network boundary. Coupled with the advantage of such a boundary, the case study approach allowed us to gather data on a small number of study objects and yielded a multifaceted view of the management of triads in the given network. For these reasons, case studies within clearly defined network and triad boundaries provided the ideal methodological combination.

About 13 triads from a total of 15 companies were identified. The FC was always one of the companies in each of the 13 triads, but playing a different role. The 13 triads were then categorised into three generic types of triads, based on categorisations given in the literature.

About 13 triads were investigated through structured questionnaires, face-to-face interviews, as well as document examination. Appendix 1 shows the backgrounds of our formal interviewees. The results presented in this paper focus on triad structures, management mechanisms and cooperative performance. Owing to space limitations, full descriptions of the 13 triads are not presented here, but are available on request. The structured questionnaires were designed with a combination of Likert-scale questions and open-ended questions, based on broader information provided in the literature. Appendix 2 gives an example of the type of questions applied. The following section explains the development of the measurement items used in the structured questionnaires.

Measurements items used in the structured questionnaires

The measurement items were developed from the literature, including triad structures, management mechanisms and cooperative performance. We present each of these three in turn.

Triad structure. The triad structure has been categorised theoretically into six triads (Figure 1). In this study, we excluded the null triad (Triad 1), isolated triad (Triad 4) and dyad (Triad 2), because, from a FC perspective, Triads 1 and 4 are defined as isolated roles and Triad 2 yields only one connection between three actors and is defined as a dyad, but not as a triad. Triads 3, 5 and 6 represent our triad structures. Depending on the structural position in which the FC is embedded, we further identified Triads 3, 5 and 6 as three specific types including:

- *Type I:* bridge role in triad, in which the FC is connected to two disconnected partners, playing both a central and bridging role between two partners in a triad (Figure 1, Triad 3).
- *Type II:* peripheral role in triad, in which the FC is connected to one of the two connected partners, playing a peripheral role in a triad (Figure 1, Triad 5).
- *Type III:* fully connected triad, in which three actors are all connected with each other (Figure 1, Triad 6).

Management mechanism. Several mechanisms for managing alliances and networks have been proposed. We have focused on three management mechanisms:

(1) Coordination mechanism is measured by the extent to which the triad is coordinated by the following five elements:
   - formal agreements and bylaws;
   - integrated decision-making;
   - resource allocation;
   - benefit distribution; and
   - conflict management (Vereecke and Muylle, 2006; Danese *et al.*, 2006; Coughlan *et al.*, 2003; Das and Teng, 2003; Jehn and Mannix, 2001; Bengtsson and Kock, 2000; Gulati and Singh, 1998; Jones *et al.*, 1997; Gulati, 1995).

(2) Trust mechanism is measured by the following two elements:
   - trust between the focal actor and the other actors; and
   - trust between two other actors in a triad (Coughlan *et al.*, 2003; Bengtsson and Kock, 2000; Jones *et al.*, 1997).

(3) Market mechanism is measured by the following two elements:
   - the extent to which the contract is determined by the price set by public bidding (i.e. price mechanism); and
   - the potential partners in the market (Ouchi and Bolton, 1988).

Cooperative performance. Cooperative performance is measured either objectively or subjectively. Rond and Bouchikhi (2004) suggest that performance cannot be considered as an objective attribute of an alliance, since different actors can legitimately hold diverse views on performance and how it ought to be measured. For the purpose of this research, subjective measurements are used, not just because information on financial performance is unavailable, but also because performance assessment in a triad is intrinsically difficult. Owing to these limitations, we use perceptual data to substitute for financial data. Danese *et al.* (2006) analysed the sequences of improvement in supply networks and indicated some useful performance measurements, such as supply network efficiency, supply network flexibility and stock-out risk in supply networks. Based on these perspectives and industrial practices, we measure cooperative performance from the FC perspective.

Perceived cooperative performance is measured by the following items (Zollo *et al.*, 2002):

- satisfaction with goal attainment;
- potential new business opportunities;
- satisfaction with the cooperative relationship; and
- willingness for continuous cooperation.

The measurement items of management mechanisms and cooperative performance were designed on five-point-scale Likert type of questions as shown in Appendix 2.

Research process

There were four steps in this research:

(1) identifying network actors;
(2) identifying network connections;
(3) defining units of analysis and samples; and
(4) collecting perceptual data pertaining to management mechanisms and cooperative performance.

These are expanded on turn:

- *Identifying network actors.* First, in order to identify the network boundary, we asked the respondents to indicate the important actors who are already positioned in the Taiwanese market. Re-confirming with all the respondents, 15 companies, including four major avionics-related domestic companies, six other domestic companies, and five foreign companies were identified. The backgrounds of the network actors are given in Table I.
- *Identifying network connections.* Second, we asked the respondents to identify all the connections between actors in the network. The connection between any two actors is identified by three circumstances:
  - long-term and frequent transactional relationships between two companies;
  - two companies have been working together for a long time to complete some project; and
  - long-term supply customer relationships between two companies.

  As indicated in Table I, the long-term relationship between the FC and its partners in this network has lasted between 12 and 30 years. Figure 3 shows the supply network and participation of the FC in the 13 triads.
- *Unit of analysis and samples.* In this study, the sample is defined as a triad comprising a focal actor and its linkages to the other two actors in a network. In this third step, when all the connections between any two actors in the network had been identified, we asked the respondents to indicate the triad that was formed by the FC and its connections with the other two actors. In order to ensure the validity of each triad sample, we cross-checked with all the respondents, until they confirmed that each triad had its structural operation in place. Finally, 13 triads were identified in this network, which constitute the research samples for the study. According to the triad structures, these 13 triad samples were categorised further into the three types of triad structure identified from the literature;, i.e. Types I, II and III. Table II shows the 13 triad samples (categorised by three types of triad structure in the network), the specific task of each triad and the correspondent FC department involved within each triad. Five triads were identified as Type I – a bridge role in triad, (shown as dark gray lines in Figure 3), four triads were identified as Type II – a peripheral role in triad (light gray lines in Figure 3), and four triads were identified as Type III – a fully connected triad (black lines in Figure 3).
- *Collecting perceptual data and analysis*. Finally, we collected data on management mechanisms and performance. We conducted the individual face-to-face interviews in order to establish how each triadic relationship was represented in practice. In addition, the structured questionnaire yields insights into the

Actors	Area of expertise	Nationality public/private	Size number of employees	Relationship with FC	Continuity of relationship (years)
FC	Aircraft manufacture, system integration	Taiwan/public	3,000	–	–
LMTAS	Aircraft manufacture, system integration	USA/private	20,000	Competitor and collaborator	25
Rockwell Collins	Aircraft manufacture, system integration	USA/private	20,000	Competitor and collaborator	25
Northrop Grumman	Aircraft manufacture, system integration	USA/private	20,000	Competitor and collaborator	25
Tele	Avionics system provider	USA/private	200	Subsystem provider	12
AGI	Parts provider	USA/private	20	Subsystem provider	12
A	Aircraft maintenance, system integration	Taiwan/private	600	Supplier, competitor	20
AR	Avionics system maintenance	Taiwan/private	100	Supplier, competitor	12
LW	Avionics system maintenance	Taiwan/private	30	Supplier, competitor	12
ITRI	Avionics system integration	Taiwan/public	250	System integration	30
B		Taiwan/private	7	Agent	12
RG		Taiwan/private	7	Agent	25
EAT	Airline, Avionics maintenance	Taiwan/private	5,000	Competitor	20
C	Avionics system maintenance	Taiwan/private	30	Supplier	12
SK	Avionics system maintenance	Taiwan/private	30	Supplier	12

Note: The "continuity of relationship" is calculated until 2008

Table I.
Network actors' background

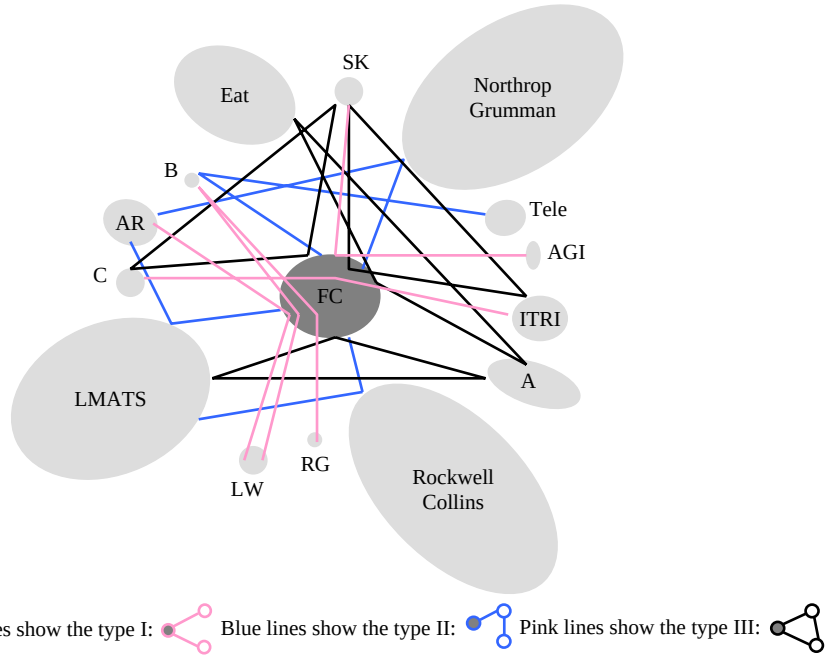


Figure 3.
The supply network of the FC

extent to which the FC perceives and uses the management mechanisms and the effect on cooperative performance. We asked respondents from the FC to reflect on each triad while answering the questionnaire. For each triad sample, the respondents were asked to circle a number from 1 to 5 on the questionnaire, to indicate the extent of perceived management mechanisms and cooperative performance. To minimise respondent bias, we triangulated the interview data and cross-checked the answers. This indicated consistency between respondents. We also supported the responses with the use of archival records and documentation. Based on the interview responses and the documentation, we are able to identify the differences in management mechanisms adopted by each triad and the cooperative performance generated.

Data collection

In total, 16 interviewees provided the data for the research, five from the FC and 11 from the other companies in the network. A total of 68 interview transcription pages resulted from 150 hours of face-to-face interviews and telephone interviews. In addition, informal interviews, those with other network employees and *in situ* document analysis formed part of the research. The interviewees were well-placed informants, including one deputy general manager, two CEOs, two vice CEOs, one chairman of the board, and ten directors. Most have had at least ten-20 years of practical experience in their areas of expertise. Appendix 1 shows the backgrounds of the interviewees.

Type of triad structure	Triads (samples) in the network	Task of triad	Correspondent FC department
Type I: bridge role in triad	I-1 LW – FC – AR	Military aircraft radar maintenance	I Radar
	I-2 B – FC – LW	Navy's radar maintenance	N Radar
	I-3 C – FC – ITRI	R&D of aerospace technologies	Avionics Maint.
	I-4 RG – FC – B	Efficient customer support	Avionics Maint.
	I-5 AGI – FC – SK	Military aircraft testing equipments	Test Station
Type II: peripheral role in triad	II-1 FC – LMTAS – AR	Parts and components supply	I Radar
	II-2 FC – Northrop – AR	Technical transfer for F-16 APG-66	F Radar
	II-3 FC – Collins – LMTAS	Navigation and communication systems	Avionics Maint.
	II-4 FC – B – Tele	Technical transfer for Navy's avionics maintenance	N Radar
Type III: fully connected triad	III-1 FC – LMTAS – A	Government-owned and company-operated project	Avionics Maint.
	III-2 FC – EAT – A	Forming a new aircraft maintenance venture	Avionics Maint.
	III-3 FC – ITRI – SK	Subcontracting the test station software	Test Station
	III-4 FC – C – SK	Outsourcing the test station software	Test Station
	Total samples: 13		

Table II.
Thirteen samples in three types of triad structures

Data analysis

Data from the structured questionnaires were analysed in two ways. First, the structured questionnaire responses were captured and analysed within a database. We synthesised the management mechanisms and cooperative performance results from each individual case. These individual results were then analysed, compared and contrasted in relation to their position and relationship within the respective triads. The synthesis of this analysis is presented in Table III. The interpretation of the data was performed by focusing on the highest scores and then comparing them with the lowest scores. Second, the content of the open-ended questions was analysed. The data were then triangulated with the structured questionnaire responses. The structured questionnaire responses from the Likert-scale questions were coupled with qualitative quotations from interviewees, a process referred to as data confirmation or confirmatory analysis. Finally, data from archival records and documentation were triangulated with the interviewee analysis (explained above); a so-called triangulation of multiple sources of information. By using different respondents, different sources of information and, to a certain extent, a variety of methods, we increased the internal validity and reliability of the research.

Results

The purpose of this study is to answer the following questions:

- in a supply network, how do different triad structures affect cooperative performance?
- from the perspective of the FC, how do the management mechanisms affect cooperative performance?

The association between types of triad structure and performance, and the relationship between management mechanisms and cooperative performance were analysed and synthesised from the interview data, questionnaires and documentation. We summarised the perceptual data on management mechanisms and cooperative performance for each triad. Table III shows the degree of perceived impact of the market mechanism, coordination mechanism, trust mechanism and cooperative performance of the 13 samples categorised according to three generic types of triad structures, demonstrating that:

(1) *Triad Type I:* where the focal actor plays the bridge role in a triad, four of five triads (Samples I-1, I-2, I-3 and I-5) perceived high levels of trust (scoring 5.0: highest level) and high levels of cooperative performance (scoring 5.0, 4.5, 4.5 and 4.0).

(2) *Triad Type II:* where the focal actor plays the peripheral role in a triad, two of four triads (Samples II-3 and II-4) perceived high levels of coordination (scoring 4.2 and 5.0), high levels of trust (scoring 4.0 and 5.0) and high levels of cooperative performance (scoring 4.0 and 5.0).

(3) *Triad Type III:* fully connected triad. Two of four triads (Samples III-3 and III-4) perceived moderate levels of trust (scoring 4.0), high levels of coordination (scoring 4.6) and high levels of cooperative performance (scoring 4.4 and 5.0). However, they perceived a low level of market mechanism such as, pricing and partner selection (by scoring 2.0).

Triad structure	Sample	Management mechanisms Coordination mechanism	Trust mechanism	Market mechanism	Cooperative performance
Type I: bridge role in triad	I-1	4.6	5.0	2.0	5.0
	I-2	2.2	5.0	2.0	4.5
	I-3	4.2	5.0	4.0	4.5
	I-4	2.2	3.0	4.0	2.0
	I-5	1.8	5.0	3.0	4.0
Type II: peripheral role in triad	II-1	1.8	1.0	4.0	2.0
	II-2	1.8	1.0	4.0	3.0
	II-3	4.2	4.0	4.0	4.0
	II-4	5.0	5.0	2.0	5.0
Type III: fully connected triad	III-1	2.2	1.0	4.0	1.25
	III-2	2.2	1.0	4.0	2.0
	III-3	4.6	4.0	2.0	4.5
	III-4	4.6	4.0	2.0	50

Note: 5 = highest, 1 = lowest

Table III.
Management mechanisms and cooperative performance

These findings show that the FC, when occupying different structural positions in a triad, may adopt different mechanisms for managing the triad. Eight of the 13 triads reveal perceived high cooperative performance; two triads are moderate and three triads yield a low level of perceived cooperative performance. From those eight high-performance triads, four have a Triad Type I configuration, two have a Triad Type II structure and two triads are of Type III. They demonstrate that the structural position of the FC within a triad, influences triad performance. More detailed discussions and implications are addressed in the following section.

Discussion and findings

The first research question was to investigate how different triad structures affect perceived cooperative performance. As shown in Table III, of the three types of triads, Type I (bridge role in triad) reveals higher perceived cooperative performance than Type II (peripheral role in triad) and Type III (fully connected triad).

It could be argued that, while occupying a bridge and central position in a triad, the focal firm perceived higher cooperative performance, in terms of satisfaction with goal attainment and cooperative relationships, possibility with respect to new business opportunities, and willingness to engage in continuous cooperation. Conversely, while occupying a peripheral position in a triad or being in a fully connected triad, the focal firm has low cooperative performance. An interviewee commented:

> Being in a central position of the triad, we were the first to know when there was a business opportunity, once we won the contact, we acquired a dominant position, which enabled us to select better supply partners, and to design and control the maintenance operation process for the whole business. Therefore, we are more satisfied with the level of goal attainment and the nature of our cooperative relationships.

Occupying a central position in a triad, the FC has the advantage of accessing unique information and having the power to control the relationship. Thus, the FC perceived higher company performance. This result is consistent with the network perspective, which asserts that firms occupying the favoured network position of bridging role are likely to perform better, because of better information access and control advantages (Burt, 1992, 2004; Madhavan *et al.*, 2004; Gulati *et al.*, 2000). Based on this analysis, our research reveals the following:

Finding 1. In a triad, a firm playing a bridging role perceives higher cooperative performance than when playing a peripheral role in the triad or those located in a fully connected triad.

We then examined the second research question. That is, what are the management mechanisms that the FC adopted to manage different triads in order to generate better performance? First, in a triad where the FC played a central bridging role, the relationship between the trust mechanism and perceived cooperative performance was quite clear. However, the relationship between the market mechanism and cooperative performance was not established at all, nor was a relationship between the coordination mechanism and cooperative performance. Four of the five triads in Type I, which experienced high trust, consistently revealed high cooperative performance. However, one exceptional triad of Type I (Sample I-4), with a moderate level of trust, showed moderate cooperative performance. In Triad I-4, an interviewee stated that:

> Because we are in the central position, keeping a long-term relationship cannot just rely on coordination and the market mechanism. Trust is the most important factor for a long-term collaborative relationship. However, in this case, both companies RG and B are our agents. We don't want to maintain closer relationships with those agents; instead, our cooperation with them is only based on "market benefits" and there is not much trust between us. Therefore, we do not expect an ongoing cooperative relationship with them.

These findings indicate that, when a FC occupies a central and bridging position, more trust is needed to manage this triad, so as to generate higher cooperative performance. Coleman (1988) adds that actors in a dense network are able to rely on norms and sanctions against opportunism. Zaheer and Venkatraman (1995) also suggest that consistent trust facilitates greater relation-specific investments, and reduces monitoring costs. The study indicates that:

> *Finding 2.* When a firm plays the bridging role in triad, high level of trust and the associated mechanisms, lead to higher perceived cooperative performance.

In the triad where the FC occupies a peripheral position, we found that simultaneously a higher level of coordination mechanism and a higher level of trust mechanism leads to a higher level of perceived cooperative performance. Two of the four triads in Type II have high levels of coordination and trust mechanisms and consistently yield a high level of perceived cooperation. By contrast, the other two triads with both low levels of coordination and trust mechanisms showed low and moderate perceived cooperative performance. However, no association between market mechanism and cooperative performance was found in any type of triad. For example, in Triad II-3, Collins is in the central position, the FC and LMTAS are located in peripheral positions. Both Collins and LMTAS are large global companies and major players in aircraft manufacturing and systems integration. A manager from the FC commented:

> Although we are in a peripheral position without dominant power, we could still retain the benefits of collaboration, because of the coordination actions associated with the agreements and bylaws in the contract. Besides, we both trust each other, because we share a common vision of working together to acquire more business opportunities, particularly in the military market. We are satisfied with the cooperative relationships. Without a trustworthy prelateship, we could only obtain what was written in the contract, but with high levels of trust, we also got extra business and benefits.

The findings suggest that, when occupying a peripheral position without the advantages of unique information access and control, firms use highly developed coordination mechanisms, such as formal contracts, since agreements and bylaws written in contracts help to define partners' commitments (Gulati, 1995). Trust is needed as well, because it facilitates consensus (Bengtsson and Kock, 2000) and diminishes misunderstanding and opportunistic behaviour (Gulati, 1998). Common behavioural norms improve mutual understanding and lower the possibility of misinterpretation of a firm's actions by its partners (Ahuja, 2000; Gulati, 1995). In supply networks, high levels of trust lead to synergistic and creative collaboration (Coughlan *et al.*, 2003). Particularly when the focal actor is not in the central position, trust can constitute a supplementary mechanism, when coordination is more difficult, due to a firm occupying a peripheral position, rather than a central one. The study indicates that:

Finding 3. When a firm plays a peripheral role in a triad, high levels of coordination mechanism combined with high levels of trust, result in higher levels of perceived cooperative performance.

In Type III, fully connected triads, two triads with low levels of market mechanism, but high levels of coordination mechanism and high levels of trust mechanism represented higher perceived cooperative performance. Conversely, the other two triads with high levels of market mechanism, but low levels of coordination mechanism and low levels of trust mechanism represented lower perceived cooperative performance. This result implies that, when located in a fully connected triad, the coordination and trust mechanisms are positively associated with cooperative performance, but the market mechanism is negatively associated with the level of cooperation. Because, in a fully connected triad, information flows equally between the three actors, no one plays a brokerage role, enabling it to take advantage of information arbitrage, as discussed by Burt (2004). Market mechanisms, such as the price mechanism and methods for selecting potential partners, are not useful for managing the triad. A manager explained:

> We all have connections with the other two actors, "market information" is open to everyone, there is no information asymmetry between us. If we rely too much on market mechanisms, such as pricing, we can benefit only by reducing the price of the bid. This is, however, not only useless for keeping a balanced relationship among three of us, but also may reduce the trust that we have established.

Ahuja (2000) argues that collaborative relationships benefit more from trust engendered by dense networks, than from information diversity garnered through a central position. In a fully connected triad, trust reduces the likelihood of mutual competitive practices (Zaheer and Bell, 2005). Coordination mechanisms, including formal contracts, integrated decision-making, resource allocation, benefit distribution and conflict management, ensure a clear definition of partner commitments (Gulati, 1995), so as to achieve strategic consistency (Das and Teng, 2003) and to resolve disputes and conflicts (Jehn and Mannix, 2001). According to these findings and theoretical perspectives, it can be argued that:

Finding 4. In a fully connected triad, when the coordination mechanism is well developed, the level of trust is high, but the level of market mechanism is low, so that the resulting level of perceived cooperation is high.

In general, our findings reflect the propositions derived from the theory that:

- The types of triad structures affect cooperative performance.
- In different types of triad structures, different management mechanisms administered by the FC affect cooperative performance.

In this study, we found that, while playing a bridging role in a triad, the FC perceives higher cooperative performance than when playing a peripheral role in a triad or when located in a fully connected triad. This finding confirms the proposition that types of triad structures affect cooperative performance. In addition, we found that while playing the bridging role in a triad, the more effective the trust mechanism, the greater the cooperative performance. While playing the peripheral role in a triad, an effective coordination mechanism, combined with an effective trust mechanism, results in

greater cooperative performance. In the case of a fully connected triad, a more effective coordination mechanism and more effective trust mechanism and lower market mechanism, result in greater cooperative performance. These findings support the proposition that the management mechanisms implemented by the FC to manage the different triads, result in different levels of perceived cooperative performance.

In this study, we examined the relationship between triadic structure and management mechanisms from the FC perspective. An issue arising from the research could be why it may be appropriate to focus on the FC's perspective, and not on those of all actors. We established that actors demonstrate different behaviour when occupying different structural positions in a triad. The structural positions of all actors take the form of relative roles (central role relative to peripheral role). That is, the three actors must hold different positions, which lead to different styles of management and subsequent performance. Therefore, the intention of this study is not to determine the level of consistency among the three actors in the triad, but rather the influence of structural roles on management mechanisms and performance.

Practical implications

Since supply networks and strategic alliances involve implicit and open-ended contracts, social mechanisms are critical to effectively functioning networks. It is important to understand how social mechanisms reinforce, substitute or undermine one another and how their specific combination influences performance (Jones *et al.*, 1997). In this study, having examined different triad structures and the management mechanisms adopted by the FC, we believe that the implications for managerial practice, based on our results from 13 triads in a supply network, are as follows:

- The more central the position in a triad structure, the greater the level of perceived cooperative performance. This implies that, when participating in a supply network, firms should first realise their structural positions, and only then try to secure a position at the centre, so as to create a bridging role in the triad. Playing a bridging role increases bargaining power and enables a rapid response to environment change. Therefore, they perceived higher levels of cooperative performance.
- A bridging position in a triad requires more trust mechanisms to yield higher perceived cooperative performance. This implies that, in the central position, firms already possess information and control advantages, so that, trust becomes more important, since it reduces monitoring costs and opportunism and increases the willingness to engage in ongoing cooperation.
- A peripheral role in a triad requires the combination of coordination and trust mechanisms. Owing to the comparative lack of advantages, a coordination mechanism enables firms to protect their benefits.
- In a fully connected triad, information and knowledge flow relatively freely between the actors, and no one takes advantage of information arbitrage and power. Therefore, trust and coordination are needed, as in central or in peripheral positions. Conversely, however, the market mechanism is not only unnecessary; it may even reduce trust, which in turn, leads to less satisfaction and unwillingness to undertake subsequent cooperation.

Conclusions

Supply management can be viewed as both an emerging academic domain and an emerging field of practice (Storey *et al.*, 2006). In practice, the military avionics maintenance industry is high-tech, high value-added and characterised by high barriers to entry. As a result of dramatic environmental changes, the companies in this industry have moved their strategic attention from internal operations management towards managing supply networks and strategic alliances.

In the academic domain, according to Pilkinton and Fitzgerald (2006), *IJOPM* articles have shown a greater integration of key concepts, a more subtle appreciation of context, and a more rounded evaluation of specific practices. Giunipero *et al.* (2006) draw attention to five major supply management trends, including strategic relationships, cost reduction, integrated systems and collaboration, total cost of ownership, and strategic orientation, indicating the importance of strategic supply network and managing inter-organisational collaborative relationships. From the strategic management perspective, triad structure represents a valuable layer of analysis in network research (Madhavan *et al.*, 2004). However, the lack of empirical evidence on managing triads in networks reveals a degree of under-investigation of triad microstructures. This study contributes to the existing strategy research on managing triads in networks. From the operations management perspective, the study contributes to linking the strategic management and social network perspectives, by exploring a practical phenomenon in a specific context that is highly related to the operations and production management field.

By examining 13 triads of the total supply network in the Taiwanese military avionics service maintenance industry, the results support our two propositions.

The propositions and findings derived from this study could be also applied to other collaborative enterprise models. Bititci *et al.* (2004) have identified different levels of collaboration and categorised existing collaborative enterprise models into supply chains, extended and virtual enterprises and clusters. Each category of collaborative enterprise model is composed of dyadic and triadic structures, so that managing dyadic and triadic relationships in the case of each collaborative enterprise model is a significant issue in the era of supply networks and strategic alliances. Because each collaborative enterprise model entails different value propositions and entails various resources and capabilities, describing a different level or format of strategic collaboration, the nature of triad structures and management mechanisms may vary with the type of cooperative network, such as value chains, extended enterprise, virtual enterprise and clusters. Moreover, exactly how triad structures and management mechanisms influence cooperative performance may demonstrate different consequences of both intrinsic and extrinsic inter-enterprise performance measures in each collaborative enterprise model, as proposed by Bititci *et al.* (2005).

This study supports and extends the existing knowledge in the field of managing inter-organisational collaboration. In particular, it emphasises that trust is a key aspect of any collaborative relationship and that coordination between partners is a key factor in determining the performance of the network.

Limitations and future research

The key limitations of this study and suggestions for future research are:

- Although the FC in this study is a leading and dominant one in the Taiwanese avionics maintenance market, a single approach from only a FC would seem to constitute a major limitation. Because we examine the inter-organisational relationships in the supply network particularly at the triadic level, the diversification and broad product/service scope of the FC enables us to identify 13 triad samples. However, collecting data from a single FC within a unique industry confirmed the robustness of the methodology. Future researchers may, therefore, safely adopt the methodology used in this present study to examine the phenomenon in other companies and industrial contexts.
- A sample of 13 triads in a highly specialised network context could be perceived as a limiting factor for statistical generalisability. However, our exploratory findings surely remain worthy of note and can be tested empirically in future research. We suggest that subsequent research could examine the hypotheses in a larger sample size or take the same approach in a specific context.
- In this study, we measured cooperative performance from the FC's point of view, because we examined triad structures from the FC perspective as well. However, we did not examine the management mechanisms used by the other two actors, nor the performance of the triad as a whole. Neely (2005) states that the nature of performance measurement across networks, rather than within organizations, is a major issue for those researchers in the field. Future research could explore how the company's structural positions of the three parties influence performance across triad partners and the performance of triad as a whole. In addition, due to the limitation that objective performance data is unavailable, we measured only perceived cooperative performance. Therefore, future research could usefully incorporate not only perceived cooperative performance, but also other dimensions of performance.
- While our study focused on the triad structure and the associated management mechanism, future research could examine other factors influencing management mechanisms and cooperative performance. For example, resource asymmetries and resource exchanges among three actors in a triad may lead to differences in competitive and cooperative behaviour among them (Gynawali *et al.*, 2006). This, in turn, results in different management mechanisms and levels of performance. Future research could examine simultaneous competition and cooperation in a triad and how this influences cooperative performance.

Despite these limitations, this research contributes to the field in three ways. First, it provides an empirical study of triads, which is important for an emerging field. Second, the respondents were all well-informed chief executives and directors; we are indebted to them for the level of access provided. Third, within a very specific context, we managed to cover the entire population.

From a theoretical perspective, this research adopted a strategic management and social network perspective, in order to examine the phenomenon in a specific industrial context that is closely related to the operations and production management field. We also propose relevant findings for future research on how structural position affects management mechanisms and cooperative performance. In particular, we selected the unit of analysis as the triad level, which is an important research layer, but one that has been accorded less attention than the other four supply network layers from Harland's

(1996) model. From a practical perspective, according to our results from 13 triads, the more central the bridging position in a triad structure, the better the cooperative performance. This implies that firms should move their locations from peripheral positions toward central ones, thus creating a bridging role in a triad. Our findings also yield implications for practitioners on how to adopt management mechanisms in order to manage different structural positions in triads.

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References

Ahuja, G. (2000), "Collaboration networks, structural holes and innovation: a longitudinal study", *Administrative Science Quarterly*, Vol. 45, pp. 425-55.

Bales, R.R., Maull, R.S. and Radnor, Z. (2004), "The development of supply chain management within the aerospace manufacturing sector", *Supply Chain Management Journal*, Vol. 9, pp. 250-6.

Bengtsson, M. and Kock, S. (2000), "Coopetition in business networks – to cooperate and compete simultaneously", *Industrial Marketing Management*, Vol. 29, pp. 411-26.

Bititci, U.S., Martinez, V., Albores, P. and Parung, J. (2004), "Creating and managing value in collaborative networks", *International Journal of Physical Distribution & Logistics Management*, Vol. 34 Nos 3/4, pp. 251-68.

Bititci, U.S., Mendibil, K., Martinez, V. and Albores, P. (2005), "Measuring and managing performance in extended enterprises", *International Journal of Operations & Production Management*, Vol. 25 No. 4, pp. 333-53.

Burt, R.S. (1992), *Structural Holes: The Social Structure of Competition*, Harvard University Press, Cambridge, MA.

Burt, R.S. (2004), "Structural holes and good ideas", *American Journal of Sociology*, Vol. 110 No. 2, pp. 349-99.

Cigolini, R., Cozzi, M. and Perona, M. (2004), "A new framework for supply chain management: conceptual model and empirical test", *International Journal of Operations & Production Management*, Vol. 24 No. 1, pp. 7-41.

Coleman, J.S. (1988), "Social capital in the creation of human capital", *American Journal of Sociology*, Vol. 94, pp. 95-120.

Coughlan, P., Coghlan, D., Lombard, F., Brennan, L., McNichols, T. and Nolan, R. (2003), "Managing collaborative relationships in a period of discontinuity", *International Journal of Operations & Production Management*, Vol. 23 No. 10, pp. 1246-59.

Cousins, P.D., Lawson, B. and Squire, B. (2006), "Supply chain management: theory and practice – the emergence of an academic discipline", *International Journal of Operations & Production Management*, Vol. 26 No. 7, pp. 697-702.

Danese, P., Romano, P. and Vinelli, A. (2006), "Sequences of improvement in supply networks: case studies from the pharmaceutical industry", *International Journal of Operations & Production Management*, Vol. 26 No. 11, pp. 1199-222.

Das, T.K. and Teng, B. (2000), "Instabilities of strategic alliances: an internal tensions perspective", *Organisation Science*, Vol. 11 No. 1, pp. 77-101.

Das, T.K. and Teng, B. (2003), "Partner analysis and alliance performance", *Scandinavian Journal of Management*, Vol. 19, pp. 279-308.

Edmondson, A.C. and McManus, S.E. (2007), "Methodological fit in management field research", *Academy of Management Review*, Vol. 32 No. 4, pp. 1155-79.

Eisenhardt, K.M. (1989), "Building theories from the case study research", *Academy of Management Review*, Vol. 14 No. 4, pp. 532-50.

Giunipero, L., Handfield, R.B. and Eltantawy, R. (2006), "Supply management's evolution: key skill sets for the supply manager of the future", *International Journal of Operations & Production Management*, Vol. 26 No. 7, pp. 822-44.

Gulati, R. (1995), "Social structure and alliance formation patterns: a longitudinal analysis", *Administrative Science Quarterly*, Vol. 40 No. 4, pp. 619-52.

Gulati, R. (1998), "Alliances and networks", *Strategic Management Journal*, Vol. 19, pp. 293-317.

Gulati, R. and Gargiulo, M. (1999), "Where do interorganisational networks come from?", *American Journal of Sociology*, Vol. 104 No. 5, pp. 1439-93.

Gulati, R. and Singh, H. (1998), "The architecture of cooperation: managing coordination uncertainty and interdependence in strategic alliances", *Administrative Science Quarterly*, Vol. 43, pp. 781-814.

Gulati, R., Nohria, N. and Zaheer, A. (2000), "Strategic network", *Strategic Management Journal*, Vol. 21, pp. 203-15.

Gynawali, D.R., He, J. and Madhavan, R. (2006), "Impact of co-opetition on firm competitive behavior: an empirical examination", *Journal of Management*, Vol. 32, pp. 507-30.

Harland, C.M. (1996), "Supply chain management: relationships, chains and networks", *British Journal of Management*, Vol. 7, pp. S63-S80, (special issue).

Harland, C.M., Lamming, R.C. and Cousins, P.D. (1999), "Developing the concept of supply strategy", *International Journal of Operations & Production Management*, Vol. 19 No. 7, pp. 660-73.

Harland, C.M., Lamming, R.C. and Zheng, J. (2006), "Supply management: is it a discipline?", *International Journal of Operations & Production Management*, Vol. 26 No. 7, pp. 730-53.

Hoskisson, R.E., Hitt, M.A., Wan, W.P. and Yiu, D. (1999), "Theory and research in strategic management: swings of a pendulum", *Journal of Management*, Vol. 25, pp. 417-56.

Ireland, R.D., Hitt, M.A. and Vaidyanath, D. (2002), "Alliance management as a source of competitive advantage", *Journal of Management*, Vol. 28 No. 3, pp. 413-46.

Jehn, K.A. and Mannix, E.A. (2001), "The dynamic nature of conflict: a longitudinal study of intragroup conflict and group performance", *Academy of Management Journal*, Vol. 44 No. 2, pp. 238-51.

Jones, C., Hesterly, W.S. and Borgatti, S.P. (1997), "A general theory of network governance: exchange conditions and social mechanisms", *Academy of Management Review*, Vol. 22 No. 4, pp. 911-45.

Karlsson, C. (2003), "The development of industrial networks? Challenges to operations management in an extraprise", *International Journal of Operations & Production Management*, Vol. 23 No. 1, pp. 44-61.

Madhavan, R., Gnyawali, D.R. and He, J. (2004), "Two's company, three's a crowd? Triads in cooperative-competitive networks", *Academy of Management Journal*, Vol. 47 No. 6, pp. 918-27.

Mills, J., Schmitz, J. and Frizelle, G. (2004), "A strategic review of 'supply networks'", *International Journal of Operations & Production Management*, Vol. 24 No. 10, pp. 1012-36.

Neely, A. (2005), "The evolution of performance measurement research: developments in the last decade and a research agenda for the next", *International Journal of Operations & Production Management*, Vol. 25 No. 12, pp. 1264-77.

Ouchi, W.G. and Bolton, M.K. (1988), "The logic of joint venture and development", *California Management Science*, Vol. 30, pp. 9-33.

Pilkinton, A. and Fitzgerald, R. (2006), "Operations management themes, concepts and relationships: a forward retrospective of *IJOPM*", *International Journal of Operations & Production Management*, Vol. 26 No. 11, pp. 1255-75.

Provan, K.G. and Sebastian, J.G. (1998), "Networks within networks: service link overlap, organisational cliques, and network effectiveness", *Academy of Management Journal*, Vol. 41 No. 4, pp. 453-63.

Rond, M.D. and Bouchikhi, H. (2004), "On the dialectics of strategic alliances", *Organisation Science*, Vol. 15 No. 1, pp. 56-69.

Storey, J., Emberson, C., Godsell, J. and Harrison, A. (2006), "Supply chain management: theory, practice and future challenges", *International Journal of Operations & Production Management*, Vol. 26 No. 7, pp. 754-74.

Taylor, A. and Taylor, M. (2009), "Operations management research: contemporary themes, trends and future directions", *International Journal of Operations & Production Management*, Vol. 29 No. 12, pp. 1316-40.

Tsai, W. (2002), "Social structure of 'coopetition' within a multiunit organisation: coordination, competition, and intraorganisational knowledge sharing", *Organisation Science*, Vol. 13 No. 2, pp. 179-90.

Vereecke, A. and Muylle, S. (2006), "Performance improvement through supply chain collaboration in Europe", *International Journal of Operations & Production Management*, Vol. 26 No. 11, pp. 1176-98.

Voss, C., Tsikriktsis, N. and Frohlich, M. (2002), "Case research in operations management", *International Journal of Operations & Production Management*, Vol. 22, pp. 195-219.

Wasserman, S. and Faust, K. (1994), *Social Network Analysis*, Cambridge University Press, Cambridge, MA.

Yin (1999), *Case Study Research – Design and Methods*, Sage, Thousand Oaks, CA.

Zaheer, A. and Bell, G.G. (2005), "Benefiting from network position: firm capabilities, structural holes, and performance", *Strategic Management Journal*, Vol. 26 No. 9, pp. 809-25.

Zaheer, A. and Venkatraman, N. (1995), "Relational governance as an interorganizatrional strategy", *Strategic Management Journal*, Vol. 16 No. 5, pp. 373-92.

Zajac, E.J. and Olsen, C.P. (1993), "From transaction cost to transactional value analysis: implications for the study of interorganisational strategies", *The Journal of Management Studies*, Vol. 30 No. 1, pp. 131-45.

Zollo, M., Reuer, J.J. and Singh, H. (2002), "Inter-organisational routines and performance in strategic alliances", *Organisation Science*, Vol. 13 No. 6, pp. 701-13.

Appendix 1

Respondents	Current position	Expertise	Experiences (years)
FC	Vice General Manager	Avionics manufacture and maintenance	20
FC	Deputy Director	Avionics manufacture	16
	Senior Manager	Avionics maintenance	6
	Section Chief	Avionics manufacture	9
	Director of Project Manager	Aircraft maintenance	4
ITRI	Director of Project Manager	Avionics system integration	15
	Project Manager	Aircraft system integration	5
RG	CEO	Avionics system integration	20
	Senior Manager	Avionics maintenance	7
A	Director of Project Manager	Avionics maintenance	10
	Senior Manager	Avionics maintenance	7
B	CEO	Avionics system integration	10
C	Chair of Board	Electrical system maintenance	15
NG	Vice CEO	Avionics system integration	8
AGI	Vice CEO	Avionics parts supplier	10
Outsider	Director of Marketing Manager	Avionics maintenance software	20

Table AI. Interviewees' backgrounds

Appendix 2. Questionnaire for management mechanisms and cooperative performance

Management mechanisms is a set of processes and means used for managing the cooperative activities in order to attain collective goals. It is measured by the extent to which the respondents perceive the following items on a 5-point scale. (1: the least agreed; 5: the most agreed)

(1)	The triad is well-coordinated by the formal agreements and bylaws mechanism	1	2	3	4	5
(2)	The triad is well-coordinated by an integrated decision-making mechanism	1	2	3	4	5
(3)	The triad is well-coordinated by a resource integration and allocation mechanism	1	2	3	4	5
(4)	The triad is well-coordinated by a benefit distribution mechanism	1	2	3	4	5
(5)	The triad is well-coordinated by a conflict management and resolution mechanism	1	2	3	4	5
(6)	The triad is well-managed by trustworthy between focal actor and the other actors	1	2	3	4	5
(7)	The triad is well-managed by trustworthy between two other actors in a triad	1	2	3	4	5
(8)	In this triad, any contract between actors is highly determined by the price of public bid	1	2	3	4	5
(9)	In this triad, any contract between actors can be easily substituted by many potential partners in the market	1	2	3	4	5

Cooperative Performance. Please circle on the number from 1 to 5 to identify the perceived performance on the following items. (1: the least agreed; 5: the most agreed)

(1) The partners in this triad are very satisfied with the goal attainment	1	2	3	4	5
(2) The partners in this triad believe that there will be much more new business opportunities in the future	1	2	3	4	5
(3) The partners in this triad are very satisfied with the cooperative relationships	1	2	3	4	5
(4) The partners in this triad are very willing to continue their cooperative relationships	1	2	3	4	5

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