Heuristics-in-use in industrial interfirm-collaborating clusters

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Abstract

Purpose – The purpose of this paper is to help interfirm-collaborating cluster (ICC) executives examine the relevance of alternative decision rules in practical business contexts. Multi-party-implemented strategies and establishing multi-lateral collaborations are necessary actions for achieving success in new product development by small and medium enterprises (SMEs). This study explores interfirm decision-making heuristics relating to industrial ICCs.

Design/methodology/approach – The study examines the relevancy to decision making in ICCs of heurstics such as "fast-and-frugal decision trees" (FFDTs) and "take-the-best" (TTB) to processing possibly influential decision-making cues. The study also examines simple heuristics versus the value of a "fully rational" approach to making decisions – calculating cue values, importance weights, multiplying values by weights, summing and selecting the option having the highest summed score. This study included interviewing executives of the pivotal firm in an ICC.

Findings – This study reveals a decision-making solution for shortening the time and processes required in seeking new business collaboration partners in an ICC. This study not only develops a FFDT for six decision-making modules to quickly identify potential collaboration partners, but it also constructs a decision systems analysis (DSA) flowchart to effectively shorten the decision-making process.

Research limitations/implications – This study is in accordance with the general type of industrial interfirm collaboration in Taiwan. The industrial interfirm collaboration could be further divided into the types of formal, semi-formal and informal industrial interfirm collaborations.

Practical implications – This study argues that firms usually find it difficult to develop their own technology because of the high costs of research and development for SMEs. Therefore, firms need to collaborate with partners to maintain their competitive advantage. However, to collaborate, firms must learn to trust their collaboration partners, and the degree of collaboration also strongly depends on the degree to which they trust their collaboration partners.

Originality/value – This study provides the efficient models of FFDT and DSA to quickly identify potential collaboration partners and to effectively shorten decision-making processes.

Keywords Decision making, Industrial performance, Cluster analysis, Network analysis

Paper type Research paper

1. Introduction

The development of industrial interfirm clusters is a striking feature of regional development and supports synergies among firms in achieving long-term collaborative objectives. Schleimer and Shulman (2011) indicate that most firms involved in the innovative development engage simultaneously in intra-firm and interfirm collaborations. However, firms must surmount difficulties in integrating collaborations; the difficulties occur based on aspects of the firm's tacit knowledge and relationship factors (Johansson *et al.*, 2011). To sustain such working collaborations, a strategic selection of new business interfirm partners is necessary. This study includes a brief introduction to some of the relevant literature on how decision-makers decide and how they should decide to identify appropriate business partners in interfirm collaborative clusters (ICC).

The main purpose of this study is to help ICC executives to make use of both blades of Simon's (1990) scissors – that is to examine the relevance of alternative heuristics in practical business contexts. Thus, this study focuses on the issue of deciding on how to decide within a given context – a core, usually implicit, activity in sense-making in decision environments (Weick, 1995).

Partly in response to changing market environments and uncertain technological trends, entrepreneurs choose partners that nurture long-term collaborations (Chisholm, 1996; Snow *et al.*, 1992). According to the studies of De Boer *et al.* (1999) and Lane and Lubatkin (1998), ICC and industrial interactive models can influence the effectiveness of collaborative innovation not only in terms of knowledge integration but also in situations that involve multiple and sometimes conflicting

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corporate cultures. Patrakosol and Olson (2007) indicate that the longer a company engages in close interfirm collaborations, the greater the impact of the collaborations have on the success of that firm's innovations.

By establishing a formal or semi-formal linkage with collaborative partners, firms can exchange resources and build profitable relationships. Morash and Clinton (1995) state that the main benefits of building a working partnership include a decrease in production time, trust, the standardization of delivery accuracy, real-time support of information systems, flexibility of manufacturing capacity and access to an alliance of industrial partnerships. Ultimately, firms hope to establish a close working relationship to achieve effective risk management and substantial synergies in planned and implemented interfirm strategies.

Firms need to strengthen their competitive advantage through collaboration because of the importance of business continuity and sustainability in clusters as well as because of the needs of moving toward the development of high value-added brands. The collaboration model must take the suitability of the collaborators' core competencies into consideration. An interfirm collaboration or alliance may help firms to obtain knowledge and skills; such collaboration can be an important source of organizational learning (Steensma, 1996). Firms and their partners invest resources, skills and knowledge to build a knowledge-skill platform. Such platforms not only provide quick access to knowledge but also allow for knowledge sharing. This study explores how decision-makers decide on collaborative strategies, the types of collaboration that develop between small and medium enterprises (SMEs) in ICCs, and how decision-makers decide when and with which firms to collaborate to execute interfirm strategies. This study provides decision algorithms that associate with high ICC performance.

2. Literature review

A collaborative interfirm relationship can serve as the source of a firm's competitive advantage. Managers in clustered industries not only perceive more benefits and opportunities for interfirm collaboration in marketing activities (Felzensztein *et al.*, 2012) but also improve their performance and collaborative innovation activities by creating acceptable institutional environments (Bek *et al.*, 2013). Many firms are seeking collaborations due to the increasingly complex nature of global competition (Lai and Tsai, 2010). A successful collaboration requires the sharing of responsibilities, risks and rewards while retaining individual autonomy among the participating firms (Pfeffer and Salancik, 1978). Kogut (1988) proposes that the strategy for an effective partnership is to avoid having potential competitors enter the market and/or to find ways to weaken the position of competitors. Kanter (1989) states that a business relationship between firms provides a potential competitive advantage, especially for suppliers and consumers, and when a company selects a partner, the following factors should be utilized to assess possible candidates: track record, past experience and friendships, cultural differences, commitment and future risks. Kogut (1988) compares strategic costs and transaction costs, and the difference between these two costs in light of different selection criteria for the collaboration and partnership among machinery manufacturing firms. The motivation for strategic costs is to pursue long-term profits, and the goal of transaction costs is to minimize the costs of exchanging products or services. When selecting a partner, the strategic focus is on a competitive position that is specifically related to competitors or consumers in a competitive position. According to the transaction cost theory, an organization aims to engage resources in the environment arising from transactions costs, and it will manage the costs incurred within the exchange to minimize them (Williamson, 1975; Coase, 1937).

Mowery *et al.* (1996) state that firms benefit from accurately understanding the degrees of complementarity and similarity within collaboration partners, and Harrigan (1988) also suggests that complementarity among firms includes complementary targets, operating philosophies and corporate cultures. If partners have similar levels of technology and less overlapped technology, the collaboration can lead to higher and better complementarity. Complementarity refers to how much the partners complement each other in terms of their operating philosophy and corporate culture (Bucklin and Sengupta, 1993). For a successful complementarity strategy, firms should aim to achieve basic goals and values in the external collaboration environment by using the other firms' resources and capabilities, as well as by matching corporate structures and systems. In addition, Douma *et al.* (2000) observe that an appropriate complementarity illustrates common interests and the concept of interdependence among the collaboration partners.

Porter (1980) proposes that a company's general competitive strategy includes three basic strategies:

1. *A price advantage strategy*: The category of the economy and the concept of a learning experience control the costs of obtaining a price advantage.
2. *A product quality advantage*: Offering unique products and services by means of special product quality and good service to establish a competitive advantage.
3. *A specialization advantage*: Focusing on particular market segments or specific product lines to meet customers' needs by having the appropriate resources to gain a competitive advantage.

Clearly, quality control is viewed as a method to create a useful product and to judge its market performance (Deming, 1982).

Juran (1986) reports that a quality performance can meet the needs of customers and emphasize a product's quality and suitability. Hill and Jones (1995) describe the issues of quality control from the perspective of company collaboration as being not only a strategic weapon but also an advantage to generate added value for the collaborating firms. Hultink and Schoormans (1995) note that better product design and increased innovation can result from increased interfirm collaboration.

To achieve common goals and share the risks and benefits of a long-term relationship, collaboration between firms may be determined by a verbal contract and an assurance of the full collaboration of all the departments in both firms to share a common goal and reduce mistakes when reaching for that goal. Blenkhorn and Noori (1991) and McCutcheon *et al.* (1997) state that a high-quality collaborative relationship among multiple firms creates more new concepts and foster integration and that the efficient communication of

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information between firms will facilitate and improve environmental adaptability and flexibility. Additionally, interfirm collaboration and coordination and the resulting abilities of the partners to change processes and/or products can facilitate the maintenance of a long-term relationship. Table I shows the definitions of the influential factors of decision-making of collaboration in ICC.

3. Research method

This study includes the research methods of the fast and frugal decision tree (FFDT), analytic hierarchy process (AHP) and decision systems analysis (DSA). In the first stage, this study presents a literature review and interviews with related firms to select and confirm the influential factors of interfirm decision-making in ICC. After obtaining the preliminary influential factors, the questionnaires are distributed to 21 experts to determine the final six factors and to calculate the cue validities for the six factors. In the second stage, this study adopts the method of AHP to decide the weights for each factor and to construct the tree structure of FFDT. In the final stage, this study uses the DSA method to establish a DSA flowchart of interfirm decision-making in ICC. Figure 1 shows the research flow of this study.

3.1 Fast and frugal decision tree

Many processes involve decision-making, which usually involves searching, considering and making judgments on a wide range with a large volume of data. The fast and frugal heuristics method proposes a model of human judgment, and it has been formalized, tested and found to be surprisingly accurate (Katsikopoulos *et al.*, 2008). A FFDT refers to simple and task-specific decision-making strategies and is a part of a decision-maker's or a company's cognitive strategy for exercising judgment and performing decision-making tasks (Gigerenzer *et al.*, 1999). Unlike many decision-making methods in the behavioral sciences, FFDT not only describes the outcome of the decision-making process but also explains the decision-making process.

FFDT specifies a number of cognitive processes, and it specifies how information is searched, how that search is stopped and how a decision is made based on the obtained information. Martignon *et al.* (2008) indicate that the labels of "fast" and "frugal" have precise meanings that represent the frugality of a tree for a set of objects with a mean number of cues. Goldstein and Gigerenzer (2002) state that FFDT meets the criteria for deriving decisions with fast and frugal heuristics, and it includes decision-making that is ecologically rational, founded in evolved psychological capacities that are precise and powerful enough to be modeled computationally. Martignon *et al.* (2008) note that a categorization tree is fast and frugal only if it has at least one exit at each level. Therefore, if a clue stems from a branch labeled 1, the decision will be positive. Conversely, a negative branch is labeled, 0.

In many contexts, people often need to make decisions quickly based on limited information. Due to the constraints of time and knowledge, computational capacities need to be taken into account to model real-time decision-making. "Take-the-Best" (TTB) is a lexicographic strategy that Gigerenzer *et al.* (1991) propose as a model of fast and frugal probabilistic inferences (Bröder, 2000). TTB estimates two alternatives by choosing a higher value on a criterion that is based on the first cue that discriminates between the alternatives and where the cues are ordered by cue validity

Table I The definitions of influential factors of decision-making in ICC

Factor	Definition
Transaction cost	Transaction cost means that with limited information and environmental uncertainty, companies' firms consider the derived costs of transactions, such as the costs for searching, negotiating, after-sales supervising and controlling costs
Mutual trust	Mutual trust means that companies should be willing to bear the uncertainty of future behaviors and stay committed to each other in spite of any friction that may be generated during their collaborations
Strategic collaboration	Strategic collaboration refers to collaboration that is designed to strategically prevent potential competitors from entering the market and to weaken the power of competitors
Knowledge sharing	Knowledge sharing means the interactive process of sharing knowledge among companies' firms, and it can potentially generate innovative knowledge. Additionally, knowledge sharing helps to develop new technologies and to reduce development costs and R&D risks
Complementarity	Complementarity means that companies' firms can differentiate between the complementary differences and the degrees of similarity between them prior to the collaboration
Experience of collaboration	Collaboration experience refers to the experience that a company has ever had acting jointly with other companies' firms
Business concept	Business concept means the strategic direction of a company, which is similar to the other companies' firms strategic direction, and it also refers to corporate cultures. In practice, a business concept can be referred to as a business plan, business model or business vision
Delivery assurance	Delivery assurance ensures that the production line is not stagnant, and the product can be safely delivered to the customers on time
Quality assurance	Quality assurance means ensuring the quality of a product. It is an ongoing process that never ends, or at least not during the life of a product
Degree of collaboration	Degree of collaboration refers to the level of closeness of companies' firms that work together to achieve a goal. It is a recursive process in which two or more organizations work together to realize shared goals

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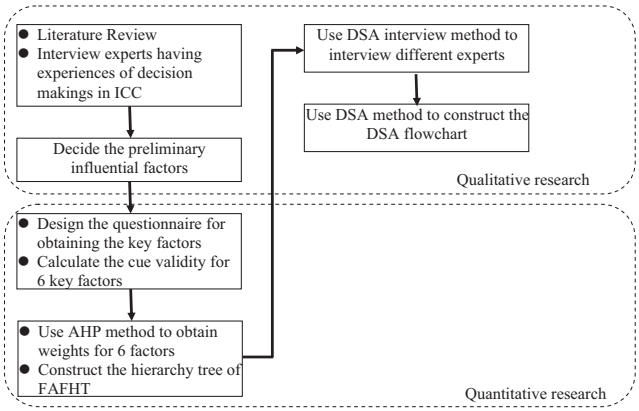
Figure 1 Research flow of this study



from the highest to the lowest values. The present study is based on this literary method to calculate the cue for each of the nodes in the FFDT. The equation of TTB is described below:

$$V = R/(R + W) \quad (1)$$

where:

V = cue validity;
R = is the number of right (correct) inferences; and
W = the number of wrong (incorrect) inferences.

According to the TTB formula, the cue validity is its predictive accuracy. The questionnaire for the ICC decision-makers that was used in this study was designed to identify important influential factors. Having collected all of the questionnaires, when a given question received a positive answer (Yes), it was assigned a value of "1"; if it received a negative answer (No), it was assigned a value of "0". Each cue with a validity of 0.5 was designated as neutral. Each cue with a validity of more than 0.5 was designated as beneficial, and each cue with a validity of less than 0.5 was designated as useless. After designing the questionnaire and arranging the ranking of the factors, only the factors with a V value > 0.5 were accepted in this study.

3.2 Analytical hierarchy process

After the factors with V value > 0.5 were selected, the AHP method was used to calculate the weights for each of the factors. AHP is a structured method for organizing and analyzing complex decisions and was developed by Thomas L. Saaty in 1970s based on mathematics and psychology. AHP is applicable for group decision-making and is used around the world in a wide variety of decision situations. The AHP helps decision-makers to make decisions that best suit their goals according to their understanding of a problem. AHP provides a comprehensive and rational framework for structuring a decision problem, for representing and quantifying its elements, for relating those elements to the overall goals and for evaluating alternative solutions.

AHP first decomposes the decision problem into a hierarchy of more comprehensive sub-problems, each of which can be analyzed independently. The elements of the hierarchy can relate to any aspect of the decision problem, tangible or intangible, carefully measured or roughly estimated, well or poorly understood and can address anything at all that might apply to the decision at hand. Once the hierarchy has been built, the decision-maker systematically evaluates its various elements by comparing them to another problem, two at a time, according to its impact on the element that has been identified in the hierarchy. In making the comparison, decision-makers can use concrete data about the elements, and they typically use their own judgment about the elements' relative meaning and importance. The AHP converts these evaluations into numerical values that can be processed and compared across the entire range of the problem. A numerical weight or priority is derived for each element of the hierarchy, enabling a rational and consistent comparison of diverse and often incommensurable elements. In the final step of the process, numerical priorities are calculated for each of the decision alternatives. These numbers represent the alternatives' relative ability to achieve the decision goal.

3.3 Decision systems analysis

Human factors include bounded rationality and opportunism, while environmental factors consist of uncertainty and complexity, a limited number of traders, information asymmetry and trading atmosphere. Because of limited rationality, the more complex the environment is, the more managed transactions there will be between organizations. Capon and Hulbert (1975), Kaynak and Ghauri (1994), Howard and Morgenroth (1968), Ronkainen (1985) and Woodside (2003) indicate that the aim of DSA is to describe configurations as to why and how a decision process actually occurs, as well as the flow of thinking, the interactions of participants, the decisions, the actions and the outcomes of the process.

The phases of the manufacturing decision-making process provide an opportunity to periodically review and evaluate changing needs, conditions and alternatives. Participants in a decision-making process may benefit from an accurate understanding of how current decisions are being made. DSA enables the systematic description of a strategic decision-making process, and this DSA description can be used as a basis for the formulation of a process. DSA can be used to understand each factor of a detailed process, and DSA flowcharts can be adapted as a follow-up to determine the collaboration factors when charting the participation of managers and individuals from different groups (Ronkainen, 1985).

Semi-structured interviewing procedures (Hulbert *et al.*, 1972) are especially useful for creating a series of detailed flowcharts describing the process decisions. DSA includes drawing a series of preliminary flowcharts of the decision phases and the interactions of managers. In the follow-up interviews, these preliminary flowcharts are shown to managers and executives to elicit additional details of the decision processes so that corrections can be made (Morgenroth, 1964). The preliminary flowcharts are then revised to enhance completeness and accuracy. The flowchart revisions should be shown to the managers in a third round of interviews, and they can be shown to other managers who have observed the decision process but have not been directly involved in the previous interviews. A final version of the

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flowchart can be completed based on the third set of interviews.

This study included interviews with several firms to determine the details of each factor when decision-makers approach making a decision. This study applied the DSA method to formalize the interview procedure for managers who participate in various phases in different multi-firm decision-making processes. This study included the selection of different firms to interview based on those that completed the questionnaire. Because this study focuses on the machinery industry, the interviewees were executives from the precision machinery industry, hand tools firms, machinery tool industries and plastics and rubber machinery firms. The interviewees work for firms that represent the wide range of the industry, and as such, they have an abundance of experience in the machinery industry to contribute to this investigation.

4. Data analysis

This study focuses on the central areas of Taiwan's machinery firms and designed its questionnaire to allow the decision-makers determine the collaboration factors. After obtaining the collaboration factors, this study then calculated the weights of the cues. In addition, an FFDT structure was established and firms were interviewed to learn about their detailed decision-making processes to obtain the DSA flowchart. This study included the collection of data from 21 firms that specialize in tool machinery, precision machinery, plastics machinery and hand tool machinery. Within the interviewed experts, eight experts were from the machine tool industry, seven were from the precision machinery industry, three were from the plastics and rubber machinery industry and three were from the hand tool industry. Additionally, of the experts, 38.09 per cent were CEOs, 19.04 per cent were inventory managers, 14.28 per cent were project managers and 28.59 per cent were general managers. These 21 experts answered not only the questionnaires designed to filter the collaboration factors and AHP, but they were also interviewed for the different rounds of the DSA process. The background information of the interviewed experts appears in Table II.

Table II Decision-makers' background information

No.	Company type	Title	Experience
First and second rounds of interviews			
1	Machine tool industry	CEO	16
2	Machine tool industry	CEO	12
3	Plastics and rubber machinery	CEO	27
4	Hand tool industry	CEO	17
5	Precision machinery industry	General Manager	19
6	Hand tool industry	Inventory Manager	7
7	Machine tool industry	General Manager	19
8	Machine tool Industry	General Manager	21
9	Machine tool industry	Project Manager	19
10	Precision machinery industry	Project Manager	28
Third round of interview			
11	Precision machinery industry	Inventory Manager	6
12	Machine tool industry	CEO	23
13	Machine tool industry	CEO	9
14	Machine tool industry	CEO	18
15	Precision machinery industry	CEO	17
16	Precision machinery industry	General Manager	22
17	Hand tool industry	General Manager	25
18	Plastics and rubber machinery	Inventory Manager	8
19	Plastics and rubber machinery	General Manager	27
20	Hand tool industry	Inventory Manager	11
21	Hand tool industry	General Manager	17

4.1 Data analysis of cue validity (V values)

By applying equation (1), the cue validities of the preliminary ten collaboration factors are calculated. There are six collaboration factors of which V values are greater than 0.5, and they are "Quality Assurance" (V = 0.95), "Degree of Collaboration" (V = 0.81), "Mutual Trust" (V = 0.81), "Delivery Accuracy" (V = 0.71), "Transaction Cost" (V = 0.57) and "Complementarity" (V = 0.52). Table III shows the cue validates of the collaboration factors. However, the V values are not calculated according to their degrees of importance; this study adapts the AHP method to obtain the weights for each of these six filtered collaboration factors.

The experts expressed that even though "Strategic Collaboration", "Collaboration Experience", "Business Concept" and "Knowledge Sharing" are important factors when considering a collaboration relationship in ICC, and there are four reasons about which decision-makers are extremely cautious. First of all, any strategic collaboration between firms that is designed to cultivate their potential can have an adverse effect on their level of competitiveness, particularly when firms enter an alliance with a competitor. It is possible to enhance the strength of that competitor because the company wants to enter new markets with the competitor's collaboration. Therefore, an alliance must rely on both firms being congenial. Therefore, decision-makers are reluctant to take a risk if they cannot be sure that the collaborative partner has the same goals. Second, excessive dependence on a partner could easily cause a disadvantage in negotiations or the possibility of being acquired. In fact, the strategic collaboration of firms in the long term must involve an in-depth dependence on each other. If one of them suddenly dissolves the partnership, it will cause a significant financial loss. The firms that are more dependent within a collaboration have a definite disadvantage, especially in negotiations, and the larger-scale company within a collaboration will most likely merge with the collaborative partner. Third, business collaboration will accelerate industrial competition if the strategic collaboration firms can share the costs and the results of research and development (R&D). However, if they cannot make use of this factor, it may destroy their collaborative relationship. Finally, before the collaboration, decision-makers must communicate with the other company to fully understand its business concept; even if the concept differs between firms, it will not be a significant problem.

However, decision-makers note that collaboration on this basis (substantively different business concepts) is unsustainable in a long-term relationship. In the machinery industry, most decision-makers look for long-term

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Table III The cue validates of the collaboration factors

Company \ Factor	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	R	W	V
Quality assurance	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	20	1	0.95
Degree of collaboration	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	17	4	0.81
Mutual trust	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	0	0	1	17	4	0.81
Delivery accuracy	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1	1	0	1	1	0	15	6	0.71
Transaction cost	1	1	1	1	1	0	0	0	0	0	0	1	0	0	0	1	1	1	1	1	1	12	9	0.57
Complementarity	1	0	0	0	0	1	1	1	0	0	0	0	1	1	1	0	0	1	1	1	1	11	10	0.52
Strategic collaboration	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	1	1	1	1	1	1	9	12	0.43
Collaboration experience	0	1	1	1	1	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	1	9	12	0.43
Business concept	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	1	0	1	0	0	9	12	0.43
Knowledge sharing	0	0	0	0	0	0	0	0	0	1	1	1	0	0	1	0	0	1	0	1	0	9	12	0.43

collaborative relationships, and if they happen to choose a partner that cannot sustain such a relationship, they will need to look again, which is a waste of time and money. Additionally, successful knowledge sharing depends on whether the firms can be honest with each other in sharing information. However, if communicators cannot clearly express their knowledge, it will result in a reduced willingness to collaborate. Small-scale firms are particularly concerned about information sharing because they fear that the disclosure of their core technology skills to a partner will result in a loss of their competitive advantage.

4.2 Data analysis of AHP

After obtaining the six collaboration factors, the AHP method was used to focus on experts as the subjects of a questionnaire survey and to select participants who had been in charge or had served as decision makers in ICC for a number of years. A total of 21 questionnaires were distributed, and 20 were retrieved, giving a validity rate of 95 per cent. The consistency of the questionnaires was judged by an AHP ratio test (CR $\leqq$ 0.1) to prove that the sample of the questionnaire was effective. Most of the experts who filled in the AHP questionnaires had more than 15 years of experience (5 of them had less than 15 years of experience). Table IV shows the pairwise comparison matrix of six collaboration factors, and Table V shows the final weights of importance for six collaboration factors.

From the results of the AHP assessment of six collaboration factors in ICC, the experts believe that "quality assurance" (w = 0.275) is relatively important and that "complementarity" (w = 0.070) is the least important compared to the other collaboration factors. Additionally, the values of C.I. and C.R. of the pairwise comparison matrix were 0.000813285 and 0.000655875, respectively, which fits Saaty's requirement for AHP consistency. To construct the FFDT, this study adopted AHP weights to set up an FFDT model containing the sequence of the factors. Quality was the first collaboration factor that most decision-makers in ICC consider to collaborate with other firms. The interviewees expressed that if partner firms manufacture sub-standard products, the decision-makers will decide not to collaborate with them (even if the costs are low) because they are not willing to risk having their reputations destroyed. After considering quality, decision-makers then consider the collaboration factor of "Transaction Cost". No matter which industry it belongs to, a company usually collaborates with others for cost considerations because it wants to reduce its cost and increase its profits.

Decision-makers not only care about the budget in the transaction costs but also try to minimize the time spent negotiating the collaboration contract. According to the interviewees, if a company has a good experience matching up with others, this can increase its willingness to collaborate. In addition, most of the decision-makers expressed that they consider the degree of collaboration, but they simultaneously consider delivery accuracy, although they believe that if the collaborating partners have a highly flexible degree of collaboration and a good record as collaborators, they should be able to deliver on time. Comparatively, the decision-makers in ICC do not consider mutual trust to be an important factor in choosing a collaborative partner because the establishment of mutual trust needs a substantial amount of time. In this

Table IV Pairwise comparison matrix of six collaboration factors

Pairwise comparison matrix	Transaction cost	Mutual trust	Complementarity	Delivery accuracy	Quality assurance	Degree of collaboration
Transaction cost	1	1.6014297	2.4705570	1.0493747	0.7590549	0.9709069
Mutual trust	0.624442	1	2.0226743	0.8224242	0.5439163	0.6565906
Complementarity	0.404767	0.404767	1	0.3621515	0.2823636	0.4176206
Delivery accuracy	0.9529485	1.2159175	2.7612751	1	0.4769794	0.92314
Quality assurance	1.3174278	1.8385182	3.5415327	2.0965266	1	1.7587413
Degree of collaboration	1.0299649	1.5230191	2.3945177	1.0832593	0.5685885	1

Notes: CI = 0.000813285; CR(C.I./1.24) = 0.000655875

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Table V Final weights of importance for six collaboration factors

Pairwise comparison matrix	Weight (*w*)
Quality assurance	0.275
Transaction cost	0.185
Degree of collaboration	0.177
Delivery accuracy	0.163
Mutual trust	0.130
Complementarity	0.070

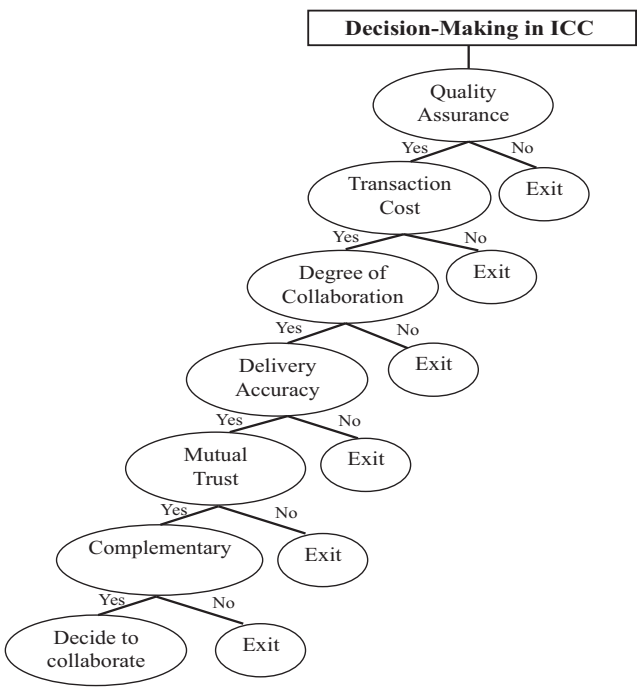
rapidly changing environment, mutual trust is not a major factor; however, if a company is looking for a long-term partner, mutual trust should be considered to expand the market and to acquire new technology. Figure 2 shows the FFDT model and nodes in ICC.

4.3 Decision systems analysis (DSA)

According to the FFDT, a DSA method involves drawing a series of preliminary flowcharts of the decision phases and the interactions of managers. In the follow-up interviews, these preliminary flowcharts were shown to managers to elicit additional details about their decision-making processes so that any necessary corrections could be made. The preliminary flowcharts were then revised to enhance their completeness and accuracy.

The flowchart revisions were shown to managers in a third round of interviews and to other managers who had observed the decision-making process but were not directly involved in previous interviews. A final version of the flowcharts was completed based on the third set of interviews. Several firms were interviewed in this study to establish the DSA diagram and to explain each factor process in detail. The DSA diagram appears as Figure 3.

Figure 2 The FFDT model and nodes in ICC



In Figure 3, to determine collaboration partners, provide accuracy and eliminate errors, a company first checks the accuracy level of the equipment of the candidate firms. The level of equipment accuracy should be within the range of $\pm 1\ \mu$ to avoid causing inaccurate product specifications. μ means standard deviation of inner diameter, outer diameter, thickness, length, roughness, etc. Usually, 1 μ equals to 0.001 mm in the machinery industry. According to the interviews, the most important factor of collaboration that is considered by many ICC professional staffs and managers is quality. Because it is not so easy to maintain a high quality of products in the machinery industry, the decision-makers need to know if firms have well-trained workers and can provide high-quality equipment. Additionally, the candidate company should be able to provide an agreement of quality assurance, which is defined as being a less than 2 per cent defective rate, and a powerful supply chain system is also required.

The biggest part of the cost in the machinery industry is the cost of materials, and if a material supplier provides sub-standard materials, firms can waste a great deal of time and budgets. Losing time means delays in the production time of products, and if firms miss the delivery of an order, they may be fined and will certainly lose customers. Having obtained good materials with a good price, the next consideration is the location. If a company chooses a partner that is located nearby, this provides a fast commutate, which is considered to be an asset because the firms in ICC need to discuss and solve issues immediately. Therefore, a close location can not only reduce travel time and costs but can also process orders immediately. There are many extra costs involved in searching for a partner, such as product warranties and after-sale service, and these extra costs are referred to as transaction costs. Firms initially need people to help them to find a good partner, so they need to spend time and money on human resources. With time constraints, decision-makers have limited time in which to decide whether to collaborate or not. If they make the wrong decision, the company will lose valuable time and the competitive advantage.

To collaborate with partners in ICC, firms should acknowledge the differences between themselves and their partners. The frequency and method of collaboration between firms and partners can be referred to as the degree of collaboration. The interviewees also emphasized that the degree of collaboration should be reinforced by increasing the firms' and partners' profits simultaneously and building an instant communication channel to create a long-term mutually successful collaborative situation. When the decision-makers decide to collaborate, they need an appropriately flexible system to enable sufficient supply chain collaboration for every party in the collaboration. This sufficient supply chain involves not only the information technology industry to ensure a high level of manufacturing flexibility but also the machinery industry to provide quick responses for manufacturing processes and product handling.

When a collaboration decision is made in ICC, it requires expedited top-down and bottom-up channels through which partners can communicate. Firms in ICC usually assign experienced and professional staff members to

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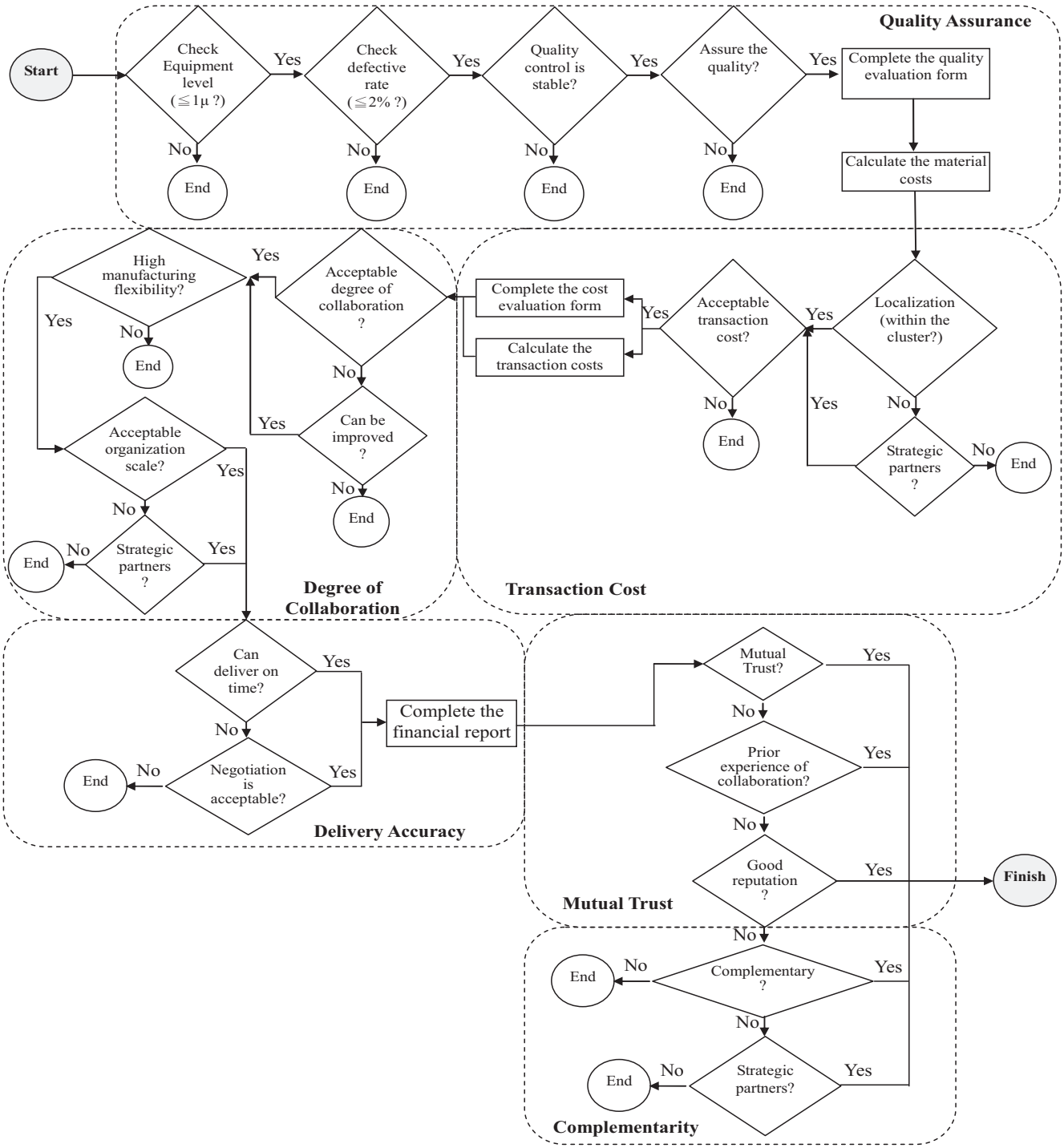
Figure 3 DSA flowchart in ICC



execute the collaboration projects. These staff members must have the ability to address fast changing situations. Thus, a more dynamic and flat organizational structure is better for firms to enable themselves and their partners to respond to a quick changing environment. When the products are completed in the collaborative projects, firms need to deliver the products without any delay because the more time they save, the more customers they serve. However, because firms have their own production capacities, they should consider their maximum production load. Because the orders are usually changed unpredictably due to the fast changing environment, the decision-makers in ICC should negotiate with their collaborators and stipulate penalties in advance in their collaboration contract for failing to meet delivery deadlines.

When the decision-makers in ICC search for partners, they usually rely on the desired partner's financial reports and past experiences. In contrast to Western businesses,

Asian firms usually rely on mutual trust. Approximately, 85 per cent of the firms interviewed expressed that they would prefer to use mutual trust to collaborate with partners rather than a written contract. A good reputation comes from being honest and providing good service. If a company has a reputation for being honest throughout the entire industry, the company will easily find good business partners and build beneficial social networks to strengthen its competitive advantages. This study also finds that the positive attitude of potential partners is an important influential factor for decision-makers because a positive attitude is usually accompanied by a good reputation. The interviewees described that collaborating with a company that has a good reputation will be extremely beneficial to improving their own company's reputations.

Due to the benefits of proximity in ICC, it is comparatively easier to find collaboration partners. The interviewees emphasized that "doing one thing at a time and focusing on your professional core abilities will bring you success." In the past, some firms have failed in collaborative projects due to poor decisions and having chosen non-productive collaboration partners. The interviewees also noted that considering complementary elements, such as the talents of a company's human resources and its core technologies, can effectively improve the success of collaboration partnership. Building a resource-sharing platform and mutually developing core technologies in ICC can lift barriers and protect the internal advantages in ICC from outside competitors.

5. Conclusion and recommendations

Most firms in Taiwan are SMEs, and SMEs need to constantly improve technology skills and peruse the high manufacturing quality and productivity to compete in a rapidly evolving and uncertain business environment. The structure of ICC influences the potential for knowledge creation, and a dense local clustering provides information transmission capacity in ICC by fostering communication and collaboration (Schilling and Phelps, 2007). According to government development policies, the machinery industry is one of the key industries in Taiwan, and the government plans to focus on the development of this industry in the future because the machinery industry has a complete industrial cluster to address future challenges. Thus, the government and the industry must pay more attention and devote more resources to improving the country's economic outlook, whether in technological innovation or innovative education. This study presents a decision-making solution to shorten the time required in the search for new business collaboration partners in ICC. This study not only develops the FFDT of decision-making notes to quickly identify potential collaboration partners but also constructs a DSA flowchart to provide a qualitative measurement of the six factors of the decision-making process and effectively shorten the decision-making processes.

This study finds that the rapidly changing economic environment is the main reason for firms in ICC to collaborate. Based on the analyses of TTB and AHP, this study obtains the weights of "Quality Assurance" ($w = 0.275$), "Transaction Cost" ($w = 0.185$), "Degree of Collaboration" ($w = 0.177$), "Delivery Assurance" ($w = 0.163$) and "Mutual Trust" ($w = 0.07$). These results indicate that the machinery industry executives have concerns with product quality because the Taiwan machinery industry relies on exports, and the key element to maintain this export advantage is to pursue product quality.

Many interviewees indicated that the modules, "degree of collaboration" and "delivery accuracy", inter-relate because if a company maintains a high degree of collaboration, it can usually deliver products on time to fulfill its delivery accuracy obligations. In Taiwan's machinery industry, firms usually find it difficult to develop their own technology because of the high costs of R&D for SMEs. Therefore, they need to collaborate with partners to maintain their competitive advantage. However, to collaborate, they must learn to trust their collaboration partners, and the degree of collaboration also strongly depends on the degree to which they trust their collaboration partners.

Due to the fast changing and complex environment of the machinery industry in Taiwan, many decision-makers in ICC consider too many influential collaboration factors while searching for collaboration partners. This phenomenon causes the problem of ignoring previous experience and can lead to failure and the waste of a company's resources. This study is in accordance with the general type of industrial interfirm collaboration in Taiwan. The industrial interfirm collaboration is divisible further into the types of formal, semi-formal and informal industrial interfirm collaborations. Although there are other methods of collaboration that can be discussed in the future, such as collaboration outsourcing, alliances and maintaining long-term relationships in ICC, this study provides the efficient models of FFDT and DSA to quickly identify potential collaboration partners and to effectively shorten decision-making processes.

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