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Cointegration relationships of strategy variables among firms within strategic groups

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Abstract This study examines the long-term, dynamic equilibrium relationship for strategy variables of firms in strategic groups by conducting a cointegration analysis. Replicating the Nair and Filer (*Strateg. Manage. J.*, 24: 145–159, 2003) methodology and extending it to four industries listed on the Taiwan Stock Exchange, we find that not all of non-stationary strategy variables have the cointegration relationships, and that only the strategy variables of strategic groups in our traditional industries (as compared to our high-tech industries) should have a long-term competitive equilibrium (cointegration relationship). In other words, we can proceed with an error correction model in some traditional industries to map out the relative positions of rival firm strategies and subsequently implement appropriate reactions.

Keywords Cointegration analysis · Dynamic equilibrium relationships · Error correction model · Strategy variables · Taiwan Stock Exchange

In the field of strategy research, understanding the relationship between changes of industrial environment and interactions among firms is critical to determining competitive advantage. One of the principal issues addressed by strategy researchers is how to exploit, in the context of within-industry competition, the primary strategy variables in response to rival actions and how to adjust strategy variables based on

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changes of industrial environment (Baum & Singh, 1994; Baum & Korn, 1996; Camerer, 1991; Chen, 1996; Chen & Hambrick, 1995; Cool & Schendel, 1987; Young, Smith, Grimm, & Simon, 2000).

Particularly, some scholars from the view of industry and firm resources explain why companies employ different business strategies (Barney, 1991; Li, 2005; Mathew, 2002; Porter, 1980). Recently, numerous scholars also explored business strategies from an organizational perspective (Luo, Tan, & O'Connor, 2001; North, 1990; Peng, 2002; Scott, 1995). For example, Peng, Tan, and Tong (2004) evaluate the relationships between ownership types and strategic groups. Based on the Miles and Snow (1978) typology, they find that state enterprises and private enterprises typically adopt defender and prospector strategies, respectively, whereas collectively owned enterprises and foreign-invested enterprises exhibit an analyzer orientation.

Furthermore, a considerable number of studies investigate mutually competitive behaviors within a strategic group. Some of these studies examine how strategic groups in certain industries are formed (Cool & Schendel, 1987; Dranove, Peteraf, & Shanley, 1998). A few studies examine firm-level competitive behaviors within a strategic group (Chen & Hambrick, 1995; Chen, Smith, & Grimm, 1992). Dranove et al. (1998) and Fiegenbaum and Thomas (1995) argue that certain criteria exist for strategic group membership in some industries, which in turn influences variation of individual company's strategy variables. Nair and Filer (2003) first propose the cointegration method for interpreting the long-term dynamic equilibrium among firms in a strategic group.

Nair and Filer (2003) utilize data from the Japanese steel industry and successfully identify the long-term dynamic equilibrium relationships among firms. These relationships illustrate that adjustment of a firm's strategy variables during a subsequent period will 'converge' or 'diverge' from an equilibrium level within the strategic group. By using this method, a firm can determine its rivals' strategic features and then implement competitive plans. Therefore, the feasibility of this approach affects whether subsequent competitive strategies will be successful. We examine the feasibility of this methodology by applying it to a variety of industries. And if the method is applicable, we can explicitly decompose complicated interactions among firms within a strategic group in various industries and subsequently execute firm's strategies effectively. Also, if the model is applicable, it will help strategy researchers understand the nature of delicate competition among firms within a strategic group. Hence, we examine the validity of the cointegration analysis in this field. We replicate Nair and Filer's (2003) procedures and extend them to four industries in Taiwan to explore the feasibility of this methodology.

In addition, we emphasize the importance of replication as we do in this paper, especially in strategy research as stated by Singh, Ang, and Leong (2003, p. 533) that "extensive replication is essential to ensure the reliability and validity of research and for rigorous theory development, particularly for pre-paradigmatic social sciences such as strategy." Also, numerous management researchers assess and explain the role played by replication for knowledge accumulation and theory development. (Hubbard, Vetter, & Little, 1998; Peng, Zhou, & York, 2006; Tsang & Kwan, 1999).

Our objectives for this study are: (1) to generalize Nair and Filer's (2003) cointegration analysis within a variety of strategic groups by replication of procedures, that is, to determine whether cointegration analysis can analyze the dynamic equilibrium relationship for numerous industries over long periods; and (2) to determine if additional industries are appropriate for cointegration analysis, by examining four industries in Taiwan.

Theoretical background and development of hypotheses

Within a competitive industry, firms pursue competitive advantages by constantly creating new niches and responding to the actions of their competitors. However, some firms follow strategies very similar to those of their rivals. Furthermore, we frequently observe that the competitive strategies adopted by firms within the same strategic group are clearly different from strategies used by firms of other strategic groups. Here we focus on the competitive dynamics of related strategies employed by firms within strategic groups in four different industries (two traditional manufacturing industries and two high-tech industries).

Competitive behavior within a strategic group

First, in investigating competitive behavior within a strategic group, Chen and Hambrick (1995) identify different competitive actions among various airlines. Their results show that small airlines should actively initiate competition and execute its actions rapidly discretely, or even secretly. Competition among similar firms plays an important role when studying strategic groups (Chen, 1996; Chen et al., 1992; Hoskisson, Hitt, Wan, & Yiu, 1999; Ketchen & Palmer, 1999). Houthoofd and Heene (1997) proposed that a firm's responses are likely influenced by a rival's behaviors. Cool and Schendel (1987) examine the performance and formation of strategic groups in the US pharmaceutical industry between 1963 and 1982.

Fiegenbaum and Thomas (1995) demonstrate that an intangible membership exists within a strategic group. Such group membership provides a referencing function, and members compare continuously their relative positions with the membership. Chen et al. (1992) and Hitt, Ireland, and Hoskisson (2001) also argue that when members within a strategic group act, they continually evaluate their market position relative to their competitors. Over the long run, member interactions will create unique relationships. And, particularly, when firms are planning or implementing strategies, they first anticipate competitor responses and then engage in strategies that are 'convergent' or 'divergent' relative to the special relationship.

Second, following Nair and Filer (2003), we apply cointegration theory, which is extensively used in examining long-term relationships between financial variables (Engle & Granger, 1987; Granger, 1983), to strategic management research. Cointegration refers to a linear combination of two or more non-stationary series, which may be stationary. If such 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 & Granger, 1987). As mentioned previously, an intangible group membership may exist in a strategic group that serves as a dynamic competitive reference among firms. With the same strategic group, the strategies of members in a strategic group typically move toward a similar relationship (Chen, 1996; Dranove et al., 1998; Fiegenbaum & Thomas, 1995). Nair and Filer (2003) demonstrate that the group membership is similar to long-term dynamic competitive equilibrium such as that indicative of a cointegration relationship. By using cointegration analysis, Nair and Filer provided evidence that cointegration phenomena exist among firms in the Japanese steel industry. This study applies the cointegration methodology used by Nair and Filer (2003) to evaluate the long-term relationships between strategy variables among firms within strategic groups for various industries. If there exists a long-term relationship among

competitive strategies employed by firms within a strategic group, then the strategy variables for these firms will be cointegrated. Therefore, we propose:

Proposition 1 In long-term adjustments, there exists a long-term relationship among competitive strategies employed by firms within a strategic group.

Industry effect *vs*. strategic groups

With regard to industry effects, in strategic management the often-quoted papers about industry effects affecting firm performance are Rumelt (1991) and McGahan and Porter (1997). Rumelt (1991) argues that business-specific effects are superior to industry effects on firm performance. Caloghirou, Protogerou, Spanos, and Papagiannakis (2004) also provide evidence that firm factors exert a much stronger impact than industry factors. However, McGahan and Porter (1997) find that industry effects significantly influence firm performance and result in different impacts in different industries. However, few studies have examined whether long-term relationships of strategy variables within strategic groups are the same for various industries. Previous studies investigating competitive dynamics between firms focus on a few strategic groups in a single industry.

Nair and Filer (2003) determine that long-term competitive equilibriums exist in strategic groups in the Japanese steel industry. Additionally, Smith, Grimm, Wally, and Young (1997) show that intense competition in a strategic group, utilizing strategies such as continual imitation and frequent price cutting, will likely result in an unstable competitive environment and harm coordination between firms. Based on the results of Smith et al. (1997), we believe that firms belonging to strategic groups that are in intensely and globally competitive industry, face not only domestic peer group competition but also encounter challenges from other firms outside their group, particularly foreign competitors.

For example, firms in high-tech industries have more foreign customers and competitors than traditional manufacturing firms. Therefore, these firms would likely choose destructive strategies (e.g., price-cutting) that will be harmful to the existence of the long-term relationships within the strategic group. Accordingly, we propose that long-term relationships within a strategic group will be affected by industry attributes. Specifically, we propose that strategic groups dispersed among different industries should lead to different competitive dynamics and different long-term relationships.

Proposition 2 The existence of long-term relationships among firm strategies within a strategic group is correlated with the attributes of the industry.

Nair and Filer (2003) point out 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. 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. By employing cointegration analysis and the error correction model (ECM),[1] they identified cointegration relationships

[1] Due to space limitations, the analytical results of ECM of related cointegration are not presented here and can be requested from the authors. As Nair and Filer (2003) propose that analysis by ECM can further explain whether a firm's strategies are converging or diverging from an equilibrium reference level. Such analysis should help us understand the relative position of individual firm strategy within a strategic group.

existing among strategy variables in the Japanese steel industry. However, is this methodology appropriate for other industries? Do long-term competitive and strategy variables within a strategic group exist in different industries? In addition to replicating the methodology of Nair and Filer (2003) with different data, we extend their work by exploring the relationship between industry effects and long-term competitive dynamics among firms.

Methodology

Cointegration analysis

Before applying cointegration analysis, we must first identify variables that belong to non-stationary series. Stationarity tests include Dickey & Fuller (1981) and Phillips & Perron (1988) ones. This study uses the latter. Additionally, cointegration tests also require that the system variables be integrated of the same order.

With respect to cointegration analysis, the method proposed by Engle & Granger (1987) has been adopted by many studies. However, this method contains some drawbacks, so we employ the method of Johansen (1988), which we introduce as follows.

Consider a vector auto-regression (VAR) of first order:

$$x_t = A_1 x_{t-1} + \varepsilon_t,$$

where x is a vector $(x_{1t}, x_{2t}, \ldots x_{nt})$ of dimension $(n \times 1)$; ε_t is an $(n \times 1)$ vector of residuals; and A_1 is an $(n \times n)$ matrix of parameters. Subtracting x_{t-1} from each side provides:

$$\begin{aligned} \Delta x_t &= A_1 x_{t-1} - x_{t-1} + \varepsilon_t \\ &= (A_1 - I) x_{t-1} + \varepsilon_t \\ &= \pi x_{t-1} + \varepsilon_t. \end{aligned}$$

Again, x_t and ε_t are $(n \times 1)$ vectors; A_1 is an $(n \times n)$ matrix; I is an $(n \times n)$ identity matrix; and π is defined to be $(A_1 - I)$. The rank of the matrix π equals the number of independent co-integrating vectors in the system and also equals the number of its nonzero characteristic roots. Therefore, we can develop a test for cointegration using the matrix π. Suppose we calculate estimates of both π and its characteristic roots (eigenvalues) λ_n. The following two statistics, as proposed by Johansen (1988), test for the number of characteristic roots that are insignificantly different from unity:

$$\lambda_{\text{Trace}} = -T \sum_{i=r+1}^{n} \ln\left(1 - \widehat{\lambda}_i\right),$$

$$\lambda_{\max}(r, r+1) = -T \ln\left(1 - \widehat{\lambda}_{r+1}\right),$$

where $\widehat{\lambda}_i$ is the estimate of the eigenvalues obtained from the estimated π matrix and T is the number of observations in the data set. The Trace statistic provides a test of a general hypothesis as follows:

$$H_0 : \text{rank}(\pi) \leq r$$
$$H_A : \text{rank}(\pi) > r.$$

Table 1 Strategy variables: definitions and measurement.

Item	Strategy variables	Practical measurement	Definition
1	Cost efficiency	Cost of goods sold/total sales	Measure of a cost leadership approach
2	Capital expenditures	Net expenditures for plant and equipment	Measure of use of technology to improve productivity and quality
3	Capital intensity	Total assets/number of employees	Measure of use of technology to improve productivity and quality
4	Firm size	The number of employees	Measure of a firm's scale
5	R&D expenditures	R&D expenditures/total sales	Measure of development of advantages for the future

Summary from past research (Cool & Schendel, 1987; Hambrick, 1983; Nair & Filer, 2003; Porter, 1980).

And the max statistic provides a test with a specific alternative:

$$H_0 : \text{rank}(\pi) = r$$
$$H_A : \text{rank}(\pi) \neq r.$$

The critical values of these tests were calculated in Johansen and Juselius (1990). Because the number of samples in our research is finite, we employ the critical values for the finite samples proposed by Osterwald-Lenum (1992).

Variable selection and data

Using previous studies, we identify a set of firm-level realized strategy variables (Cool & Schendel, 1987; Hambrick, 1983; Nair & Filer, 2003; Porter, 1980). There are five measures related to research and development (R&D), resource commitments, scale and scope, efficiency, and asset parsimony: R&D expenditures, the size of firm, cost efficiency, capital expenditures, and capital intensity. They are described and their measurements are given in Table 1.

This study concentrates on the long-run relationships of firms' strategy variables within a strategic group and the dynamic equilibrium adjustment among these firms. Sample firms are chosen from companies listed on the Taiwan Stock Exchange in four industries (paper companies, home appliance manufacturing companies, integrated circuit assembly and testing companies, and integrated circuit wafer manufacturing companies), with a total of 11 firms. The data are collected from Taiwan Economic Journal (TEJ), and the strategy variables are calculated for all 11 firms for the sample period 1993–2004 by seasons.

In Table 2, we list the companies and provide the average of the strategy variables R&D expenditures and capital expenditures for each industry. The table shows that the averages of R&D expenses and annual capital expenditures in the groups of paper companies and home appliance companies are much lower than in the groups of integrated circuit (IC) wafer manufacturing companies and IC assembly and testing companies. Based on the characteristics of each industry, the strategic groups[2] of paper companies and home

[2] For identification of strategic groups within the four industries, we cite the competitive interaction view for group formation from Pegels, Song, and Yang (2000). Their paper explains that without directly investigating the patterns of competitive interactions, one would never be sure that grouping of firms by strategic profiles is the correct reflection of interdependence patterns of firms in an industry.

Table 2 Unit root tests for non-stationarity.

Company name	Cost efficiency	Capital expenditure	Capital intensity	Firm size	R&D expenditure
Original series					
Paper company group (average ratio of R&D expenses: 0.31%; average annual capital expenditures: NT*$0.34b)					
Yuen Foong Yu	−0.13	−5.61**	2.90	−2.21*	−0.26
Cheng Loong	−0.36	−4.52**	1.86	0.58	−0.36
Chung Hwa	−1.18	−6.04**	1.17	−2.54*	−3.92**
Long Chen	0.04	−5.52**	0.42	0.02	−1.00
Home appliance company group (average ratio of R&D expenses: 1.49%; average annual capital expenditures: NT*$0.46b)					
Sampo	1.71	−5.91**	1.06	−1.97*	−0.40
Kolin	1.35	−6.49**	0.89	−2.60*	−0.68
IC assembly and testing company group (average ratio of R&D expenses: 1.89%; average annual capital expenditures: NT*$1.02b)					
Advanced Semiconduct	0.62	−4.41**	−0.19	3.49	0.42
Siliconware	0.23	−7.79**	0.12	3.27	0.71
Orients	0.42	−5.13**	0.11	0.52	0.34
IC wafer manufacturing company group (average ratio of R&D expenses: 6.69%; average annual capital expenditures: NT*$5.99b)					
Taiwan Semiconductor	−0.45	−3.37**	0.67	2.50	−0.23
United microelectronics	−0.17	−8.29**	−0.67	1.03	−0.90

The test performed is the Phillips-Perron test on a model with no constant or time trend and one lag of the endogenous variable. This is a test of the null hypothesis of a unit root against the alternative that the variable is a stationary process. The critical values at 5% and 1% are −1.95 and −2.62, respectively.

(*) and (**) denote values are significance at 5% and 1%, respectively. Also, these variables belong to stationary series [I(0)]. Other variables that achieve stationary situations after being engaged in first difference belong to series of I(1). They can be addressed using cointegration analysis.

appliance companies are categorized as traditional manufacturing industries; in contrast, the strategic groups of IC wafer manufacturing companies and IC assembly and testing companies are classified as high-technology industries.

Results and discussion

As discussed in "Methodology: cointegration analysis," the first identify the non-stationary strategy variables for each industry by using the Phillips and Perron (1988) test. Then the Johansen (1988) cointegration test is applied. Finally, in this section, we discuss how our results relate to our two hypotheses regarding the long-term relationships of firms in strategic groups.

Stationarity tests

We perform the Phillips & Perron (1988) unit root test (PP) for non-stationarity. The results of the PP test are presented in Table 2. The results indicate that the original series of capital expenditures of all firms are statistically significant at the 1% level, rejecting non-stationarity. Similarly, the strategy variable of firm size is significant at the 5% level for two

of the paper manufacturing companies (Yuen Foong Yu and Chung Hwa) and both of the home appliance firms, rejecting non-stationarity. Finally, the tests also reject non-stationarity of variable R&D expenditure for the paper company Chung Hwa. Thus, the variables capital expenditure for all firms and firm size for the home appliance firms are stationary. This stability means that these strategy variables cannot be analyzed using the cointegration method, rather, they can be evaluated using traditional regression techniques such as those used applied by Fiegenbaum and Thomas (1995). On the other hand, cost efficiency, capital intensity, firm size (except for both of the home appliance firms and the firms Yuen Foong Yu and Chung Hwa), and R&D expenditures (except for the firm Chung Hwa) have a unit root property. However, after taking first-order difference for these variables, we find that they reject the unit root test and reach the stationary property. Thus, these variables can be analyzed using cointegration analysis.

Cointegration analysis

Table 3 presents cointegration analysis results. For each variable, we calculate two test statistics: λ_{max} and Trace. Each row represents a test of the null hypothesis of rank = r, where r is given in the first column.

In Table 3, for the group of paper companies, results indicate that the R&D expenditure strategy clearly has one cointegration relationship with the value of λ_{max} (32.84), which exceeds the critical value of 27.07. In addition, the Trace value of 50.41 exceeds the critical value of 47.21 at 95% of the null of rank = 0. For all other ranks (1, 2, and 3), there is no support for a cointegrated relationship for the variable R&D expenditure.

Table 3 Johansen cointegration test.

	Cost efficiency		Capital intensity		Firm size		R&D expenditure		95% critical value	
	Trace	λ_{max}	Trace	λ_{max}	Trace	λ_{max}	Trace	λ_{max}	Trace	λ_{max}
Paper company group*										
$r = 0$	52.86*	19.68	32.04	14.31	31.91	13.20	50.41*	32.84*	47.21	27.07
$r = 1$	33.18*	16.24	17.22	12.81	18.71	11.70	17.57	9.52	29.68	20.97
$r = 2$	16.94*	11.24	4.42	4.09	7.01	4.58	8.05	5.06	15.41	14.07
$r = 3$	5.70*	5.70*	0.32	0.33	2.43	2.43	2.99	2.99	3.76	3.76
Home appliance company group**										
$r = 0$	5.00	4.82	25.06**	25.06**			8.24	4.73	15.41	14.07
$r = 1$	0.18	0.18	0.01	0.01			3.51	3.51	3.76	3.76
IC assembly and testing company group										
$r = 0$	25.08	15.65	25.79	12.18	27.81	17.60	13.66	10.20	29.68	20.97
$r = 1$	9.43	7.66	13.61	10.25	10.21	9.77	3.47	3.34	15.41	14.07
$r = 2$	1.76	1.76	3.36	3.36	0.44	0.44	0.12	0.12	3.76	3.76
IC wafer manufacturing company group***										
$r = 0$	10.59	7.10	9.62	5.63	19.72***	19.71***	10.44	6.05	15.41	14.07
$r = 1$	3.49	3.49	3.98	3.98	0.01	0.01	4.39	4.39	3.76	3.76

*Value is greater than 95% critical value. The table indicates that the variable of cost efficiency contains four co-integrating vectors and that R&D expenditure contains one co-integrating vector.

**Value is greater than 95% critical value. The table indicates that capital intensity contain one co-integrating vector.

***Value is greater than 95% critical value. The table indicates that firm size contains one co-integrating vector. The critical values are the finite sample values reported in Osterwald-Lenum (1992). The model is run with one lag of the endogenous variables.

Results for the cost efficiency variable express the presence of four integrating vectors. At 95%, for the Trace statistic, the null of rank = 0, 1, 2, and 3 are rejected, and for the λ_{max} statistic, the null of rank = 3 is rejected. These findings are not unusual for such an analysis. However, as with a multiple equilibrium findings, when multiple co-integrating vectors are identified, typically only one cointegration relationship is feasible (Nair & Filer, 2003). This study adopted the first co-integrating vector as it holds most of the explanatory power. As for the firm size and capital intensity variables, the null of rank = 0 cannot be rejected under the λ_{max} and Trace tests, suggesting that no cointegration relationship exists between the two variables.

Next, in Table 3, the cointegration relationships in home appliance companies are examined. Only the capital intensity variable rejects the null of rank = 0 and contains a co-integrating vector. No other variables have a cointegration relationship.

Using the same cointegration method, the high-tech industries are analyzed, which includes the strategic groups in the IC assembly and testing industry (Table 3) and the IC wafer manufacturing industry (Table 3). Results reveal that a cointegration relationship is only identified for the firm size variable for IC wafer manufacturing companies and that no other variables have a cointegration relationship in these groups.

Implications

Understanding firms' relative position within an industry is of considerable importance for companies building firm-level competitive strategies. The methodology developed by Nair and Filer (2003) can help managers identify competitors' positions with respect to particular strategies within a strategic group. These strategy variables need to satisfy the cointegration relationship when using this method. That is, the cointegration relationship determines whether a long-term equilibrium exists in firm strategies in a strategic group.

Nair and Filer (2003) use the Japanese steel industry as a study example and identify cointegration relationships in all non-stationary strategy variables. Their analytical findings point toward a method for clarifying the relative positions of strategies among firms. This study replicates their methods by using the data of 11 companies in four industries listed on Taiwan's stock exchange. Based on our analyses discussed above, we do not find support for our Proposition 1 that there exists a long-term relationship among competitive strategies employed by firms within a strategic group. However, our results support Proposition 2 that the existence of long-term relationships among firm strategies within a strategic group should be correlated with the attributes of the industry.

The following arguments with respect to our propositions are based on our analytical findings:

(1) Most unit root tests results are similar to those obtained by Nair and Filer (2003). Only capital expenditures for all firms and firm size for the home appliance firms are stationary and must be examined by the conventional method proposed by Fiegenbaum and Thomas (1995) to determine a firm's position relative to the reference level for an entire industry. Cost efficiency, capital intensity, R&D expenditure and firm size (except the home appliance firms) variables belong to the I(1) series and are thus suited to cointegration analysis for determining a firm's position relative to the reference level of a strategic group.

(2) Cointegration analysis results show that not all strategy variables with I(1) have a cointegration relationship—namely, only some of the I(1) strategy variables contain a dynamic equilibrium over the long-term. These results reject our Proposition 1. This

result is very different from that obtained by Nair and Filer (2003), which suggests that all I(1) strategy variables conform to a cointegration relationship. In our study, 15 strategy variables in totality, which include four variables in individual group of paper companies, IC assembly and testing companies and IC wafer manufacturing companies, and three variables in the group of home appliance companies, are examined using cointegration tests. Only four of these variables contain cointegration relationships, including three variables (of seven strategy variables) distributed throughout the strategic groups of paper and home appliance companies (traditional industries), and only one variable (of eight strategy variables) in the high-tech industry. These results support Proposition 2. That is, the existence of a long-term relationship among firm strategies in a strategic group should be correlated with an industry's characteristics. A comparison of strategy variables for traditional industries with those of the high-tech industry shows that traditional industries may be more easily to achieve a long-term dynamic equilibrium relationship.

Compared with the high-tech industry, the traditional industry has slower technology improvement, cost structure enhancement, and interaction between firms. Therefore, each firm in a traditional industry can easily determine the variation in the entire industry and then adapt using suitable strategies. Based on the industrial attributes, the strategy variables of these firms are more likely to form cointegration relationships.

The high-tech industry—represented in this study by the IC assembly and testing industry and the IC wafer manufacturing industry—is subject to rapid technological progress, cost efficiency influenced strongly by demand variation, and close correlations between domestic and foreign industrial environments. The high-tech industry is less likely to develop cointegration relationships if only domestic competitors in a strategic group are considered. If we include foreign competitors in the strategic group of the high-tech industry, cointegration relationships may be more likely to develop. However, in this globally specialized and integrated era, most high-tech and large companies are involved in several different industries. Hence, obtaining precise data pertaining to a specific strategic group for cointegration analysis is difficult, and this study only has access to domestic (Taiwanese) data. Future research will need to collect significantly more data from non-domestic competitors in order to further advance this research.

Conclusion

Attempting to identify the position of each firm, numerous studies examine the interactions between firm strategies within a strategic group using a number of methods. The cointegration method proposed by Nair and Filer (2003) is a feasible approach for examining the position of each member in a strategic group. Although their study results in some solid conclusions for the Japanese steel industry, the appropriateness of this method for other industries remains controversial. Accordingly, our contribution is to replicate of the methodology of Nair and Filer (2003) and extend it to different strategic groups in four industries, and concurrently examine whether the cointegration relationship is influenced by industry effects. We further classify the four industries into two strategic groups, traditional manufacturing industries and high-tech industries, so that we can compare the cointegration effect of industries with distinctively different competitive characteristics.

We draw our principal conclusions as follows. First, not all non-stationary strategy variables are characterized by the cointegration phenomenon. If a strategy variable does not

contain cointegration relationships, the Nair and Filer (2003) method cannot be applied to investigate whether a rival is a group leader or group follower with respect to a given strategy.

Second, analytical results indicate that the existence of cointegration relationships among firms in strategy variables should be correlated with an industry's characteristics. Cointegration relationships are more likely to exist in traditional industries, which are defined in this study as industries with low technology, cost orientation and producing more standardized products. Thus, a traditional industry could utilize this method to determine the relative competitive positions among firms and then make decisions for development of appropriate competitive strategies.

For example, if a firm has a competitor that is identified as a passive follower for cost efficiency, the firm can employ pertinent strategies in an attempt to influence the competitor's performance. A long-term strategy can enhance efficiency and cost-effective production process, enabling the firm itself to benefit from reduced costs. A short-term strategy can aggressively promote its products to increase market share, and, consequently, cause the competitor to increase its short-term cost expenses to maintain relative marketing power. Manipulating such strategies could, in turn, exhaust the competitor when it attempts to keep pace with the industry. Hence, the competitor will likely perform poorly due to such disturbances.

Conversely, for high-tech industries, analytical results demonstrate that little opportunity exist for obtaining long-term equilibrium among firms using the cointegration method, particularly because the industry's unique characteristics, such as heavily information exchange with foreign environment, highly developed technology, complex industrial relations, ambiguous industrial boundaries, etc. In this study, only one of eight strategy variables achieves a cointegration relationship in the high-tech industry.

Finally, this study suggests that additional research in firm-level competition using cointegration analysis is warranted. In addition to the industry effects examined here, similar firm groups in different countries (country or cultural effects) and different sampling frequencies (time effect) may, to some extent, affect the formation of cointegration relationships. These potential effects merit further investigation.

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