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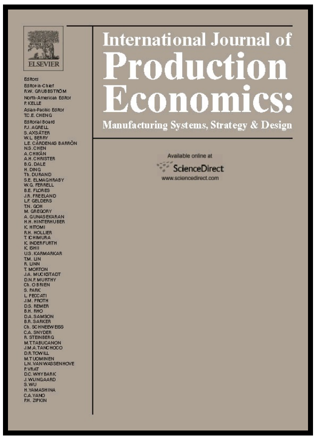
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Achieving competitive advantage through supply chain agility under uncertainty: A novel multi-criteria decision-making structure

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Abstract

The electronic industry suffers a rapid changing and highly rival environment. Thus, firms have an essential need to strive for acquiring the competitive advantage. Supply chain agility (SCA) is a tool which enable to assist firms to attain the competitive advantage. Therefore, this study benchmarks the core competencies from a case study within the supply chain network and establishes a set of attributes for augmenting SCA. A novel multi-criteria decision-making structure is proposed to deal with the complex interrelationships among the aspects and attributes. Fuzzy Delphi method uses for screening out the unnecessary attributes, then integrating fuzzy set theory with decision-making trials and evaluation laboratory method and closed-loop analytical network process to evaluate the SCA in determining the core competitive advantage. The empirical results indicate that flexibility significantly impacts by process integration, information integration and strategic alliances for eco-design in supply chain. Then, process integration has the highest influence in developing the competitive advantage of innovation. The managerial and theoretical implications are discussed.

Keywords: closed-loop analytical network process, decision-making trials and evaluation laboratory method (DEMATEL), fuzzy Delphi method, fuzzy set theory, supply chain agility

1. Introduction

Electronics industry encounters rapid changes in market, intense competition, fast-paced technological innovations and customer's environmental awareness increasing. Hence, firms have an essential need to develop the agility for surviving in this rival environment. Agility exists in supply chain network can help firms to achieve the competitive advantage (Hayes and Wheelwright, 1984). Previous studies emphasized that supply chain agility (SCA) focuses on promoting innovation, flexibility and speed, and then reducing the costs of production (Lin and Tseng, 2014; Tseng et al., 2008). In addition, SCA not only consider as a tool to quick respond the changes in the markets (Fayezi et al., 2015; Lin et al., 2006; Wong et al., 2014; Yusuf et al., 1999), but also encourage individual firms to work together for enhancing the environmental credentials in terms of green raw materials, eco-product design, process integration and customer-based measures (Tseng, 2010; Tseng, 2011; Tseng et al., 2015). Although supply chain network is a collaborative group that formed together to attain the mutual benefit in the economic and environmental performance, it still lacks a logical and crystal structure to guide the group in achieving the competitive advantage through SCA.

To address this gap, this study proposes a closed-loop hierarchical decision-making structure to explore the key drivers of SCA for developing the competitive advantage. In addition, SCA has to be structured from multidimensional considerations to reflect the real situation, which might enhance the challenge and complex in the evaluation. Thus, Van der Vorst and Beulens (2002) proposed an evaluation model to reduce the uncertainty and enhancing effectiveness in searching the key drivers. This model contained the information integration, estimating the impact of alternative actions, lean production, organizational agility, quick response and individual actions. DeGroote and Marx (2013) demonstrated that information technology can increases SCA through quick respond market changes and enhance supply chain collaboration, so firms enable to reach the cost reduction, quality improvement and the innovative processes and product design support. Several studies emphasized that developing a set of measurements for exploring the key drivers of SCA is an urgent task (Venkatraman, 1989; Agarwal et al., 2007). For filling up this gap, a comprehensive measure is required to consider in integrating with interdisciplinary knowledge and real practices. Once the key SCA drivers have been found, firms enable to improve the competitive advantage under limited resources.

The measurement of SCA belongs to qualitative analysis, which uses for capture the interrelationship and interdependence within firms (Tseng, 2011; Tseng & Chiu, 2013; Tseng et al., 2015). These data are generally described into subjective ways and linguistic terms rather than numbers, so the conventional assessment approaches suffer the difficulty to deal with non-numeric analysis. Then, fuzzy set theory offers an effective means to overcome these imprecise and vague phenomena (Lin et al., 2014; Tseng et al., 2014). The transformation process of fuzzy set theory enables to convert these qualitative measures into comparable scales. This study adopts closed-loop decision making structure in order to reduce the complexity and emotionally burdened decision with resembling the existing real situation. Subsequently, decision-making trial and evaluation laboratory (DEMATEL) applies to determine the interrelationships among the selected attributes (Tseng, 2009; Tseng and Lin, 2009; Tseng, 2010). Closed-loop analytical network process (ANP) method is used for gathering the ranking and dealing with the hierarchical structure through interdependence measures (Lin & Tseng, 2014; Tseng, 2011; Tseng et al., 2015; Uygun et al., 2014).

Therefore, the objective of this study is to develop a SCA decision-making hierarchical structure and explore the key drivers for leading firms to achieve the competitive advantage under uncertainty. Previous studies have been proposed several necessary attributes for assessing SCA, nevertheless, these attributes haven’t been integrated as a comprehensive consideration in the measurement. In view of this, a hybrid method and systematic analysis procedure are required to overcome the interrelationships, interdependence and the hierarchical structure. This is the first study to consider SCA as a closed-loop hierarchical decision-making structure and adopts hybrid method to conquer the uncertainty. The detail discussion is organized as following. Section 2 presents the theoretical basis and extensive literature review. Hybrid method is composing of fuzzy Delphi method, fuzzy set theory, DEMATEL and closed-loop ANP, which illustrate in the section 3. Empirical results and significant findings are stated in section 4. Section 5 expresses the implications. Conclusion, research limitations and future researches are provided in the final section.

2. Literature review

This section contains the background of competitive advantage, SCA, proposed measures and the proposed analytical method. These discussions provide a comprehensive theoretical basis to support the concept of this study and forming structure.

2.1 Theoretical background

Competitive advantage refers to a capability, which acquires from the attributes and resources to perform in a higher level within the industry (Hayes & Wheelwright, 1984; Tseng et al., 2008). Blome et al. (2013) presented that SCA is a complex set of dynamic aspects, these are the necessary for developing the competitive advantage. These dynamic aspects enable to underpin the performance in changing market conditions through integrating, building and reconfiguring internal and external competences (Teece et al., 1997; Wu et al., 2015). However, several obstructions contain insufficient collaboration, lacking information technology integration, inadequate alliance with eco-design, and failing to satisfy customer's needs, which might generate the gaps in achieving competitive advantage (Cao & Zhang, 2010; MacDonald & She, 2015; Ngai et al., 2011; Sharifi et al., 2006; van Hoof & Thiell, 2014; Xu, 2006).

Undoubtedly, SCA is a tool for enhancing the competitive advantage in terms of reducing cost through operational process integration, maintaining customer-based measures, speeding up the reflection of customer’s needs, improving information access and transparent, supporting eco-design alignment with supply chain partners, increasing flexibility in production and suppliers (Eisenhardt et al., 2010; Yusuf et al., 2004; Wong et al., 2014; Yang, 2014). However, the linkage between SCA and competitive advantage still remains the uncertainty and undiscovered relationship in previous studies (Zhang et al., 2003). To fill up the gap, it requires a comprehensive structure to measure and relies on a hybrid method to overcome the uncertainty.

Agility uses for transferring and applying the winning strategy to the newly accepted units of business under environment changing (Harrison et al., 1999). To increase the agility among entire supply chain, it not only requires upstream and downstream collaboration from suppliers to customer, but also seeks the lateral collaboration with competitor for integrating the total value creation process (Gligor, 2014). Once these collaborations are aligned, it can generate the agility to use for responding short-term changes in demand or supply, mitigating the external disruption occurrence, and generating the value adding to customers for ensuring the uninterrupted service (Lee, 2004; Van der Vorst and Beulens, 2002). In addition, outsourcing function, downstream customer-based functions with eco-product design and process integration are required firms to concern in developing the agility through collaboration (Tseng et al., 2014; Wong et al., 2014; Yusuf et al., 2004).

SCA can consider as flexibility, which possess a capability to assist firms in reflecting the rapid market changing and preventing the disruption among supply chain (Christopher, 2000). Swafford et al. (2006) presented that internal integration, cross-functional alignment and external integration between customers and suppliers play important roles in developing the flexibility. Agarwal et al. (2007) emphasized that information integration, networking and collaboration are stimulated the performance of agility in quality improvement, cost minimization and lead-time reduction respectively. Therefore, Vinodh and Prasanna (2011) considered SCA as the operational dynamics, which reflects an ability to deal with the uncertainties around business environment and reflect the rapid changes.

However, SCA not only promotes the competitive advantage in terms of flexibility, speed, innovation and cost to some specific customers and markets, but also assists firms in improving their capability of collaborations, process integration, information integration and so on (McCullen et al., 2006; Zhang et al., 2003). It retains the individual firms’ competitive advantage in satisfying the extensive range of needs for responding the rapid changes in the market (Braunscheidel & Suresh, 2009; Yusuf et al., 2004). Hence, SCA has to consider as a multi-level hierarchical structure in minimizing uncertainty and resistance among the entire supply chain (Li et al, 2008; Sangari et al., 2015). This study proposes a close-loop hierarchical structure and concern the interrelationships and interdependence among proposed measures to develop the competitive advantage through SCA.

2.2 Proposed SCA measures

Ngai et al. (2011) proposed a set of competencies that included information technology, operations and management, which shows the effective operational functions to improve the performance through SCA. It is composed of a sequence or network of interrelationships fostered through strategic alliances, collaborations, process integration, information integration and customer-based measures. For achieving the competitive advantage through SCA efficiently, it requires to explore the key attributes under uncertainty. SCA is composed of four interrelationship aspects, which includes strategic alliances, collaborations, process integration, information integration and customer-based measures. To demonstrate the relationships with these aspects in developing the competitive advantage, this study selects twenty-nine attributes through comprehensive literature review and real practices to reflect the real situation with validity and reliability. Collaborations play an important role in SCA, due to it is not just a transaction, but leverages the information sharing and market knowledge creation for reaching the competitive advantage (Ding and Huang, 2010; Lin &

Tseng, 2014). In addition, collaborations enable to provide the befits to partners among the entire supply chain. However, these benefits have to depend on the following seven attributes: trust-based relationships and long tern collaboration with customers/suppliers; focused on developing core competencies through process excellence; increasing suggested improvement in quality, social and environment health and safety with partners; management and technical team-based goals and measures; first/second order choice partner in performance and capability basis; actively share intellectual property with partners; concurrent execution of activities throughout the supply chain (Chen & Paulraj, 2004; Lin et al., 2006; Tseng, 2010; Tseng et al., 2014; Tseng et al., 2015; Yang, 2014; Yusuf et al., 2004; Gligor et al., 2015).

Information integration (e.g. demand information on demand, data and files for supply chain partners) is part of critical drivers also. Because of the data and information can be easily accessed by entire supply chain partners simultaneously. Such virtual connections possess the ability to detect the market changing, enhance responsiveness in reducing cost and ensure the quality and operation flow. To enhance the information integration, several studies proposed to capture demand information immediately; prefer to keep information on file for supply chain partners; virtual connection and information sharing to all partners; information accessible supply chain-wide; customer/marketing sensitivity; quickly detect changes in our environment (Chen & Paulraj, 2004; Lin et al., 2006; Nagi et al., 2011;

DeGroote & Marx, 2013; Yang, 2014).

The process integration can be divided into two measurements; one is the vertical integration – information reach extends from firm to firm through to the networks; another one is the horizontal integration – the range of eco-product design activities widens from process integration to alliance with entire supply chain. Subsequently, five attributes are proposed to measure the process integration upon SCA, which includes reduce dispersion of toxic and hazardous materials; infrastructure in place to encourage eco-innovation within shortening time-frames; pro-actively update the mix of available manufacturing processes in the supply chain network; effectiveness of master production schedule; vertical integration in supply chain (Chen & Paulraj, 2004; Lin et al., 2006; Tseng, 2010; Tseng et al., 2014; Wonget al., 2014; Yang, 2014).

Strategic alliances for eco-design can consider as long-term collaboration with preferred suppliers and customers. The goal is to secure cost and quality advantage as well as to ensure the smooth flow of operations, within the framework of deliveries of small volumes of output (Yusuf et al., 2004). In support of this goal, collaborative initiatives have incorporated virtual connections and information sharing with suppliers and other partners (Gligor, 2014; Sharifi and Ismail, 2006; Wu and Barnes, 2011). Several studies have been investigated the strategic alliances for eco-design among the supply chain in terms of design, process and structure (MacDonald and She, 2015; Tseng et al., 2015). Only few studies have demonstrated how these attributes can be aligned to achieve eco-product design. Thus, design eco-products for ease of use with suppliers; design eco-product with social norms in mind; reducing eco-product costs in process and supplier together; reducing eco-product development cycle time with supply chain partners and horizontal eco-product development are the important attributes that need to concern in SCA measurement (Chen & Paulraj, 2004; Lin et al., 2006; Tseng, 2010; Wu & Barnes, 2011; Yang, 2014; MacDonald & She, 2015; Tseng et al, 2015).

Customer-based measures are to jointly find solutions to material problems and address the issues. Customers and suppliers must exchange and share the information in the sensitive design (Carr and Pearson, 1999; Sharifi et al., 2006). Sharp et al. (1999) conceptualized SCA as the ability of a supply chain to rapidly respond to changes in market and customer demand. Previous literatures suggested to drive customer needs, which require to increase the competition in the market and the speed of innovation (Mentzer et al., 2008; Tseng et al., 2009). Accordingly, customer–based measures shall consider following six attributes to build up the SCA, product ready for use by individual customers, see opportunities to increase customer value, customer-driven eco-products design, retain and grow customer relationships, products with substantial added value for customers and fast introduction of new products (Lin et al, 2006; Tseng et al., 2014; Yang, 2014; Gligor et al., 2015).

Summary of above points, collaborations, process integration, information integration, customer-based measures and strategic alliances for eco-design in supply chain are the main SCA aspects for developing the competitive advantage. Although prior studies have been identified and provided various attributes to increase the understanding of SCA, it is still insufficient in concerning the measures within a hierarchical structure. Thus, this study proposes twenty-nine attributes to construct a closed-loop hierarchical structure to ponder the interrelationship under uncertainty. Table 1 presents the measures of SCA within a hierarchical structure.

2.3 Proposed analytical method

A hybrid multi-criteria decision making method can address the uncertainty that surrounds with SCA. As result of the characters of SCA contains multidimensional considerations, complex interconnections and interdisciplinary attributes, which required to adopt several approaches to deal with it. In addition, the decision maker often suffers the uncertainty during the decision making process due to the series of attributes, time pressure, lack of knowledge, limited attention and insufficient information to enhance the subjective judgement complexity and conflicts (Xu, 2006; Wu et al., 2016). To overcome these uncertain and unpredictable situation, Lin et al. (2006) adopted triangular fuzzy number (TFN) to represent the importance and performance weights to evaluate the SCA, therein, collaborative relationships, process integration, information integration and marketing sensitivity were selected as measures. Then, Vinodh and Prasanna (2011) tried to develop an open hierarchical conceptual model with multi-grade fuzzy approach.

SCA exits interrelationships and interdependent among the aspects and attributes. Thus, several studies proposed to develop the structures for clarifying these interrelationships. Agarwal et al. (2007) utilized interpretive structural modelling to generate a multi-hierarchical structure to explore the driving powers among attributes. Sangari et al. (2015) provided a set of measures and used ANP and DEMATEL to verify the critical attributes for improving SCA. The advantage of employing ANP in this study is to provide an effective evaluation of interdependence and acquire the appropriate weight to the most important attributes for reaching the selected SCA aspects (Tseng et al., 2014). Furthermore, DEMATEL is a comprehensive technique, which enables to categorize the attributes into cause and effect group and offer the visual analysis. Although these methods can conquer the interrelationship and independence, it still requires to select the appropriate measures before construct the hierarchical structure.

In the current studies, most of them are consider the individual attribute and analysis in an open hierarchical structure for evaluating SCA (Agarwal et al., 2007; Lin and Tseng, 2014; Tseng, 2011). Hierarchical structures and decision-making closed-loop processes have been examined in previous SCA studies, which assist to search the interrelationship and interdependence between SCA aspects and competitive advantage (Tseng, 2014). ANP enables to gather the weightage, benchmarking and ranking the attributes within the closed-loop hierarchical structures (Tseng and Chiu, 2013; Tseng et al., 2014; Lin et al., 2014). The analytical structure contains interrelationship, interdependence and closed-loop consideration are address in Figure 1.

3. Method

3.1 Fuzzy set theory

Fuzzy set theory can transfer the qualitative information into quantitative figures for making further analysis. Before the transformation, assuming that there is a universe of discourse $A = \{a_1, a_2, \cdots, a_n\}$. Then, denote a fuzzy set as ∀ to present the set of pairs $\{(a_1, f_\forall(a_1)), (a_2, f_\forall(a_2)), (a_n, f_\forall(a_n))\}$ of A. Moreover, $f_\forall(A)$ is a 0 to 1 membership function of ∀, thereinto, $f_\forall(a_i)$ represent the membership degree a_i in ∀. There are several definitions and notations of fuzzy set theory were proposed by Tseng (2012) and Wu et al. (2015) as below:

Definition 1. If the fuzzy set ∀ is s normal universe of discourse A, the membership function $f_\forall(A)$ has to satisfy $\max f_\forall(A) = 1$.

Definition 2. The fuzzy α-cut $\forall^\alpha$ of the fuzzy set ∀ in the universe of discourse A is expressed as

$$\forall^{\alpha} = \{a_i | f_{\forall}(a_i) \geq \alpha, a_i \in A\}, where\ \alpha \in [0,1] \tag{1}$$

Definition 3. Once the fuzzy set ∀ of the universe of discourse A occurs the convex condition and each $\forall^{\alpha}$ is convex. The $\forall^{\alpha}$ approximates to interval value $\forall^{i}$, so it can rewrite as

$$\forall^{\alpha} = \left[\forall_1^i, \forall_2^i\right], where\ \alpha \in [0,1] \tag{2}$$

Definition 4. Triangular Fuzzy Numbers (TFNs) can be presented in a triplet (x, y, z). Hence the membership function of fuzzy number ∀ is stated as following

$$f_{\forall}(a_i) = \begin{cases} 0, a_i \prec x \\ (a_i - x)/(y - x), x \leq a_i \leq y \\ (z - a_i)/(z - y), y \leq a_i \leq x \\ 0, z \succ a_i \end{cases} \tag{3}$$

3.2 Delphi method

Supposing that g experts are assigned to evaluate the selected attributes by using linguistic variable. This qualitative information requires to convert into quantitative evaluation through Table 1. Therefore, $G_{ij} = \left(x_{ij}, y_{ij}, z_{ij}\right), i = 1,2, \cdots n, j = 1,2, \cdots m$ shows the i^{th} expert gave the evaluation of j^{th} criterion. So the fuzzy weightage of j^{th} attribute can present as below:

$$G_j = (x_j, y_j, z_j), j = 1,2, \cdots m,\ x_j = \min_i(x_{ij}), y_j = \frac{\sum_{i=1}^{n}(y_{ij})}{n}, z_j = \max_i(z_{ij}) \tag{4}$$

This study adopts α-cut approach to defuzzy, thus the equation (1) and (2) would use for the computation of convex combination values $[\forall_l^i, \forall_u^i]$, and $\forall_h^i$ is definite value which can acquire from the following equation.

$$\begin{cases} \forall_l^i = x_j - \alpha(y_j - x_j) \\ \forall_u^i = z_j - \alpha(z_j - y_j) \\ \forall_h^i = f(\forall_l^i, \forall_u^i) = \lambda[\forall_u^i + (1-\lambda)\forall_l^i] \end{cases} \tag{5}$$

where λ states the uncertainty of decision making, 0 shows the highest degree of uncertainty, contrarily, 1 means the least uncertainty. This study utilizes 0.5 to address the general uncertain condition for decision makers. In addition, λ presents the degree of optimism, the value between 0 and 1 represent the decision maker from conservatism to optimism adopter. Moreover, the study assumes the experts are the neutral adopter, so the λ=0.5 is applied in the computations. Subsequently, $\gamma = \sum_{i=1}^{m} \forall_h^i / n, h = 1,2, \cdots n$ is the threshold value, the acceptable criteria can be selected from the following equation:

$$\begin{array}{c} If\ \forall_h^i \geq \gamma, \text{the } h^{th} \text{ criterion accepts for evaluating criterion} \\ If\ \forall_h^i < \gamma, \text{then the criterion shall be reject} \end{array} \tag{6}$$

3.3 DEMATEL

When the screening criteria are obtained from Delphi method, it needs DEMATEL to diagnose the interrelationship through cause and effect diagram. This requires experts have to make a pairwise evaluation of the accepted attributes. The evaluations can denote as a matrix $X^d = [x_{ij}]_{n \times n}$, called direct relation matrix. x_{ij} presents the degree that *i*th

attribute influences to j^{th} attribute. The next step is to apply the following equation to acquire the normalized direct relation matrix X^n.

$$X^n = \tau \times X^d, where\ \tau = \frac{1}{\max_{1 \le i \le n} \sum_{j=1}^{n} x_{ij}}, i, j = 1,2, \cdots n \tag{7}$$

Once the X^n obtained, the total relation matrix is able to attain through the equation as below, thereinto, I represents the identity matrix:

$$X^t = X^n \times (I - X^n)^{-1} \tag{8}$$

From the total relation matrix X^t, sum of the rows and columns to gather the vector X^h and X^v by using the subsequent equations.

$$X^t = \left[\tilde{x}_{ij}\right]_{n \times n}, i, j = 1,2, \cdots n \tag{9}$$

$$X^h = \left[\sum_{j=1}^{n} \tilde{x}_{ij}\right]_{1 \times n} = \left[\tilde{x}_j\right]_{1 \times n} \tag{10}$$

$$X^v = \left[\sum_{i=1}^{n} \tilde{x}_{ij}\right]_{n \times 1} = [\tilde{x}_i]_{n \times 1} \tag{11}$$

Hence, $(X^v - X^h)$ and $(X^v + X^h)$ represent the vertical and horizontal axis in the cause and effect diagram individually. If $(X^v - X^h)$ is negative, then these criteria are classified into causal group, oppositely, the criteria will be categorized in effect group. And then $(X^v + X^h)$ shows the importance of criteria.

3.4 Analytical network process

There are n number of attributes which have to form a pairwise comparison matrix $X^a = \left[x_{ij}\right]_{n \times n}$, in which x_{ij} expresses the relative significance of i^{th} to j^{th} attribute. Similarly,

X^a needs to normalize by using the row vector average. Approximate calculation of the weight ε_i for criterion i can utilize the following equation.

$$\varepsilon_i = \frac{\sum_{j=1}^{n}\left(\frac{x_{ij}}{\sum_{i=1}^{n} x_{ij}}\right)}{n}, i, j = 1,2, \cdots n \tag{12}$$

Therefore, to ensure the consistency of experts during the evaluating process, Saaty (1980) proposed the consistency index (C.I.) to monitor the degree of consistency.

$$C.I. = \frac{\lambda_{max} - n}{n-1} \tag{13}$$

where λ_{max} is the maximum eigenvalue which needs to decompose X^a to acquire.

In addition, the consistency ratio $(C.R.)$ consists of $C.I.$ and random consistency index $(R.I.)$ and obtain through the following equations.

$$\begin{gathered} C.R. = \frac{C.I.}{R.I.} \\ R.I. = \frac{1.98(n-2)}{n} \end{gathered} \tag{14}$$

If $C.R. \leq 0.1$ means the consistency level of pairwise comparison is acceptable, otherwise, the pairwise comparison musts redo again until reaching the acceptable consistency level. Supermatrix allows ANP to manage the relationship of feedback and interdependence within the criteria. When there is no interdependent relationship between the attributes, the value of pairwise comparison should state in 0. But the relationship of feedback and interdependence occur among the attributes, such values could not be 0 anymore, thus the unweighted supermatrix X^s would be attained. In case of the supermatrix does not column stochastic (column musts sum up to 1), the decision maker is required to offer the weight to adjust the supermatrix into column stochastic. Then it becomes a weighted supermatrix X^s.

Finally, the limited weighted supermatrix X^{ℓ} can be acquired from the following equation which states the accurate relative weights within the attributes.

$$X^{\ell} = \lim_{*\to\infty} X^{s*} \tag{15}$$

4. Empirical Results

Taiwanese electronics is one of the largest manufacturing sectors in the world. For acquiring the significant results and enhancing the reliability for this study, a focal firm is selected as case, which is a leading firm in Taiwan, called MWT. The detail background of the MWT, data gathering and analytical results are addressed in the following subsection.

4.1 Case information and data gathering

MWT specializes in manufacturing and selling electronic connectors, wire harnesses and cable assemblies. Its innovation and quality have underpinned its continuous growth to meet customer demand for high-quality and cost-effective connectors. It has strong research and development teams dedicated to product design and development. The firm’s priorities are meeting customers’ exact production needs and the provision of trouble-free equipment at low cost. MWT focuses on providing the best solutions with flexibility, speed, adaptability and cost-effectiveness. The firm provides an excellent example of SCA, and consequently it is able to manufacture a wide variety of products even in small quantities for its customers. As a result of the SCA performance, MWT has had with 20% gross margin for past ten years and nearly a 10% net profit margin.

To benchmark current practices of SCA for investigating the competitive advantage development, it requires to make an assessment of focal firm through expert committee, which is composed of 30 experts. These experts have more than seven years working experience in developing SCA or serve in the relevant departments. Before starting the assessment, committee has to prove the proposed measures (include aspects and attributes) that are able to reflect the real situation of MWT. Once it has an expert disagree with the proposed measures, committee needs to re-discuss about the argue points until all experts get the agreements. Normally, this kind of the re-discussion might repeat several rounds, but it could enhance the reliability in the assessment. Consequently, the data gathering adopts face-to-face interview individually for raising the consistency and preventing the judgements affected by other experts.

4.2 Analysis results

Linguistic preferences transformation

After collecting the respondence from expert committee, these respondence needs to transfer into comparable scale through TFN. The initial respodence is stated in the linguistic preference, such as 1-7 scale, thereinto, 1 represent the very low performance; 2 means the low performance; 3 is fairly low performance; 4 shows the medium performance; 5 presents the fairly high performance; 6 is high performance and 7 demonstrates the very high performance. Each scale has the parallel corresponding TFN, which provide in Table 2. The higher scale expresses the better performance in SCA. Then, the transformation process adopts Eq. (1)-(3) to convert the linguistic preferences into TFN.

Fuzzy Delphi method

From the transferred data, experts' assessments need to arrange into Delph method to screen out the unnecessary attributes by applying Eq. (4)-(6). The 33 attributes were selected in the initial proposed measures that reduce to current 29 measures, due to four attributes couldn't reach the threshold value 0.5314. These four deleted attributes are recycling revenues, green image, employee satisfaction and total supply chain cycle time respectively. The accepted rate is 88% from 33 reduced to 29. In Table 3, it shows the screening results and the remaining attributes. This purified process promotes the effectiveness and makes the measures, which more concentrate in reflecting the current problem (Noorderhaben, 1995; Tseng et al., 2015).

DEMATEL

Eq. (7)-(11) are used for categorizing the measures into cause and effect group, then providing the visual analysis through mapping these measures. The interrelationship matrix of aspects is addressed in Table 4. Therein, the value is between 0 and 1.33 shows the weak interrelationship; 1.34-2.66 represents the medium interrelationship and 2.67-4 expresses the high interrelationship. For example, collaboration (AS1) has high interrelationship with customer-based measures (AS4) upon interrelationship value 4. In order to assist decision maker to identify the core problem easily, proposed aspects need to categorize into cause and effect group as Table 5 shown.

Obviously, only two aspects can consider as cause group only, which are collaboration (AS1) and information integration(AS3), otherwise process integration (AS2), customer-based measures (AS4) and strategic alliances for eco-design in the supply chain (AS5) are belong to effect group. Based on these degree of interrelationship, the causal diagram with interrelationship can map into Figure 2. It shows that collaboration (AS1) is the key driver for developing and retaining the process integration (AS2), information integration (AS3), customer-based measures (AS4) and strategic alliances for eco-design in the supply chain (AS5) among SCA. Particularly, collaboration (AS1) and information integration (AS3); information integration (AS3) and operation integration (AS2); collaboration (AS1) and customer-based measures (AS4) can be explored the strong mutual interrelationship in Figure 2.

Closed-loop ANP

ANP uses for dealing with complex interrelationship through developing a hierarchical structure based on Eq. (12)-(14). For obtaining the converged supermatrix, the performance weights have to be evaluated first as Table 6 shown. It displays the related performance weights under collaboration (AS1). Hence, there are five pairwise comparison matrices are required to procure for arranging to the unconverged supermatrix.

Table 7 presents the unconverged supermatrix, which gathers from the pairwise comparison of aspects and attributes. This supermatrix considers the effect of interrelationship and interdependence as Figure 1 addressed. The closed-loop supermatrix allows to overcome the uncertainty and eliminate the external effects. Unconverged supermatrix needs to apply Eq. (15) to attain the converged supermatrix as Table 8 expressed. The top three aspects are collaborations (AS1), process integration (AS2) and strategic alliances for eco-design in the supply chain (AS5). Top five attributes contain with increasing suggested improvement in quality, social and environment health and safety with partners (A3); first/second-order choice partner in performance and capability basis (A5); infrastructure in place to encourage eco-innovation within shortening time-frames (A9); customer/marketing sensitivity (A17); and effectiveness of master production schedule (A11). It has the similar result with DEMATEL as Figure 2 presented, top two attributes in the closed-loop ANP reflect the collaboration is the most important SCA aspect for developing the competitive advantage.

This study makes a comparison between “none-interrelationships” and “interrelationships” for exploring the difference of coefficient. Because the coefficient weights need to multiply by the importance weights, so the difference of coefficient has to be confirmed through this comparison analysis. Table 9 expresses the final result when the coefficient is loaded with “none-interrelationships” and “interrelationships” unweighted supermatrices. For the SCA aspects and competitive advantage, it shows the same ranking result. Furthermore, attributes have almost the same result between “none-interrelationships” and “interrelationships”, only pro-actively update the mix of available manufacturing processes in the supply chain network (A10) and effectiveness of master production schedule (A11) have slightly difference. In order words, it has no big difference between “none-interrelationships” and “interrelationships” in the top five ranking. Thereinto, most of the top five attributes fall into process integration (AS2).

4.3 The relationship between SCA and competitive advantage

The interrelationship weights can obtain from previous subsection, it uses for exploring the effects between SCA and competitive advantages, the detail relationships are addressed in Table 10. Table shows that process integration has strong linkage in developing the competitive advantage, especially in innovation, flexibility and cost. Moreover, flexibility can be improved through process integration, information integration and strategic alliances for eco-design in supply chain. The significant implications are addressed in the following section.

5. Implications

This study provides a precise guideline for assisting firms in achieving the competitive advantage with extensive theoretical basis and convincible case. SCA is an important component for achieving competitive advantage, so "how to improve the performance of SCA" become a critical issue that firms are striving toward. Based on the significant results demonstrated, there are six attributes are able to assist firms in auditing the performance of SCA, such as increasing suggested improvement in quality, social and environment health and safety with partners; first/second order choice partner in performance and capability basis; infrastructure in place to encourage eco-innovation within shortening time-frames; customer/marketing sensitivity; pro-actively update the mix of available manufacturing processes in the supply chain network and effectiveness of master production schedule. These attributes confirm that collaboration and process integration are the important aspects.

An effective management relies on SCA to align with the competitive advantage under uncertain condition. Empirical results reveal that process integration is the most effective way to acquire the competitiveness in terms of innovation, flexibility and cost. However, the process integration categorizes into effect group, firms have to enhance it through information integration. Among the competitive advantage, establishing the innovation encounters the difficulty through the implementation, due to process integration is the only aspect which has the significant effect. Considering the resources constraint, flexibility is an effective competiveness that firms are able to attain easily. Because of flexibility allows firms to deal with the extent of changes and adapt to the unanticipated situations through optimizing the process integration for achieving business goal (Eisenhardt et al., 2010; Fayezi et al., 2015). To improve the competiveness of flexibility, it requires to concern the process integration, information integration and strategic alliances for eco-design in supply chain.

Furthermore, SCA and flexibility are complemented with each other which proved in this study; once a firm lacks the flexibility, and then the performance of SCA is insufficient (Fayezi et al., 2015). SCA considers as an ability to explore unexpected environmental changes and exploit these changes to enrich the competitive advantage. It requires to supervise the operational independent suppliers in maintaining the coordinated interrelationship for improving the flexibility, increase the speed in operations and retain the competitive position through process integration (Braunscheidel and Suresh, 2009; Lin et al., 2006). Information integration is a critical driver of SCA for developing the flexibility. Thus, a firm wants to improve their flexibility, which needs to involve in large degree of supply chain partners and share the information through process and information integration (Nagi et al., 2011). In addition, the results of this study confirm that information integration not only enables to expand the performance of SCA in developing flexibility, but also possesses the ability in improving market share, profitability, speed to market and customers (DeGroote & Marx, 2013).

The focal firm shows how to capitalize SCA to respond the market changing for attaining the competitive advantage in an intense rival environment. This environment encourages supply chain partners to search an opportunity of collaboration for developing the competitiveness. Collaboration and information integration exist a strong interrelationship and the character of complement. Hence, firms want to improve the product quality and the performance of society and environment together upon the collaboration, which has to concern the information integration simultaneously. The analysis results not only indicate that collaboration and information integration play significant roles and work as the drivers in affecting SCA and able to conquer the rapid changing environment under uncertainty, but allow firms to obtain the competiveness of innovation and flexibility as well.

More and more studies have been considered SCA as an important component in supply chain management filed. Most of previous studies adopted Likert scale to collect the feedback of respondent, however, the interrelationship, interdependence and precise structure were always missing discussed. SCA is composed of multidimensional considerations with highly complexity and uncertainty. Accordingly, it causes the efficiency and effectiveness reduction in making decision. For overcoming these gaps, this study proposes a closed-loop hierarchical decision-making structure associate with a hybrid method. The comparison result discovers that "interrelationship" and "non-interrelationship" only exists slightly difference. Subsequently, the complexity enables to decrease through developing a closed-loop hierarchical structure. Fuzzy set theory, Delphi method, DEMATEL and closed-loop ANP are integrated as hybrid method to address the uncertainty.

6. Conclusions

Competitive advantage is acquired through developing SCA for dealing with the repaid changes and intense competition within Taiwanese electronic industry. Hence, this study adopts focal firm to benchmark the SCA with 5 aspects; collaboration, process integration, information integration, customer-based measures and strategic alliances for eco-design in supply chain. For achieving the competitive advantage, firms need to know what is their core competitiveness very well. Innovation, flexibility, cost and speed are the 4 core competeiveness for achieving competitive advantage that concerned in this study. Previous studies have argued that firms should improve SCA in operating with uncertain environment and trying to gathering the competitive advantage. However, the linkage between SCA and competitive advantage is still infancy, due to the interrelationship, interdependence and precise structure increase the complexity during the analysis.

To overcome these gaps, there are several contributions can be obtained from this study. It offers better understanding of SCA in what particular aspects can assist firms to acquire the competitive advantage with convincible case. The developed closed-loop decision-making structure enable to consider the interrelationship and interdependence among proposed measures simultaneously for reducing the complexity and provides a systematic analysis. Subsequently, this study applies fuzzy set theory, Delphi method, DEMATEL and closed-loop ANP as a hybrid method under uncertainty. This hybrid method is specific to benchmark the focal firm in dynamic environment, which allows to prioritize the attributes, offer a visual analysis in aspects and demonstrate the relationships between SCA and competitiveness.

The significant results reveal that collaboration and information integration are the major drivers to affect the performance of SCA, which confirmed the result of DeGroote and Marx (2013). Thereinto, collaboration has strong interrelationship with information integration and customer-based measures. If a firm has limited resource for improving the SCA performance, collaboration is the trigger that can lead the improvement effectively, and then it might achieve the competitive in cost. From the competitive advantage point, process integration is the most effective aspects to attain the competitiveness in terms of innovation, flexibility and cost, nevertheless, it belongs to the effect group. Therefore, firms want to reach the competiveness effectiveness and efficiency, information integration is the most influential aspect due to it has strong interrelationship with process integration and categorize in cause group.

There are several limitations exist in this study. Although the proposed measures have been selected through comprehensive literature review, some of the attributes and information might not be able to discuss within this study. In addition, this study adopts a focal Taiwanese firm to benchmark the SCA and competitive advantage, future study can consider another leading firm or multiple focal firms to make a comparison based on the proposed analytical procedure for benchmarking an industrial norm and guiding a specific industry. Expert committee was consisted with the supply chain management experts, other experts from different fields can form into committee for enhancing the values and different consideration in further research. The role of SCA in facilitating flexibility and speed needs to make deeper discussion and examination for completing the understanding.

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FIGURES

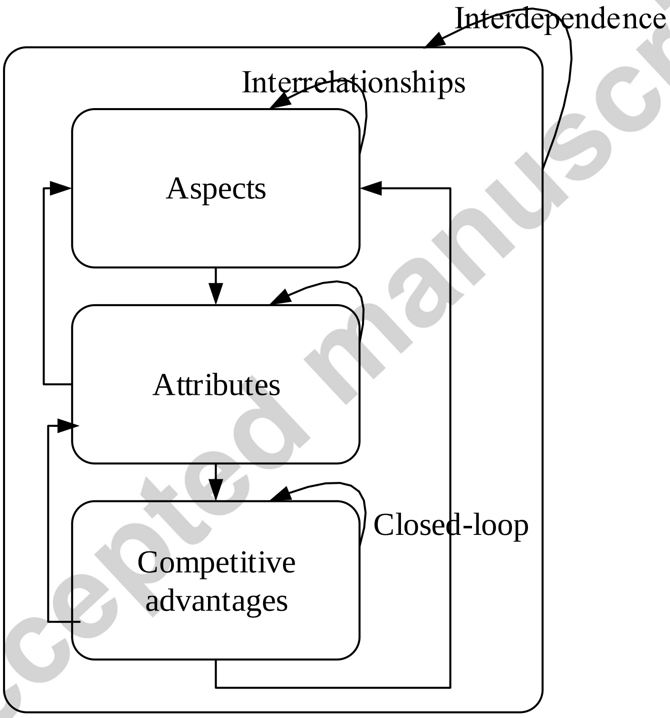

Figure 1. Analytical structure with interrelationships, interdependence and closed-loop hierarchical structure consideration

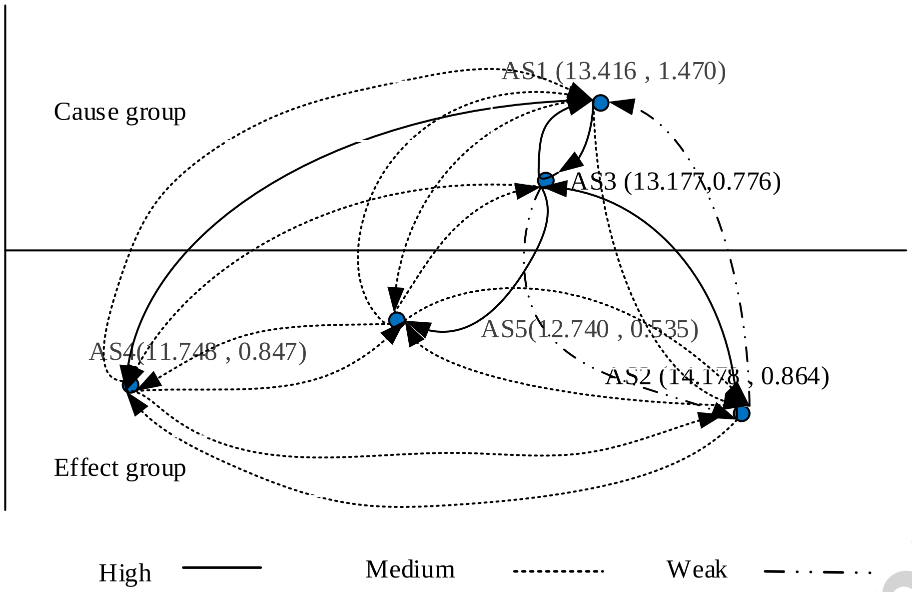

Figure 2. Causal diagram with Interrelationships

Table 1. A hierarchical structure of SCA measures

Aspects	Attributes	References
Collaborations (AS1)	A1 Trust-based relationships and long tern collaboration with customers/suppliers	Chen & Paulraj, 2004; Yusuf et al., 2004; Lin et al., 2006; Tseng, 2010; Tseng et al., 2014; Yang, 2014; Gligor et al., 2015; Tseng et al., 2015
	A2 Focused on developing core competencies through process excellence	
	A3 Increasing suggested improvement in quality, social and environment health and safety with partners	
	A4 Management and technical team-based goals and measures	
	A5 First/second order choice partner in performance and capability basis	
	A Actively share intellectual	

	6	property with partners	
	A7	Concurrent execution of activities throughout the supply chain	
	A8	Reduce dispersion of toxic and hazardous materials	
	A9	Infrastructure in place to encourage eco-innovation within shortening time-frames	
Process integration (AS2)	A10	Pro-actively update the mix of available manufacturing processes in the SC network	Chen & Paulraj, 2004; Lin et al., 2006; Tseng, 2010; Tseng et al., 2014; Yang, 2014; Wonget al., 2014; Tseng et al., 2015
	A11	Effectiveness of master production schedule	
	A12	Vertical integration in supply chain	
	A13	Capture demand information immediately	
	A14	Prefer to keep information on file for supply chain partners	
Information integration (AS3)	A15	Information accessible supply chain-wide	Chen & Paulraj, 2004; Lin et al., 2006; Nagi et al., 2011; DeGroote & Marx, 2013; Yang, 2014; Gligor et al., 2015
	A16	Virtual connection and information sharing to all partners	
	A17	Customer/marketing sensitivity	
	A18	Quickly detect changes in our environment	
Customer-base	A	Product ready for use by	Lin et al., 2006; Tseng et al., 2014; Yang,

d measures (AS4)	19	individual customers	2014; Gligor et al., 2015
	A20	See opportunities to increase customer value	
	A21	Customer-driven eco-products design	
	A22	Retain and grow customer relationships	
	A23	Products with substantial added value for customers	
	A24	Fast introduction of new products	
	A25	Design eco-products for ease of use with suppliers	
Strategic alliances for eco-design in supply chain (AS5)	A26	Design eco-product with social norms in mind	Chen & Paulraj, 2004; Yusuf et al., 2004; Lin et al., 2006; Tseng, 2010; Wu & Barnes, 2011; Yang, 2014; MacDonald & She, 2015; Tseng et al., 2015
	A27	Reducing eco-product costs in process and supplier together	
	A28	Reducing eco-product development cycle time with supply chain partners	
	A29	Horizontal eco-product development	

Table 2. Transformation values between linguistic scale and corresponding TFNs

Scale	Linguistic Preference	Corresponding TFNs
1	very low performance	(0, 0.05, 0.15)
2	low performance	(0.1, 0.2, 0.3)

3	fairly low performance	(0.2, 0.35, 0.5)
4	medium performance	(0.3, 0.5, 0.7)
5	fairly high performance	(0.5, 0.65, 0.8)
6	high performance	(0.7,0.8,0.9)
7	very high performance	(0.85,0.95,1.0)

Table 3. The screening results of fuzzy Delphi method

	l	*m*	*u*	*l*	*u*	*S*	
A1	0.030	0.677	1.000	(0.294)	0.839	0.569	Accepted
A2	0.030	0.677	1.000	(0.294)	0.839	0.569	Accepted
A3	0.050	0.729	1.000	(0.290)	0.865	0.593	Accepted
A4	0.050	0.695	1.000	(0.272)	0.847	0.582	Accepted
A5	0.030	0.646	1.000	(0.278)	0.823	0.559	Accepted
A6	0.030	0.642	1.000	(0.276)	0.821	0.557	Accepted
A7	0.030	0.686	1.000	(0.298)	0.843	0.572	Accepted
A8	0.030	0.642	1.000	(0.276)	0.821	0.557	Accepted
A9	0.030	0.632	1.000	(0.271)	0.816	0.554	Accepted
A10	0.030	0.632	1.000	(0.271)	0.816	0.554	Accepted
A11	0.030	0.666	1.000	(0.288)	0.833	0.565	Accepted
A12	0.050	0.769	1.000	(0.309)	0.884	0.606	Accepted
A13	0.030	0.666	1.000	(0.288)	0.833	0.565	Accepted
A14	0.030	0.666	1.000	(0.288)	0.833	0.565	Accepted
A15	0.030	0.666	1.000	(0.288)	0.833	0.565	Accepted
A16	0.030	0.642	1.000	(0.276)	0.821	0.557	Accepted
A17	0.030	0.642	1.000	(0.276)	0.821	0.557	Accepted
A18	0.030	0.642	1.000	(0.276)	0.821	0.557	Accepted
A19	0.030	0.686	1.000	(0.298)	0.843	0.572	Accepted
A20	0.030	0.666	1.000	(0.288)	0.833	0.565	Accepted
A21	0.050	0.695	1.000	(0.272)	0.847	0.582	Accepted
A22	0.030	0.642	1.000	(0.276)	0.821	0.557	Accepted
A23	0.030	0.666	1.000	(0.288)	0.833	0.565	Accepted
A24	0.030	0.642	1.000	(0.276)	0.821	0.557	Accepted
A25	0.030	0.642	1.000	(0.276)	0.821	0.578	Accepted
A26	0.030	0.703	1.000	(0.306)	0.851	0.557	Accepted
A27	0.030	0.642	1.000	(0.276)	0.821	0.578	Accepted
A28	0.030	0.703	1.000	(0.306)	0.851	0.557	Accepted
A29	0.030	0.642	1.000	(0.276)	0.821	0.569	Accepted

Note: Threshold 0.5314

Table 4. Interrelationship matrix among aspects

	AS1	AS2	AS3	AS4	AS5
AS1	2.800	2.600	3.200	4.000	3.200
AS2	3.200	3.000	2.000	3.000	2.800
AS3	2.200	4.000	3.200	2.200	3.000
AS4	1.000	3.000	3.200	1.000	3.200
AS5	3.200	3.200	1.600	3.000	1.800

Note: Weak: 0-1.33; Medium: 1.34-2.66; High: 2.67-4.0

Table 5. The degree of cause and effect interrelationships

	AS1	AS2	AS3	AS4	AS5	D (Sum)	R(Sum)	Cause (D+R)	Effect(D-R)
AS1	1.352	1.653	1.431	1.491	1.516	7.443	5.973	13.416	1.470
AS2	1.260	1.516	1.223	1.306	1.352	6.657	7.521	14.178	(0.864)
AS3	1.253	1.649	1.347	1.309	1.418	6.976	6.201	13.177	0.776
AS4	0.938	1.285	1.092	0.978	1.157	5.450	6.298	11.748	(0.847)
AS5	1.170	1.417	1.109	1.213	1.194	6.102	6.637	12.740	(0.535)

Table 6. Performance weight matrix of five aspects under collaborations (AS1)

	AS1	AS2	AS3	AS4	AS5	Eigen value	Weight
AS1	1.000	0.144	0.144	1.518	1.687	0.257	0.118
AS2	6.952	1.000	0.167	1.458	0.689	0.444	0.203
AS3	0.767	6.000	1.000	0.158	0.639	0.482	0.221
AS4	0.659	0.686	6.316	1.000	0.369	0.548	0.251
AS5	0.593	1.451	1.565	2.712	1.000	0.452	0.207

Table 7. Unconverged supermatrix

.850	AS1	AS2	AS3	AS4	AS5	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	A20	A21	A22	A23	A24	A25	A26	A27	A28	A29	CA1	CA2	CA3	CA4
AS1	**0.118**	0.263	0.192	0.242	0.138	0.205	0.219	0.177	0.167	0.203	0.183	0.192	0.201	0.236	0.225	0.188	0.147	0.222	0.297	0.238	0.213	0.253	0.233	0.228	0.227	0.194	0.223	0.203	0.238	0.218	0.244	0.230	0.207	0.239	0.216	0.207	0.208	0.185
AS2	**0.203**	0.151	0.201	0.181	0.345	0.193	0.201	0.184	0.250	0.235	0.196	0.230	0.181	0.195	0.169	0.163	0.202	0.183	0.200	0.221	0.208	0.123	0.229	0.173	0.206	0.211	0.197	0.217	0.224	0.207	0.214	0.234	0.264	0.183	0.251	0.218	0.196	0.206
AS3	**0.221**	0.177	0.230	0.057	0.167	0.229	0.233	0.240	0.230	0.128	0.201	0.084	0.196	0.186	0.193	0.255	0.130	0.235	0.177	0.178	0.175	0.191	0.194	0.229	0.201	0.195	0.190	0.186	0.155	0.195	0.188	0.188	0.195	0.180	0.195	0.201	0.203	0.198
AS4	**0.251**	0.175	0.200	0.263	0.185	0.205	0.198	0.167	0.202	0.204	0.212	0.236	0.229	0.186	0.226	0.201	0.265	0.230	0.112	0.186	0.200	0.203	0.153	0.177	0.184	0.199	0.197	0.204	0.196	0.188	0.159	0.160	0.184	0.202	0.158	0.179	0.193	0.208
AS5	**0.207**	0.234	0.177	0.257	0.164	0.167	0.150	0.233	0.150	0.230	0.208	0.259	0.193	0.196	0.186	0.193	0.255	0.130	0.215	0.177	0.205	0.230	0.191	0.194	0.181	0.201	0.195	0.190	0.186	0.191	0.195	0.188	0.150	0.195	0.180	0.195	0.201	0.203
A1	0.038	0.031	0.033	0.032	0.037	0.037	0.038	0.038	0.037	0.045	0.037	0.036	0.036	0.035	0.034	0.035	0.035	0.036	0.035	0.035	0.036	0.034	0.033	0.034	0.034	0.035	0.030	0.034	0.038	0.038	0.011	0.042	0.021	0.040	0.037	0.041	0.036	0.033
A2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	37	26	32	33	34	35	37	37	35	36	35	34	35	38	38	39	38	39	38	38	39	38	38	38	37	39	33	38	21	43	29	29	29	31	19	17	30	27
A3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	39	32	25	36	36	38	39	39	38	39	37	37	37	51	51	21	31	37	43	37	37	37	36	36	36	37	32	36	10	41	24	12	52	21	46	63	54	61
A4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	16	23	33	34	37	37	39	40	37	39	37	36	37	37	50	11	38	32	48	37	38	37	36	36	37	37	34	37	21	41	34	32	32	32	19	29	32	27
A5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	39	33	34	36	40	38	40	40	38	40	38	37	37	31	44	36	33	33	40	12	24	40	39	40	40	41	36	39	39	45	21	59	19	58	27	39	42	70
A6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	38	31	33	34	28	36	38	38	37	38	36	36	37	33	56	53	53	31	38	37	38	38	37	38	38	38	34	37	42	42	38	38	38	40	34	40	38	40
A7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	34	31	36	33	30	36	38	38	37	38	36	35	37	11	21	59	63	37	43	35	35	34	33	34	35	35	31	34	38	38	37	37	37	36	40	39	42	37
A8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	35	29	31	32	33	13	21	35	34	35	34	33	34	36	12	38	37	31	38	40	40	39	39	39	39	09	36	38	44	44	38	52	11	32	40	45	57	18
A9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	38	32	33	35	32	37	38	38	37	39	37	36	53	42	29	29	35	39	45	37	37	36	35	36	36	37	32	36	40	41	38	43	42	30	38	48	49	43
A1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0	38	31	29	34	31	35	38	38	36	38	36	35	37	33	32	36	36	37	43	35	36	34	34	34	35	36	31	34	39	40	48	48	47	49	30	48	31	58
A1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	38	49	32	34	40	36	38	39	37	38	36	36	37	36	36	34	36	37	36	36	37	35	35	36	36	37	32	36	40	40	48	48	46	30	37	21	29	55
A1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	32	38	25	45	33	31	33	33	32	33	31	56	31	34	35	35	33	35	34	35	36	34	34	34	34	36	30	34	38	38	21	47	45	49	42	11	32	53
A1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	37	53	23	37	31	36	37	38	37	38	36	35	36	37	37	37	37	35	11	37	38	36	36	36	37	38	32	36	41	41	58	52	24	26	38	39	23	45
A1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	08	32	32	34	34	36	38	38	37	38	36	35	36	37	36	37	37	38	34	37	38	37	36	37	43	38	32	36	41	10	30	32	32	32	37	36	32	32
A1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	21	42	30	29	31	34	35	35	34	35	33	32	33	38	37	38	23	39	27	36	39	37	36	36	37	37	33	38	42	21	45	45	46	47	48	31	54	29
A1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	48	36	46	33	32	34	32	25	26	28	30	30	34	35	36	36	36	37	36	37	35	36	28	36	36	37	41	36	40	35	53	52	52	52	32	21	53	11
A1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	50	40	41	37	31	41	38	18	22	15	29	26	21	36	36	35	37	37	35	37	37	33	35	35	35	37	31	36	41	41	38	37	39	37	47	37	39	37
A1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	35	40	31	32	33	34	35	35	34	35	34	33	34	33	33	33	34	34	33	33	34	33	31	34	34	35	29	33	39	39	40	38	38	37	11	38	36	39
A1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	38	32	33	35	32	37	38	38	37	39	37	36	37	36	36	37	37	38	36	37	37	36	36	34	36	38	52	36	42	42	32	33	33	31	44	32	40	33
A2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0	38	31	29	34	31	35	06	38	36	38	36	35	37	35	36	35	36	37	35	37	36	36	36	35	33	37	32	35	40	20	02	11	11	10	03	03	03	03
A2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	38	37	32	34	29	17	38	39	37	38	36	36	37	36	35	36	37	36	35	36	36	35	36	36	35	35	40	36	41	14	03	21	02	03	02	02	03	04
A2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	13	39	37	29	33	31	33	33	32	33	31	30	31	31	31	30	32	32	31	31	32	31	31	31	31	32	26	30	35	35	37	38	37	39	34	37	33	30
A2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	37	37	23	34	35	36	37	55	37	38	36	35	36	36	35	35	37	37	35	36	36	20	35	36	36	37	31	33	30	25	36	36	36	37	38	34	37	37
A2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	35	32	32	34	57	36	38	38	37	38	36	35	36	36	34	36	11	36	36	37	37	35	35	36	35	37	31	32	37	40	39	11	39	11	46	41	28	41
A2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	30	35	30	43	31	34	35	35	34	35	33	32	33	33	32	32	33	33	32	33	33	33	33	33	33	35	29	33	35	35	36	36	36	37	38	37	37	38
A2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	29	36	46	33	52	34	32	25	30	28	30	30	34	38	28	42	29	27	08	29	25	36	28	26	21	28	70	22	11	15	71	21	39	32	48	52	21	11
A2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	33	27	75	37	31	41	38	18	22	15	29	46	21	28	26	21	19	24	24	26	30	27	30	30	25	28	29	39	37	42	55	31	44	41	47	39	11	21
A2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	53	36	47	33	35	41	32	26	50	38	24	32	29	32	25	37	25	24	37	37	20	31	38	27	25	25	37	30	13	35	11	09	35	38	40	41	41	38
A2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	36	29	35	35	32	38	19	11	21	15	44	17	28	27	29	18	30	30	32	31	25	31	29	28	28	31	35	27	27	19	30	11	40	41	40	40	37	32
CA	0.2	0.4	0.2	0.2	0.1	0.2	0.2	0.3	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.4	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1	49	08	26	84	62	41	58	05	96	39	15	26	37	78	65	72	96	61	25	80	50	97	74	68	67	89	62	86	80	56	87	71	44	81	54	44	45	80
CA	0.2	0.1	0.2	0.2	0.4	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.2	0.2	0.3	0.2	0.2

2	59	78	37	14	22	48	36	17	94	76	31	70	63	30	41	91	38	15	35	60	44	39	69	03	79	48	84	55	64	93	52	75	10	69	95	09	90	42
CA	0.2	0.2	0.3	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.3	0.2	0.2	0.2	0.2	0.3	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
3	75	08	03	93	97	70	74	82	71	45	04	27	31	19	28	00	53	53	08	41	71	25	28	13	37	29	23	19	25	30	21	21	29	12	29	36	38	33
CA	0.2	0.2	0.2	0.3	0.2	0.2	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	17	06	35	09	18	41	33	96	38	40	50	78	70	73	66	37	12	71	31	19	35	39	29	08	17	34	31	40	31	21	40	33	17	38	21	11	27	44

Table 8. Converged supermatrix

	AS 1	AS 2	AS 3	AS 4	AS 5	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	A20	A21	A22	A23	A24	A25	A26	A27	A28	A29	CA1	CA2	CA3	CA4
A	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
S1	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95
A	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
S2	04	04	04	04	04	04	04	04	04	04	04	04	04	04	04	04	04	04	04	04	04	04	04	04	04	04	04	04	04	04	04	04	04	04	04	04	04	04
A	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
S3	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23
A	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
S4	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39
A	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
S5	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47
A	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17
A	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
2	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
A	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
3	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38
A	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
4	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
A	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
5	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29
A	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
6	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
A	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
7	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
A	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
8	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17
A	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
9	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28
A	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
10	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23
A	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
11	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22
A	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
12	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
A	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
13	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
A	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
14	07	07	07	07	07	07	07	07	07	07	07	07	07	07	07	07	07	07	07	07	07	07	07	07	07	07	07	07	07	07	07	07	07	07	07	07	07	07
A	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
15	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18
A	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
A	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
17	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
A	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
18	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
A	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19
A20	0.0073	0.0073	0.0073	0.0073	0.0073	0.0073	0.0073	0.0073	0.0073	0.0073	0.0073	0.0073	0.0073	0.0073	0.0073	0.0073	0.0073	0.0073	0.0073	0.0073	0.0073	0.0073	0.0073	0.0073	0.0073	0.0073	0.0073	0.0073	0.0073	0.0073	0.0073	0.0073	0.0073	0.0073	0.0073	0.0073	0.0073	0.0073
A21	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075
A22	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106
A23	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116
A24	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122
A25	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116
A26	0.0115	0.0115	0.0115	0.0115	0.0115	0.0115	0.0115	0.0115	0.0115	0.0115	0.0115	0.0115	0.0115	0.0115	0.0115	0.0115	0.0115	0.0115	0.0115	0.0115	0.0115	0.0115	0.0115	0.0115	0.0115	0.0115	0.0115	0.0115	0.0115	0.0115	0.0115	0.0115	0.0115	0.0115	0.0115	0.0115	0.0115	0.0115
A27	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111
A28	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122
A29	0.0108	0.0108	0.0108	0.0108	0.0108	0.0108	0.0108	0.0108	0.0108	0.0108	0.0108	0.0108	0.0108	0.0108	0.0108	0.0108	0.0108	0.0108	0.0108	0.0108	0.0108	0.0108	0.0108	0.0108	0.0108	0.0108	0.0108	0.0108	0.0108	0.0108	0.0108	0.0108	0.0108	0.0108	0.0108	0.0108	0.0108	0.0108
CA1	0.0875	0.0875	0.0875	0.0875	0.0875	0.0875	0.0875	0.0875	0.0875	0.0875	0.0875	0.0875	0.0875	0.0875	0.0875	0.0875	0.0875	0.0875	0.0875	0.0875	0.0875	0.0875	0.0875	0.0875	0.0875	0.0875	0.0875	0.0875	0.0875	0.0875	0.0875	0.0875	0.0875	0.0875	0.0875	0.0875	0.0875	0.0875
CA2	0.0879	0.0879	0.0879	0.0879	0.0879	0.0879	0.0879	0.0879	0.0879	0.0879	0.0879	0.0879	0.0879	0.0879	0.0879	0.0879	0.0879	0.0879	0.0879	0.0879	0.0879	0.0879	0.0879	0.0879	0.0879	0.0879	0.0879	0.0879	0.0879	0.0879	0.0879	0.0879	0.0879	0.0879	0.0879	0.0879	0.0879	0.0879
CA3	0.0780	0.0780	0.0780	0.0780	0.0780	0.0780	0.0780	0.0780	0.0780	0.0780	0.0780	0.0780	0.0780	0.0780	0.0780	0.0780	0.0780	0.0780	0.0780	0.0780	0.0780	0.0780	0.0780	0.0780	0.0780	0.0780	0.0780	0.0780	0.0780	0.0780	0.0780	0.0780	0.0780	0.0780	0.0780	0.0780	0.0780	0.0780
CA4	0.0770	0.0770	0.0770	0.0770	0.0770	0.0770	0.0770	0.0770	0.0770	0.0770	0.0770	0.0770	0.0770	0.0770	0.0770	0.0770	0.0770	0.0770	0.0770	0.0770	0.0770	0.0770	0.0770	0.0770	0.0770	0.0770	0.0770	0.0770	0.0770	0.0770	0.0770	0.0770	0.0770	0.0770	0.0770	0.0770	0.0770	0.0770

Table 9. Comparison of SCA interrelationship and none-interrelationship

Attributes	interrelationships		none-Interrelationships	
	Weights	Ranking	Weights	Ranking
AS1	0.0695	**2**	0.0696	**2**
AS2	0.0704	**1**	0.0711	**1**
AS3	0.0623	**5**	0.0623	**5**
AS4	0.0639	**4**	0.0649	**4**
AS5	0.0647	**3**	0.0655	**3**
A1	0.0117	15	0.0118	14
A2	0.0100	26	0.0101	26
A3	0.0138	**1**	0.0139	**1**
A4	0.0100	27	0.0101	27
A5	0.0129	**2**	0.0131	**2**
A6	0.0121	9	0.0123	9
A7	0.0120	11	0.0121	10

A8	0.0117	14	0.0117	18
A9	0.0128	**3**	0.0128	**3**
A10	0.0123	**5**	0.0123	**6**
A11	0.0122	**6**	0.0123	**5**
A12	0.0114	20	0.0117	15
A13	0.0121	10	0.0121	11
A14	0.0107	24	0.0109	23
A15	0.0118	13	0.0119	13
A16	0.0116	18	0.0115	19
A17	0.0125	**4**	0.0125	**4**
A18	0.0110	22	0.0109	22
A19	0.0119	12	0.0121	12
A20	0.0073	29	0.0075	29
A21	0.0075	28	0.0077	28
A22	0.0106	25	0.0107	25
A23	0.0116	16	0.0117	16
A24	0.0122	8	0.0123	8
A25	0.0116	17	0.0117	17
A26	0.0115	19	0.0114	20
A27	0.0111	21	0.0111	21
A28	0.0122	7	0.0123	7
A29	0.0108	23	0.0108	24
CA1	0.0875	**2**	0.0880	**2**
CA2	0.0879	**1**	0.0884	**1**
CA3	0.0780	**3**	0.0785	**3**
CA4	0.0770	**4**	0.0781	**4**

Table 10. The relationships between SCA aspects and competitive advantages

Competitiveness Aspects	Innovation (CA1)	Flexibility (CA2)	Cost (CA3)	Speed (CA4)
Collaborations (AS1)	Medium	Medium	**High**	Low
Process integration (AS2)	**High**	**High**	**High**	Medium
Information integration(AS3)	Medium	**High**	Medium	Medium
Customer-based measures(AS4)	Low	Medium	Low	**High**
Strategic alliances for eco-design in supply chain (AS5)	Low	**High**	Low	**High**