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Full Length Research Paper

Effect of relationships in supply networks: A long-term analysis in the automotive industry

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This work uses cointegration analysis to study the strength of relationships with the partners in supply networks in the Taiwan automotive industry. The purposes of this paper are: (1) to examine how firms form networks and to explore whether firms in supply networks should have long-term relationships; (2) to investigate the strength of relationships with the other partners and illustrate firm behavior in supply networks. The analytical results demonstrate two findings. First, the assembly and the automotive component manufactures have long-term relationships in a supply network. Subsequently, the results of cointegration analysis illustrated firms' convergent (divergent) behavior. Sharing shareholder value, complementary resources, and sustained competitive advantage enables firms to converge to the long-term equilibrium. Partners will be amalgamated with other firms to construct a financial vision caused divergent behavior. Thus, this study provides empirical evidence of the strength of relationships and contemporaneously examines firm behavior in supply networks.

Key words: Supply networks, relationship, cointegration analysis.

INTRODUCTION

Networks are becoming increasingly important as competitive pressures force firms to adopt flexible and more focused organizational structures (Chan et al., 1997). Supply networks are nested within wider inter-organization networks and consist of interconnected entities whose primary purpose is the procurement, use, and transformation of resources to provide packages of goods and services (Harland et al., 2004). Long-term relationships are critical to supply networks, as they are the foundation of both network stability and change. Kotabe et al. (2003) stated that by maintaining long-term relationships, a supplier will become part of a well-managed chain, and that such suppliers will have a lasting effect on the competitiveness of the entire supply chain. Furthermore, Ebers and Jarillo (1998) indicated that supply network and competitive interaction tend towards long-tern purposeful arrangements in order to obtain long-term sustainable competitive advantage. This reflects two observations. Firstly, there has been renewed interest in linking supply networks with inter-connected relationships (Harland et al., 2004). Networks of interdependent relationships can be developed and fostered through strategic collaboration with the goal of deriving mutual benefits (Chen and Paulraj, 2004a; Dyer, 2000a). Secondly, opportunism (Walter et al., 2003) and dependence asymmetry (Narayandas and Rangan, 2004) may undermine a firm's network strategy in various ways. However, research on cooperative and competitive relationship in such networks remains limited.

The current Taiwanese automotive industry provides a representative, real-world example of both collaboration within and competition among assembly manufacturers and the automotive component manufacturers. In identifying the numerous theoretical determinants of supply networks, we test our conceptual arguments in the context of vertical supply networks in the automotive industry. Specifically, our study examines the relationship

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among the automotive assembly manufacturers and their independent upstream suppliers (automotive component manufacturers). In summary, the aims of this paper are as follows:

1. To examine why firms form networks and to explore whether firms in supply networks should have long-term relationships;
2. If firms have formed a network and maintained long-term relationships, then we investigate the strength of relationships with partners and illustrate firm behavior from a single supply network.

The remainder of this paper is organized as follows: First, we review the literature on relationships and supply networks, and develop some propositions. Second, we discuss the automotive industry, data sources and describe the methodology. Third, we formulate our conclusions and present the empirical results, and discuss their implications for supply networks. Finally, the study concludes by presenting the significant research findings and managerial implications.

Literature review

In today's world of interconnected economies, firms are no longer stand-alone organizations. Extended production networks and expanded trade have intensified competition in most industries. Consequently, firms exploit core resources and competences to develop and sustain a strong market position. In the following subsections we describe the relationships research from network and strategy perspectives; then, we discuss the strength of the relationships within the supply networks and develop the propositions.

Relationships in network research

A network is defined as a way of organizing economic activities through inter-firm coordination and cooperation in order to exchange or share information or resources. Network actors are influenced by their conceptual frameworks, which allow them to comprehend and act in the network, and to set network boundaries by including or excluding others. Network theories reflect actors' capabilities and intentions in the network. Network theory when applied to relationships emphasizes the role of relationship dyads in understanding changes in supply networks. In this context, the concept of a supply network represents the verifiable determination of relevant network components (Jüttner and Schlange, 1996). Moreover, the relatively recent incorporation of the term "network" into supply chain management (SCM) research represents an attempt to make the concept wider and more strategic by enabling firms to harness the resource potential of the network in a more effective manner.

Supply networks can be defined as sets of supply chains, describing the flow of goods and services from original sources to end customers (Harland et al., 2004). Hertz (2006) noted that supply chain networks are a very specific type of network, and are concerned with the connections and dependencies between firms, going from raw materials to final customers. A network is an aggregate of actors that are interrelated and interconnected through relationships. In order to understand a network, we thus have to study and understand relationships, and early studies attempted to explain the nature of relationship processes. Supply chains have traditionally been examined as a set of sequential, vertically organized transactions representing successive stages of value creation (Mabert and Venkataramanan, 1998). While this view allows the examination of operational efficiencies, it tends to restrict the examination of interdependencies at different relationships types that exist among supply chain partners. For example, Choi et al. (2002) indicated that for effective supply chain management how firms interact among themselves to promote establishment strategic relationships.

Some investigators have studied long-term cooperative relationships with key suppliers (Carr and Pearson, 1999; Chen et al., 2004b). Choi and Krause (2006) describe how in an automotive supply network, a plastic molding company and a metal parts manufacturer can be interdependent. They found such interdependencies often occur beyond the purview of the focal company. In such relational patterns, these suppliers may continue to pursue a cooperative strategy in spite of the exit strategy adopted by the focal buying company (Choi and Wu, 2009). Nelson (1989) argued actors engage in repeated and transitive relational exchanges facilitate how trust and social norms emerge over time. However, the results highlight that the norms or meta-norms established among the firms in the supply networks inhibit an increasing proportion of agents from defecting. Even in situations where firms are able to gain high rewards from opportunistic behavior, mutual cooperative behavior would survive and thrive as long as there is sufficient incentive to do so. For instance, Denso as the major top-tier supplier to Toyota has had a history of showing comparable or sometimes higher earnings compared to Toyota (Nair et al., 2009). Therefore, it is important to study supply chains from the network-based perspective and from the long-term equilibrium as to move closer to the realistic relational behaviors in supply chains.

An important sub-topic in these research streams has been the issue of defection behavior. Pathak et al. (2007) highlight the relevance of complexity in supply chain and operations management research and shown in an ongoing buyer-supplier dyadic relationship when the decision is to exit, a buyer would act opportunistically in short term which we refer to as defection behavior. Rossetti and Choi (2005) describe how large buying companies in the aerospace industry made short-term, opportunistic decisions that led to long-term consequences.

In addition, we have considered why the arrangement of networks among organizations can yield long-term sustainable competitive advantages, as well as examining the potential importance of close relationships as strategic assets (Johnson, 1999; Kale et al., 2000).

However, firms often use cooperative relationships to reduce the uncertainty in their product markets through information sharing and cross-firm communication in the form of cooperative relationships that range from cooperative marketing to pooled research and development cooperatives (Bresser, 1988). As a result, ensuring stable relationships between suppliers and their customers is important to both parties. Thus, consequences of relationship continuity relate to long-term financial stability for both the supplier and the customer. Research also suggests that strategic relationships extend the boundaries of investigation and give access to the resources of others (McEvily and Zaheer, 1999; Gulati et al., 2000).

Moreover, because strategic relationships embody a promise of fair play and a mutually beneficial, long-term relationship, they provide pressure not to behave opportunistically and support investment in relationships that often pay returns only in the long run. As Harland (1996) acutely described putting "network" into supply chain management reflects an attempt to make the latter wider and more strategic by harnessing the resource potential of the network in a more effective manner than competing firms.

The important point to note is supply networks as a complex adaptive system are simulated using cellular automata through a dynamic evolution of cooperation and defection among supply network agents. Beyond the goal of achieving product performance, strategic relationship provide a sharing of risk and trust at a level that allows extensive cooperation in strategic business areas and product development from engineering and marketing to production planning, inventory and quality management (Walter et al., 2003).

Therefore, Holmen et al. (2007) described how to develop and to maintain a supply network from upstream and longitudinal supply perspectives. Patnayakuni et al. (2006) denoted strategic supply networks as a series of collective goals and aspirations, in which members have a high level of integration in the operation and each partner has a long-term orientation. By actively engaging in such network, firms recognize that value-generation increasingly rests at the network level rather than at that of the individual firm. Here we adopt the concepts in Hertz (2006) and Gulati et al. (2000) to define supply networks as consisting of interconnected entities whose primary purpose is accessing resources and adding ca-pabilities, moving from raw materials to final customers. Therefore, this study suggests that a firm can benefit from harnessing complementarities in supply networks, and that such benefits can accrue more strongly to firms that foster durable linkages. We thus make the following proposition:

Proposition 1: Firms in supply networks should have significant long-term relationships.

Strength of the relationships in the supply networks

With regard to the relationships in a supply network, three elements have been identified: competition, dependence asymmetry and resources. All three factors are important tools when describing the general structure or strength of the relationships. Firms cooperate and coordinate with others in order to exchange or share information or resources. Scholars have argued that firms can generate economic rents and achieve superior, long-run performance through simultaneous competition and cooperation (Lado et al., 1997) and that coopetition is the most advantageous relationship between competitors. However, the manufacturer and supplier are separate companies that have individual goals (Iyer and Bergen, 1997), and it is not certain that the supplier will support the manufacturer's requests. Although some scholars suggest that collaboration among rivals may inhibit competition by facilitating (Porter and Fuller, 1986), others suggest that firms derive valuable resources from their collaborative-competitive relationships and strengthen their competitive capabilities (Gnyawali and Madhavan, 2001). This point is supported by Wathne and Heide (2004), who consider the likelihood that a manufacturer's request for modifications will be accommodated. Dependence asymmetry refers to the difference between the organization's dependence on a partner and the partner's dependence on the organization (Geyskens et al., 1996). Gadde and Håkansson (2001) mentioned that the focal firm can search for alternative suppliers to become less dependent on specific ones, but both parties can also handle power and dependence in a more constructive way. Narayandas and Rangan (2004) indicated that higher levels of dependence asymmetry may cause relationships to become unstable and dysfunctional. For example, the less dependent organization may exercise its power advantage in the relationship, and thus the more dependent organization may attempt to balance the relationship by becoming less so. We therefore note that dependence asymmetry may influence firm behavior with regard to strategy development.

On the other hand, change may concern the resource ties and capabilities which exist in firms. When these resources and their related active systems have complementarities, their potential to create sustained competitive advantage is enhanced. Dyer and Nobeoka (2000b), representing the resource based view (RBV), claimed that large companies are able to create, adapt, and control a specific network structure due to their position as central actors in a network, and that this forms the basis for strategic action. Additionally, an increasing competitive environment makes it difficult for firms to mobilize the resources that they needed to compete effectively, and the ensuing exchanges have lead to relational interdependency (Arin˜o and de la Torre, 1998; Wernerfelt, 1984; Svahn and Westerlund, 2007). Möller and Halinen (1999) indicated that network vision capability refers to management skills and competencies in creating valid views of networks and their potential evolution. For example, the technological capabilities of a supplier stem from its ability to access and deploy those that exist within its supply network (Walter et al., 2003).

A firm has a collection of different roles toward other actors. In this study we try to describe the strength of relationships within a network. The thesis has its foundation on the network perspective, which assumes that firms are interrelated and interconnected to other partners in supply networks through their relationships. Firms react to converging behavior in supply networks, which means a firm that has strong relationships causes its partners to discount the possibility that it will appropriate their idiosyncratic investments, and relational bonds increase the willingness to make RSIs (Relationship-specific Investments) because firms do not want to jeopardize a difficult-to-replace relationship (Palmatier et al., 2007). Alternatively, with increased potential for the disintegration of the relationship, the more dependent organization feels less need to be compliant. In addition, cohesiveness is also lower, and individual firms would tend to divergent behavior as they make adjustments to the strategies made by their peers, and thus depart from the network equilibrium. Thus we present the following proposition:

Proposition 2: Firms react to partners' deviations from the long-term equilibrium by converging or diverging their own behavior towards the equilibrium over the subsequent periods.

In testing these propositions we need to include a number of control variables that the literature suggests effect firms and firm behavior in supply networks. Papadakis (2006) discussed the stock performance of two different SCM systems during accounting periods affected in the 921 earthquake in Taiwan. Singh et al. (2005) indicated that the average abnormal stock returns of firms experiencing disruption were about 40% within one to two years after the disruption announcement date. All of above studies have used event history analysis to illustrate the interactions among firms. Meanwhile, all these studies consider the expected profit associated with announcements, as reflected in the abnormal returns of a firm. Abnormal returns are measured using event study methodology. Although a firm's profit is influenced by several factors, and isolating the contribution of any one variable is difficult, the event study methodology provides a means and unique opportunity to assess the impact of a particular strategy on a firm's expected future profits (Nair and Filer, 2003). However, event study methodology may be inappropriate for reactions that are unobservable and occur after considerable delay, when responses may be contaminated by other events. In this study, we adopt Nair and Filer (2003) method to test the strength of relationships. This cointegration analysis overcomes some of the limitations associated with prior attempts at modeling firm behavior in supply networks, and allows us to illustrate the firm behavior to the other partners in supply networks.

Research setting and data collection

Taiwan's automotive industry

In Taiwan, the structure of the automotive industry consists of upstream, midstream, and downstream segments working together cooperatively in a consolidated chain. In 2005, Taiwan's automotive manufacturing industry currently produces about 444,470 vehicles per annum and accounts for 5.50% of the global output. It consists of four vehicle producers: Kuozui Motors, Ltd., Yulon Motor Co., China Motor Co. and Ford Lio Ho Motor Co., Ltd. The majority of these firms have contractual joint ventures with foreign companies, mostly from Japan, and the export areas are in China and American. Linking the manufacturers to end customers is a large number of dealerships. Servicing these core groups are another parties such as designers, marketing consultants and logistics providers. Consequently, the assembly industry and automotive component manufacturing industry not only are the main parts of the automotive industry, but also the midstream of automotive supply chain. Additionally, Table 1 shows both industries sell their products to venders, agents, and automotive manufacturing companies, in the ratio of 69% domestically and 31% internationally (Taiwan Institute of Economic Research, 2005/12).

In addition, the automotive component manufacturers are original equipment manufacturers (OEM) which follow the automotive assembly plans to make automotive parts. There are about 2,500 automotive component companies in Taiwan, and the majority of them are small- to medium-sized enterprises (SMEs). Taiwan automotive components firms confronted considerable difficulties at home. In the early years of growth, firms in this segment of the automotive sector benefited from strong government support and extensive technical linkages with Japanese firms. Subsequently, OEM firms remained reliant on foreign partners for advanced technology, and the small market constrained growth. Rising labor costs from the 1980s onwards, the rapid development of China, and accession into the World and Trade Organization (WTO) have forced Taiwanese automotive assembly manufactures, such us YML to begin searching for new survival strategies. As in many advanced industrial nations, moving offshore is one of the most popular strategies for promoting sustained growth and taking advantage of flexible supplier networks, strong operations management

Table 1. Product value of Taiwan's automotive component and assembly industry (In millions of US dollars)

	2001	2002	2003	2004	2005 (Q1~Q3)
①Automotive Assembly industry (%)	4,300 (54.7)	5,200 (54.7)	6,400(57.7)	7,200 (56.7)	5,800 (58)
②Automotive component industry (%)	3,500 (45.3)	4,300 (45.3)	4,700 (42.3)	5,500 (43.3)	4,200 (42.1)
①+②	7,800	9,500	11,200	12,700	10,000

Source: TTVMA, Ministry of Economic Affairs, Taiwan Institute of Economic Research (2005/12).

capability, obtaining orders for higher value-added products and making long-term relationships with internationally branded automakers (Berger and Lester, 2005, p. 100). Furthermore, Taiwanese foreign investors began relocating extensively in China in the 1990s to lower production costs. Taiwanese automotive components firms then followed, relocating labor- and scale-intensive assembly activities in China while retaining knowledge-intensive and small batch production within Taiwan. Relocation in China also helped Taiwanese suppliers to take advantage of Chinese supply networks, enabling them to connect with Japanese and American assembly manufacturers operating in the country (Li and Sadoi, 2008).

The automotive component industry has also developed as local producers have made steady quality and technical gains and tap into the international aftermarket (AM) demand. In year, Taiwan automotive component manufacturers produced between 85 to 90% of the collision parts in global aftermarket. According to figures compiled by the Taiwan Transportation Vehicle Manufacturers Association, Taiwan firms held over 80 percent of aftermarket collision parts market in North America in 2008, accounting for about 15% of the overall automotive market in North America. In Taiwan, TY is the world's largest manufacturer of aftermarket plastic body parts. TY's international clients include Ford, GM-Opel, Mazda, Mitsubishi, Honda, Nissan, Toyota and Volkswagen (TY website). Taiwan aftermarket component manufactures are currently migrating up the global value chain by focusing on logistics and having integrated capital and intensive technology (Berger and Lester 2005, p. 100; TY website). In this research, we focus on supply networks among automotive component and assembly manufactures.

Data

Although the automotive component industry comprises hundreds of independent suppliers, this research identified the seven main automotive component manufacturers that work with the Yulon Motor. These are considered the permanent and long-term relationships that Yulon Motor has, in contrast to the many short-term relationships that it maintains with other component manufacturers. Also, the choice of the component manufacturers for this research was dependent upon obtaining adequate data to conduct cointegration analysis. In addition, Tumarkin (2002) suggests that only stocks with a sufficient numbers of messages should be included in such studies, because significant noise and error are introduced by stocks followings. Therefore, the study was based on data collection on each of the eight publicly traded firms which are listed on the Taiwan Stock Exchange, with the data running from February 14, 2001 to December 31, 2002, and consisting of 491 observations. As Yulon Motor (YML) has a complete supply chain in Taiwan, we selected this firm as the sample in the automotive assembly industry. The stock prices for the eight firms: YML, TY, RW, Juili, TY, KY, CH and Calsonic, are used as samples to observe the network relationships among the assembly manufacturers and the automotive component manufacturers (Figure 1).

These firms are listed on the Taiwan Stock Exchanges. Data on these firms were obtained from the database, an annual publication of Taiwan Institute of Economic Research, a leading institute in Taiwan. To ensure data reliability, the data collected from the database were cross-checked with information obtained from the Taiwan Company Handbook. This investigation found no discrepancies in the data set. Sample was captured by interviewing a few managers at Yulon Motor in Taiwan and also was listed in Taiwan's 500 largest wealth creator companies. In sampling, it was tried to ensure that the sample companies fulfill two minimum criteria: firstly, the annual turnover is more than one million of dollars, and secondly, the employee strength is more than 100. Appendix A lists the full names of these companies and their main products.

Table 2 shows the background of the automotive component manufacturers. TY started to produce automotive parts in 1976 and is focused on obtaining orders for higher value-added products, including instrument panels and chroming parts in the OEM market. Additionally, TY has over 80% market share for plastic parts in Taiwan. RW produces pistons, connecting rods, steering system parts. Juili produces metal stamping molds, welding materials, inspection jigs. Taiyih has over 85% market share for automotive lamps in Taiwan. KY was the first producer in sheet metal parts to enter the aftermarket in 2006.

CH produces forged products for automobile parts. Calsonic undertakes technical cooperation with Calsonic-Kansei, and focuses on the OEM market of the car air-conditioning systems. All of these automotive component manufacturers have built long-term cooperative

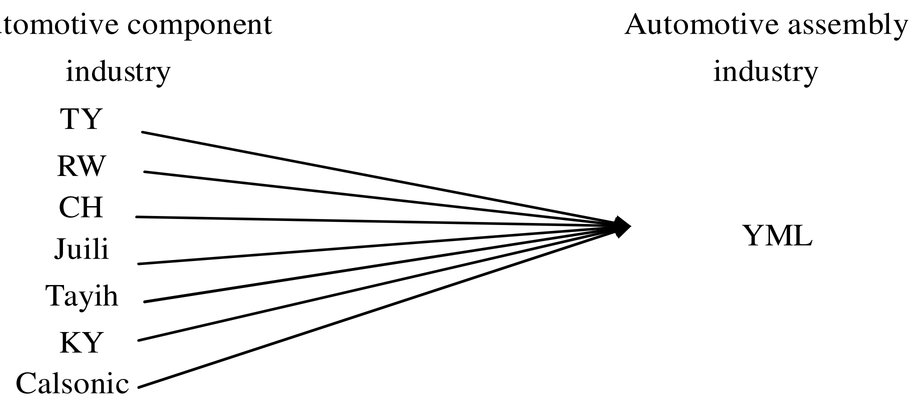

Figure 1. Supply network of the automotive industry.

Table 2. Overview of the automotive component manufacturers.

	OEM	Aftermarket
Plastic parts	TY	TY
Stamping mold	RW	
Forging	CH	-
Metal stamping mold Parts	Juili	Juili, KY
Lamps	Taiyih	-
Air Conditioners	Calsonic	-

relationships with YML, and TY, Juili and KY were the first suppliers of aftermarket in the North American market. Data on these firms were obtained from the Taiwan Economic Journal Database. The data set adopts the adjusted daily stock price.

METHODOLOGY

In empirical analysis, when historical data are non-stationary, cointegration analysis is commonly used to investigate co-movements. However, most of the studies that use this method have some weaknesses, and thus this study employs the method in Johansen (1988) to estimate the cointegration vector, and assumes that all the variables in the model are endogenous. The study adopts the perspective of Nair and Filer (2003) to evaluate whether supply networks include long- term relationships in the Taiwanese automotive industry.

Dividing component manufacturers into groups

To ensure that products are sufficiently profitable when launched, many firms subject them to target costing. The profit margin is a good measurement which can evaluate a firm's ability to control the costs incurred to generate revenues and can also reflect its operating efficiency (Fairfield and Yohn, 2001).

Consequently, the study uses the profit margin as a variable in the cluster analysis was used to produce the number of acceptable groups. This method of cluster analysis was very different from the joining (Tree Clustering). The study adopted k-means clustering algorithm to produce exactly k different clusters of greatest possible distinction. It should be mentioned that the best number of clusters k leading to the greatest separation (distance) is not known as a priori and must be computed from the data. The purpose of the study is to detect supplier segments, for example, groups of respondents that are somehow more similar to each other (to all other members of the same cluster) when compared to respondents that belonged to other clusters.

In addition to identifying such clusters, it was usually equally of interest to determine how the clusters are different, for example, determine the profit margin or dimensions that vary and how they vary in regard to members in different clusters. In addition, before undertaking a cointegration test, a nonstationarity test must be performed.

Unit root test

If a stationary linear combination exists, the non-stationary time series are said to be cointegrated. The stationary linear combination may be interpreted as a long-run equilibrium relationship among the variables (Engle and Granger, 1987). A necessary condition for the existence of cointegration between series is that each be nonstationarity. Dickey and Fuller (1981) indicated that there are three models that can test for this, and this paper uses the ADF test, as follows. The model used in this study includes a drift and a time trend.

$$\Delta y_t = a_0 + r y_{t-1} + \sum_{i=2}^{p} \beta_i \Delta \mathrm{y}_{t-i+1} + \varepsilon_t \quad (1)$$

The null hypothesis for the ADF test is: H_0: r =0, with the alternative

H_1: -2<r<0. We also adopt the Dickey and Fuller (1981) unit root test for nonstationarity. Our specification contains neither a constant term nor a time trend.

The estimation might be biased if the lag length is pre-designed without rigorous determination. Hence, the study uses Akaike's information criterion (AIC) to determine the optimal number of lags based on the principle of "parsimony". The econometric software package EViews 4 is used for the empirical analysis.

Cointegration analyses

Nair and Filer (2003) indicated that previous studies examining the dynamic competitive equilibrium in a strategic group are based on short-term analyses and methodologies inappropriate to assessing long-term phenomena. Therefore, Nair and Filer thought that competitive equilibrium should be specific to long-term phenomena and that the cointegration analysis can be used to analyze dynamic competitive equilibrium. Next, we apply the more powerful Johansen Multivariate Maximum Likelihood cointegration test to investigate the long-run relationship. However, this method contains some drawbacks, so we employ the method presented in Johansen (1988), which we introduce as follows.

The hypothesis is formulated as the restriction for the reduced rank of Π: $H_0(r): \Pi = \alpha\beta'$ for the reduced form error correction model (ECM):

$$\Delta Y_t = \Gamma_1 \Delta Y_{t-1} + ... + \Gamma_k \Delta Y_{t-(k-1)} + \prod Y_{t-1} + \psi D_t + \in_t \quad (2)$$

Where, $\in_t$ is white noise, and α and β are both $(p \times r)$ matrices, and represent the speed of the adjustment parameter and cointegration vector, respectively. The likelihood ratio test statistic for the hypothesis that there are at most r cointegrating vectors (that is. H(r): rank $(\Pi) \leq r$ is: -2 ln Q (H(r)/ H (p) = $-T\sum_{i=r+1}^{p}\ln(1-\hat{\lambda}_i)$. This study adopted Nieh and Lee's (2001) method, which is based on both Johansen (1988) and Johansen (1994). There are total five Johansen VAR models with ECM, which are summarized in the following forms:

H_0 (r): ΔY_t =

$$\Gamma_1 \Delta Y_{t-1} + ... + \Gamma_{k-1} \Delta Y_{t-k+1} + \Pi Y_{t-1} + \alpha\beta' Y_{t-1} + \psi D_t + \in_t \quad (3)$$

H_1^* (r): ΔY_t =

$$\Gamma_1 \Delta Y_{t-1} + ... + \Gamma_{k-1} \Delta Y_{t-k+1} + \Pi Y_{t-1} + \alpha(\beta', \beta_0)(Y'_{t-1}, 1)' + \psi D_t + \in_t \quad (4)$$

H_1 (r): ΔY_t =

$$\Gamma_1 \Delta Y_{t-1} + ... + \Gamma_{k-1} \Delta Y_{t-k+1} + \Pi Y_{t-1} + \alpha\beta' Y_{t-1} + \mu_0 + \psi D_t + \in_t \quad (5)$$

H_2^* (r): ΔY_t =

$$\Gamma_1 \Delta Y_{t-1} + ... + \Gamma_{k-1} \Delta Y_{t-k+1} + \Pi Y_{t-1} + \alpha(\beta', \beta_0)(Y'_{t-1}, 1)' + \mu_0 + \psi D_t + \in_t \quad (6)$$

H_2 (r): ΔY_t =

$$\Gamma_1 \Delta Y_{t-1} + ... + \Gamma_{k-1} \Delta Y_{t-k+1} + \Pi Y_{t-1} + \alpha\beta' Y_{t-1} + \mu_0 + \mu_1 t + \psi D_t + \in_t \quad (7)$$

To analyze the deterministic term, Johansen decomposed the parameters μ_0 and μ_1 in the directions of α and $\alpha_\perp$ as $\mu_i = \alpha\beta_i + \alpha_\perp r_i$, and thus the researchers have $\beta_i = (\alpha'\alpha)^{-1}\alpha'\mu_i$ and $r_i = (\alpha'_\perp\alpha_\perp)^{-1}\alpha'_\perp\mu_i$. The nested sub-models of the general model of null hypothesis $\Pi = \alpha\beta'$ are therefore defined as:

H_0 (r): Y=0

H_1^* (r): Y=$\alpha\beta_0$

H_1 (r): Y=$\alpha\beta_0 + \alpha \perp r_0$

H_2^* (r): Y=$\alpha\beta_0 + \alpha \perp r_0 + \alpha\beta_1 t$

H_2 (r): Y=$\alpha\beta_0 + \alpha \perp r_0 + (\alpha\beta_1 + \alpha \perp r_1)t$

Johansen (1994) emphasized the role of the deterministic term, Y= $\mu_0 + \mu_1 t$, which includes constant and linear terms in the Gaussian VAR. Johansen (1994) tested the hypotheses H (r) and H* (r) for the five different models is presented in the following order:

H_0 (0)→ H_1^* (0)→ H_1 (0)→ H_2^* (0)→ H_2 (0)→ H_0 (1)→ H_1^* (1)→ H_1 (1)→ H_2^* (1)→ H_2 (1)…→…→…→H_0 (p-1)→ H_1^*(p-1)→ H_1 (p-1)→ H_2^* (p-1)→ H_2 (p-1)

Applying the idea of Nieh et al. (2005), the decision adopt Johansen (1994) and Johansen (1988) methodologies for a long-term relationship of YML and YML's suppliers (automotive component manufacturers) with the consideration of a linear trend and a quadratic trend in stock price.

Error correction analyses

The discovery of cointegration among variables indicates the presence of a stable, long-run relationship. Therefore, we can estimate this relationship and examine the adjustment to deviations from this equilibrium. Engle and Granger (1987) formalized this intuition by developing a representation theorem connecting the moving average, autoregressive and error correction representations for cointegrated systems. The resulting model, known as a vector error correction model (ECM), is a generalization of a vector autoregression to allow for variables which contain I (1) processes. Since the ECM can capture both the short-run dynamic and the long-run equilibrium relationship among variables, in this paper we adopt it to examine the relationship among firms' stock prices. Therefore, consider the following equation system:

$$\Delta A_{jt} = \beta_0 + \beta_{j\varepsilon}(\varepsilon_{t-1}) + \sum_{j=1}^{m}\sum_{i=0}^{n_j}\beta_j \Delta A_{jt-i} + \sum_{j=1}^{m}\sum_{i=0}^{n_j}\beta_{ji}\Delta C_{jt-i} + \in_{jt} \quad (8)$$

Table 3. Cluster analysis of automotive component manufacturers.

Firm stock	TY	RW	CH	Juili	Tayih	KY	Calsonic
Clusters	1	1	1	2	2	3	3

The error correct term, ε_{t-1}, represents the previous period's disequilibrium ($A_{jt-1} - \alpha_1 C_{jt-1}$). ε_{at} and ε_{ct} are stationary random processes intended to capture other pertinent information not contained in the lagged values of A_{jt} and C_{jt}. Nonetheless, we use Akaike's information criterion (AIC) to determine the optimal number of lags based on the principle of "parsimony". The short-run parameters β_{ji} along with estimates of the error correction term (ECT) can be obtained through maximum likelihood estimation. The ECT consists of the speed of adjustment parameters $\beta_{j\varepsilon}$, which exists of a long-run relationship among the stock prices of the automotive assembly and component manufacturers, and is validated from the statistically significant finding of the speed of adjustment coefficients.

Nair and Filer (2003) indicated that the speed of adjustment parameters can be interpreted as follows. A negative $\beta_{j\varepsilon}$ is indicative of converging behavior by the firm. Therefore, the cointegration relationship within the group acts as an equilibrium relationship for these firms. However, if the firm responds to the positive deviation from the equilibrium in the subsequent periods by making this deviation even larger this produces a positive $\beta_{j\varepsilon}$, indicating that a firm is referencing its peers and yet diverges from them. Such nonconforming behavior may be characterized as differentiating or entrepreneurial.

RESULTS

We perform the k-means clustering algorithm to produce exactly three different clusters of greatest possible distinction, and the automotive component manufacturers are further divided into three groups. Table 3 shows that TY, RW and CH are the first group, Juili and Tayih are the second group, and KY and Calsonic are the third group.

Unit-root test

The stationary linear combination may be interpreted as a long-run equilibrium relationship among the variables (Engle and Granger, 1987). Therefore, before undertaking tests of cointegration nonstationarity tests must be performed. Such tests include Dickey and Fuller (1981) who indicated that there are three models that can test for this, and this paper uses the ADF test, as follows. In addition to the nonstationarity condition, tests of cointegration also require that the system variables be integrated of the same order. For example, suppose the researcher detects nonstationarity in the level of a variable, but subsequently finds stationarity in the first difference of the series; they would conclude that the series is integrated of order 1, denoted I(1). Therefore, before testing for cointegration the researcher must be assured that the variables involved are all nonstationary (that is, not I(0)) and integrated of the same order.

Table 4 shows that all the firms' stock prices do not reject the unit root test at least a 5% significance level. However, the results from Dickey- Fuller unit roots test reveal for the first difference of each variable are stationary.

Cointegration analysis

Table 5 presents the empirical findings from the Johansen methodology for the long-run relationship with the consideration of a linear trend and a quadratic trend in stock price for each partnership network. YML and YML's component manufacturers are divided into three groups of high, medium and low profit margin. For the first group, the results indicate that the firm's stock price has one cointegration relationship with the trance value of T_0(r) (44.87) exceeds the critical value of 39.89 at 95% of the null of rank=0. In addition, these empirical finding again suggests that there exists one cointegration vector among the three groups' stock prices for each supply network according to the trance values exceeds the critical values. When each group has a cointegration relationship it means that there is a comovement phenomenon among the assembly company (YML) and YML's component manufacturers (TY, RW, CH, Juili, Tayih, Kaiyih, Calsonic) in supply networks. Thus, overall the results show that all the nonstationarity series in the three groups of YML with YML's component manufacturers were cointegrated. The results tend to support proposition 1, that firms in supply networks should have significant long-term relationships.

Estimation of the vector error correction model

Table 6 also provides the estimates of the speed of adjustment parameter along with the corresponding results from the t-test of significance. First, the model for the high profit margin group contains two significant speed of adjustment parameters: that of TY (0.024) and RW (-0.005). In addition, the TY estimate is positive and the RW estimate is negative, suggesting that any action by the firm that leads to a positive (negative) deviation from the long-run relationship results in the firm continuing

Table 4. Tests for the order of integration based on the Dickey-Fuller test.

Variables	R(0)	R(1)
TY	-1.05	-19.28*
RW	-2.24	-16.74*
CH	-1.92	-33.61*
Tayih	-1.20	-18.12*
Juili	-4.02	-15.00*
KY	-1.15	-15.65*
Calsonic	-1.25	-16.46*
YML	-1.34	-16.98*

The unit root test is based on the AIC with fours lags, and the 5% and 1% critical values are -3.45 and -4.04, respectively.
* denotes rejection of the hypothesis at the 5% critical value

Table 5. Determination of cointegration rank in the presence of a linear trend and a quadratic trend.

YML and YML's suppliers (component manufacturers)										
					YML TY RW CH					
	Model 1 H0(R)		Model 2 H1* (R)		Model 3 H1 (R)		Model 4 H2* (R)		Model 5 H2 (R)	
Rank	T0(r)	Critical value	T_1^*(r)	Critical value	T1(R)	Critical Value	T_2^* (r)	Critical Value	T2(r)	Critical Value
r=0	44.87*	39.89	56.33*	53.12	50.91*	47.21	59.79*	62.99	50.42	54.64
r≤1	24.31	24.31	27.87	34.91	22.76	29.68	31.46	42.44	22.27	34.55
					YML Juili Tayih					
r=0	31.68*	24.31	34.50	34.91	29.40	29.68	36.61	42.44	26.75	40.49
r≤1	12.66	12.53	13.31	19.96	11.49	15.41	17.18	25.32	13.55	23.46
					YML KY Calsonic					
r=0	23.90	24.31	37.84*	34.91	35.03*	29.68	42.44*	42.44	36.66	40.49
r≤1	6.10	12.53	19.23	19.96	16.45	15.41	23.26	25.32	18.00	23.46

T0(r), T_1^* (r), T1(r), T_2^* (r), and T2(r) denote the likelihood ratio test statistics for all the null hypotheses of H(r) versus the alternative of H(p) which include all the cases. The numbering of the rank is from left to right and top to bottom and decide to reject a hypothesis if all hypothesis with smaller number are also rejected. * (**) denotes rejection of the hypothesis at the 5% (1%) level. VAR length is selected based on the smallest number of AIC.

to diverge (converge) in the subsequent periods. Second, in the medium profit margin group contains one significant and positive speed of adjustment parameter: that of Juili (0.003) and Tayih (0.006). Tayih also shows divergent behavior (0.002), but the estimate is insignificant. Finally, in the model for the low profit margin group, KY displays convergent behavior (-0.005), but the estimate is insignificant. The estimate for Calsonic is positive and significant. The results tend to support proposition 2, that when partners have a long-term equilibrium, individual firms tend to converge or diverge behavior towards the equilibrium.

DISCUSSION

This paper had two aims: first, to explore the long-term relationships among the assembly companies and their component manufacturers; and second, we investigated the strength of relationships with the other partners. Next, we discuss how the work addressed these two aims.

Cointegration in the supply network relationships

We found that all firms' stock prices are nonstationary. These non-stationary series display no long-term mean reversion, and shocks to the series tend to die out slowly over time. The purpose of the paper was to examine long-term relationships among the assembly companies and the component manufacturers. Our cointegration analysis finds that firms have significant long-term relationships in supply networks. These results lead to the conclusion that relationships among automotive

Table 6. Error correction model.

YML with its suppliers		
TY	RW	CH
0.024***	-0.005**	0.004
VAR assumes no deterministic trend and no intercept in CE (model3 of Table 5).		
Juili	Tayih	
0.003**	0.006**	
VAR assumes no deterministic trend and no intercept in CE (model 1 of Table 5).		
KY	Calsonic	
-0.005	0.018**	
VAR assumes no deterministic trend and no intercept in CE (model 3 of table 5).		

(*), (**) and(***) denote significance at 10, 5 and 1%, respectively. The significance tests with 10, 5 and 1% critical values for the traditional t-test with a d.o.f. of 4 and 3 are (1.5332, 2.1318, 3.7469) and (1.63, 2.35, 4.5407), respectively.
The model is estimated with one lag of the endogenous variables.

component and assembly manufactures have been transformed. First-tier component firms have become more involved with their customers and tend to provide black box parts or systems. It is also important to understand what integrates the pieces of the network - the "glue" that holds it together. In this case the "glue" consists primarily of the information technologies that are the heart of modern retailing. Venkatraman and Henderson (1998) provides scenarios how e-integration can support network resource configuration. First, IT can support sourcing standard models or components in the form of electronic data interchange (EDI), Web site, and trading process network. Second, IT is the backbone of process outsourcing, where firms outsource their information intensive business process, such as accounting, to external specialists without loss of control. In some cases, effective integration requires updating information on even a daily basis. While coordination activities had been crucial, their importance across vehicle systems has increased dramatically over the past twenty years with the introduction of advanced electronics that impact multiple systems (2009). Third, IT can provide electronic exchange platforms, such as B2B, to support resource coalitions where firms become part of a dynamic network of complementary capabilities.

Briefly, the characteristic of IT in dynamic network was included full-disclosure information systems, which denoted participants agreed on a general structure of payment for value added and then hooked themselves together in a continuously updated information system so that contributions can be mutually and instantaneously verified (Miles and Snow, 1986).

Estimates of adjustment behavior

Once we identified the presence of long-term interdependence within the groups, we examined the exact nature of the cooperative relationships. The finding of ECM indicates that the firms are referencing each other in a consistent way, and this may result in convergent or divergent behavior. In one (out of seven) instances, a firm demonstrated an error correction process that was significant and converged towards the group equilibrium. Woo and Ennew (2004) noted that maintaining long-term relationships requires institutionalization and adaptation, as well as coordination. This point is support by Smyth and Pryke (2008), who pointed out that collaborative relationships operate both in frameworks and within networks of contacts, e.g. relational contracting in partnering, SCM and other procurement-driven initiatives.

However in three instances we found positive and significant results, suggesting that some firms displayed behavior that was divergent with others. According to Woo and Ennew (2004, p.1255), short-term relationships develops through product or service exchange, information exchange, financial exchange, and social exchange between the buyer and suppliers. Moreover, it is without doubt that supply chain collaboration activities can lead to product innovations. More specifically, partners amalgamate with other firms to construct a financial vision, and some firms are absorbed into others due to the cost factors surrounding the supply chain collaboration relationship. In the context of this study, global automakers transfer their production to East Asia in order to reduce their costs, and this causes local region component manufacturers to reduce their reliance on local automotive assembly manufactures. For example, Tayih has successfully tapped into the global component manufacturers and tier-one automotive parts supply chains, while TY and Juili produce automotive parts for OEM and the aftermarket in the North American market. Table 7 shows that TY and Juili continuously increased

Table 7. The production value of TY and Juili in the aftermarket.

		2000		2001		2002		2003	
		Aftermarket	OEM	Aftermarket	OEM	Aftermarket	OEM	Aftermarket	OEM
TY	Average monthly revenue	4.47	3.65	4.90	2.67	5.39	3.25	6.02	4.16
	RR (%) ①	32.26	25.98	36.08	19.65	37.95	22.89	35.86	24.74
Juili	Average monthly revenue	5.75	1.17	4.91	1.21	5.58	1.01	6.39	1.15
	RR (%) ①	80.12	16.26	77.88	19.26	82.57	15.01	83.91	15.12

In millions of US dollars, exchange rate calculation according to Central Bank of China (Taiwan) ① ratio to total revenue, RR: revenue divided by total revenue.

their production value in the aftermarket from 2000 to 2003.

Conclusions

This study provides empirical evidence of the strength of relationships and at the same time examines firm behavior in supply networks. It found that long-term relationships are a driver of complementary resources and sustained competitive advantage (Dyer and Singh, 1998). In addition, firms tend to follow relational and organizational norms to ensure that they are consistent in their behavior (Cannon et al., 2000; Palmatier et al., 2007). Womack et al. (1990) on the global automotive industry showed the significance of establishing a basic contract to ensure the long-term commitment of all parties during both product development and operation, and to allow sensitive information and knowledge to be exchanged. Luo and Kim (2009) indicated that Japanese automotive suppliers emphasize the focus on quality, cost and delivery in their current product portfolio for current customers, and their reluctance to develop radical new products and explore new customer base. Explanations include: the reliance on the pull of the automakers, slow-paced "corporate DNA" formed in the historical and deep involvement in the automotive business for long-term transactional relationships with customers.

On the other hand, this study's examination of short-term relationships shows that some firms construct a financial vision and are absorbed into others due to the cost factors surrounding the supply chain collaboration relationship. However, there are two reasons that explain this. First, firms often establish relationships based on contracts to deal with arm's length relationships and seek to maximize their own bargaining powers (Singh et al., 2005). Automotive components manufacturers in the West have traditionally been strong adherents to the contractual model, especially in the aftermarket; this causes component manufacturers to reduce reliance on automotive assembly manufactures. Second, aftermarket suppliers not only offer an opportunity to provide replacement parts, but also follow the requirement for continual cost reductions. Such financial exchanges cause firms to have divergent behavior.

The results show that supply networks are complex; they often play out over long periods, and may result in different behavior. We chose the Cointegration analysis because it is well suited to examining the dynamic competitive equilibrium in a strategic group to assessing long-term phenomena over time (Nair and Filer, 2003). It also allows us to examine the occurrence of long-term and short-term relationship in an automotive supply network. Large-scale survey and case studies are inappropriate or impractical to pursue the objectives of the study. Large-scale survey would have to entail longitudinal data collection to capture the evolutionary nature of the supply networks and that would also be extremely difficult, if not impossible, to execute. Case studies would lack external validity, and when conducted in a longitudinal context long enough to capture the evolutionary decision-making patterns, the amount of data would simply be unmanageable (Nair et al., 2009). Unlike most studies in the literature, which only estimate the contemporaneous relationships, this paper also explored the strength of relationships in an automotive supply networks. This paper supports the findings of most of the previous studies that significant long-term relationships exists in supply networks, and that such networks need long-term cooperation and the development of mutually beneficial and interdependent relationships (Chan et al., 1997; Kale et al., 2002).

Consequently, the results of this study can help managers and academics better understand why firms form long-term relationships in supply networks, and illustrate firms' strategies with regard to convergent (divergent) behavior. Moreover, the article contributes to the supply chain management literature by undertaking an extensive examination of dynamic behavior by firms that are embedded in supply networks as buyers and suppliers in the automotive industry. The role of incentive structures in shaping behavior in the supply network level is presented. More specifically, the reason why the interaction between suppliers is much more complicated is because automotive component manufacturers are from multiple sources, and the assembly firms make contracts with component manufacturers over a long period before the vehicles are sold to the market. It is thus important for collaborative partners in the automotive industry to develop and maintain long-term relationships, as by doing so they are able to obtain more benefits and become more competitive.

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Appendix

Appendix A. Main products and acronyms used in the Taiwan automotive industry.

	Abbreviation	Full name	Main products
Automotive component industry	TY	Tong Yang Industry Co., Ltd.	Bumper, grill, instrument panel, spoiler, fender, hood, etc...
	RW	Right Way Industrial Co., Ltd.	Forging, piston, etc…
	Juili	Jui Li Enterprise Co., Ltd.	Metal stamping mold, welding, inspection jigs, etc…
	Tayih	Ta Yih Industrial Co., Ltd.	Lamps, mold, etc…
	KY	Taiwan Kai Yih Industrial Co., Ltd.	Automotive sheet metal parts, molds, and hardware component
	CH	Chian Hsing Forging Industry Co., Ltd.	Forging, parts, etc…
	Calsonic	Taiwan Calsonic Co., Ltd.	Condition, electrical parts
Automotive assembly industry	YML	Yulon Motor Co., Ltd.	Car assembling