A Fuzzy Hierarchy Integral Analytic Expert Decision Process in Evaluating Foreign Investment Entry-mode Selection for Taiwanese Bio-tech Firms

Hsu-Hua Lee[1]

[1]Graduate Institute of Management Sciences, Tamkang University, Taiwan

e-mail: 132576@mail.tku.edu.tw

Tsau-Tang Yang[2]

[2]Graduate Institute of Management Sciences, Tamkang University, Taiwan

e-mail: giddi.john@msa.hinet.net

Chie-Bein Chen[3]

[3]Department of Logistics Management, Takming University of Science and Technology & Department of International Business, College of Management, National Dong Hwa University, Taiwan,

e-mail: cbchen@takming.edu.tw

Yen-Lin Chen[4]

[4]Chief Executive Master Program in Business Administration, College of Management, National Dong Hwa University, Taiwan

e-mail: class_netsite@yahoo.com.tw

Abstract

***Abstract* - The purpose of this study is to help bio-tech firms solve the foreign investment (FI) entry mode selection problem. This study combines the concepts of factor analysis, analytic hierarchy process (AHP), genetic algorithm (GA), and fuzzy integral to construct an entry mode selection approach.**

This study produces several interesting findings. (1) In the different investment entry modes, there are large differences in evaluation focus when investors select their entry modes. (2) For example, Taiwanese bio-tech firms entering mainland China consider merger and acquisitions to be first priority, and followd by strategic alliances. This research shows that if the stock share holding is unlimited, Taiwanese bio-tech firms prefer to select a high stock share holding investing mode (3) In various investment modes, the aspects of "Capital and Risk" and "Technology Ability" have the most consistent effect on entry mode selection.

Keywords:* *Foreign investment, factor analysis, analytic hierarchy process (AHP), genetic algorithm, fuzzy integral

I. Introduction

Zadeh (1965) introduced fuzzy set theory to illustrate the fuzzy phenomena occurring in human activities. Human behaviors and conceptual languages can be converted into fuzzy numbers using the uncertain elements of fuzzy set membership. Van Laarhoven and Pedrycz (1983) showed that these fuzzy numbers can be calculated and ranked. In addition, Mikhailov and Singh (1999) performed a comparative study on traditional crisp values and fuzzy intervals, and found that fuzzy measures perform better than crisp values. In complex multi-criteria scenarios, an expert decision-maker often has too much information to analyze and evaluate, and thus cannot easily make consistent decisions. Chen et al. (2006) used four different types of membership functions to represent the weighted linguistic variables of the different professional abilities of expert decision-makers. They also measured these linguistic variables using three distinct types of membership functions, and quantified linguistic variables. Chen and Klein (1997) introduced the defuzzying method to calculate crisp values by the relationship between the referential rectangle and triangle fuzzy numbers.

Fuzzy measures view the performance of criteria as candidate fuzzy sets, and can be used to determine the degree to which X are involved in the performance of criteria in fuzzy set membership. The value of the fuzzy measure includes the connotative weights of criteria performance. In other words, the fuzzy measure has an dependent interaction effect on the criteria under consideration. Eliminating the assumption that the probability of all sets is 1, the fuzzy measure transfers the additive probability into non-additive fuzzy measures. The λ-fuzzy measure, called the Sugeno measure (Sugeno, 1974), can fulfill the λ additive axiom, making it easier to define the fuzzy measure. The constrained parameter, λ, of the λ-fuzzy measure indicates additivity among its elements. Compared with other fuzzy numbers, the λ-fuzzy measure is easily and extensively applied to determine the value of fuzzy measures (Chen and Wang, 2001; Lee and Leekwang, 1995). When an expert decision-maker evaluates the alternatives, more criteria create more sophisticated calculations of the λ-fuzzy measure. Lee and Leekwang (1995) employed a genetic algorithm (GA) to calculate the value of the λ-fuzzy measure without complete information. Chou (2007) provided a GA computer program to obtain the optimal value of λ using Matlab R2007a software. Takahagi (2000) normalized the λ-fuzzy measure to easily explain the value of the fuzzy measure.

In 1970, Thomas L. Saaty developed an analytic hierarchy process (AHP) decision model that is suitable to exercise the multi-criteria group decision of subjective judgment (Lai, Wong and Cheung, 2002). Even through traditional AHP has many defects in reality, it can decomposes complex problems using hierarchical structures, and ultimately benefit the construction of the decision model. Chen (2001) employed the fuzzy integral to amend the disadvantages of traditional AHP. The fuzzy integral successfully accounts for the process of human subjective judgment and more accurately reflects real situations. Moreover, the revised fuzzy integral considers the relationships between criteria at any given time. By calculating the weights of AHP through multiple or transited effects among criteria, the revised fuzzy integral can accurately reflect real situations. Comment integrals include the Sugeno Integral, Weber Integral, and Choquet Integral. Among these integrals, the Choquet Integral is a non-additive utility function that is suitable to exercise multi-criteria decision problems. Therefore, this study adopts Choquet's fuzzy integral to calculate the overall performance of each alternative. Furthermore, Takahagi (2005) designed a Choquet Integral program of λ fuzzy measure to calculate the value of the Choquet Integral more easily.

From the viewpoints of organizational management and operation, Root (1994) separated the modes into: (1) Exports, including indirect exports, direct exports and others; (2) Contract cooperation, including licensing, franchising, technical agreements, service contracts, management contracts, turnkey, contract/manufacture, counter trade arrangements, and others; and (3) Local investment, including unique investment – investing in a new establishment, unique investment – acquisition, joint venture – creating a new establishment, joint venture – purchasing the stocks of existing company, and others. Pan and Tse (2000) differentiated between the level of entry modes for equity and non-equity relationships. Furthermore, Chen and Luo (2004) illustrated the modes of strategic alliance using the exchange types of the relationship between the degree of integration and control. Yoshino and Rangan (1995) divided strategic alliances into contract agreements and equity agreements based on the types of equity. Finally, Narula and Hagedoorn (1999) differentiated between the modes of technology transfer for equity and non-equity agreements.

To summarize the categories of entry modes in the literature described above, this study simplifies these research processes by considering current bio-tech developing situations. The foreign entry modes of the bio-tech (or pharmacy) industry indicated by Chen and Luo (2004) not only effectively measure different assessment criteria, but can also reduce the complexity of assessment factors in various entry modes and their alternatives.

Considering the questionnaires release and the respondent willingness to reply, Chen and Luo (2004) developed the following entry modes: (1) joint venture, (2) minority holding strategic alliance, (3) joint R&D, (4) joint production, (5) joint marketing and promotion, (6) enhancing the partner relationship with a provider, (7) R&D contract, and (8) licensing agreement. This study simplifies and rearranges theses entry modes into the following four categories: "joint venture," "strategic alliance," "merger and acquisition," and "cooperation contract."

The research subjects in this study are Taiwanese bio-tech firm experts who are willing to invest in, or are currently investing in, Mainland China.

Facing growing international competition, many Taiwanese bio-tech firms have begun to invest heavily in R&D to develop innovative products or processes. Bio-tech firms in particular face the challenge of high barriers to entry, long-development time, and a high failure rate. Most of bio-tech firms are small and medium enterprises whose main revenues come from manufacturing and selling products, and they often lack investment capital. The models in Table A1 in Appendix I show that cooperation among universities, research institutes, bio-tech firms, and other related industrial companies is becoming one of the major strategies in bio-tech business operations.

According to previous studies (Kim and Hwabg, 1992; Dumming, 1998), the aspects of strategic motivation, knowledge, and techniques (Agarwal and Ramaswami, 1992; Pearce and Papanastassiou, 1996; Shan and Song, 1997; Cho and Yu, 2000), location-specific advantage (Agarwal and Ramaswami, 1992; Pearce and Papanastassiou, 1996; Shan and Song, 1997; Robertson and Gatignon, 1998; Dalton and Serapio, 1999; Deeds et al., 2000; Allansdottir et al., 2002; Brouthers, 2002; Cho and Yu, 2000; Yiu and Makino, 2002; Richards and DeCarolis, 2003; Shih, 2006; Isbasoiu, 2006), ownership-specific advantages (Agarwal and Ramaswami, 1992; Deeds and Hill, 1996; Ekeledo and Sivakumar, 2004; Coombs et al., 2006; Shih; 2006), internalization advantage (Woiceshyn and Hartel, 1996), and their influence on foreign investment (FI) are the primary factors affecting FI for bio-tech firms.

Other research on the bio-tech industry is directed at internationalized joint ventures. Richards and DeCarolis (2003) found that similar and complementary product lines from the cooperative enterprises, culture distances, country risks, and prior cooperative experiences all result in different forms of joint-ventures in R&D activities. Vanderbyl and Kobelak (2007) conducted a study on the key success factors of 247 Canadian bio-tech firms. Their study demonstrates that bio-tech firms rely more on external resources in the early stages, and modern bio-tech firms usually acquire more venture capital. No matter what stage bio-tech firms are in, the key success factors is the accumulation of intellectual capital. As a result, the number of patents a bio-tech firm possesses can measure its technical capital (Deeds, DeCarolis and Coombs, 1997; Shan and Song, 1997). Greetham (1998) assumed that the key success factors for bio-tech firms lie in the acquisition of venture capital (VC), business partners, success of initial public offering (IPO), accomplishment of clinical trials, electable products, or technology commercialization. Hence, sufficient long-term capital is an important factor in the survival of bio-tech firms. Table A2 in Appendix II lists the influential factors of foreign investment and their related studies.

II. Fuzzy Scheme for Decision Process in Evaluating FI Entry-mode

The following section describes six steps in the fuzzy scheme decision process for evaluating FI entry modes.

Step 1： Setting up the Fuzzy Linguistic

This study employs five triangular fuzzy numbers, $\tilde{1}$ through $\tilde{5}$, as scales to express the differentiation of subjective intensity of expert decision-makers and measure assessment criteria. The triangular fuzzy number, $\tilde{X}_{ij}$, represents the assessment linguistic variable and $\tilde{g}_{ij}$ represents the fuzzy weighted variable for the i^{th} aspect and the j^{th} assessment criteria.

$$\tilde{X}_{ij}^{k} = \left({}_{L}\tilde{X}_{ij}^{k},\ \ {}_{M}\tilde{X}_{ij}^{k},\ \ {}_{R}\tilde{X}_{ij}^{k} \right)$$ and

$$\tilde{g}_{ij}^{k} = \left({}_{L}\tilde{g}_{ij}^{k},\ \ {}_{M}\tilde{g}_{ij}^{k},\ \ {}_{R}\tilde{g}_{ij}^{k} \right),$$

where L, M and R indicate the left-medium-right point of the triangular fuzzy number (see Fig. 1).

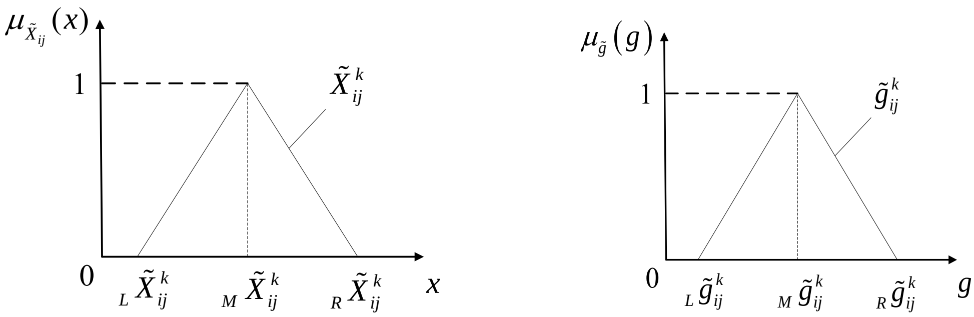

Figure 1 Illustration of Fuzzy Triangular Fuzzy Numbers for Linguistic Assessment Variable, $\tilde{X}_{ij}^{k}$, and its Fuzzy Weighted Variable, $\tilde{g}_{ij}^{k}$

This study uses 7 different types of linguistic modes belonging to two classifications. The first one grades of importance of the foreign investment influence factor (or criteria), and the second one measures the effectiveness of the foreign investment influence factor. These X were designed by Chen et al. (2006). Tables A3.1 and A3.2, and Fig. A3.1 and A3.2. present two of the seven types of membership functions. The principle was established based on the different professional judgment ability of expert decision-makers. Tables 1 and 2 quantify the linguistic assessment variables.

Table 1 The Linguistic Variable Models and the Three-point Triangular Fuzzy Weighted Values

Model	Extremely Unimportant			Unimportant			Equal Important			Important			Extremely Important		
	L	M	R	L	M	R	L	M	R	L	M	R	L	M	R
LM_{G1}	0	0	0.20	0.20	0.30	0.40	0.40	0.50	0.60	0.60	0.70	0.80	0.80	1	1
LM_{G2}	0	0	0.25	0.20	0.30	0.40	0.35	0.50	0.65	0.60	0.70	0.80	0.75	1	1
LM_{G3}	0	0	0.35	0.15	0.30	0.45	0.25	0.50	0.75	0.55	0.70	0.85	0.65	1	1
LM_{G4}	0	0	0.55	0.05	0.30	0.60	0.05	0.50	0.95	0.60	0.70	0.95	0.45	1	1

Table 2 The Linguistic Variable Models and the Three-point Triangular Fuzzy

Criteria Assessment Values

Model	Extremely Weak			Weak			Equal Strong			Strong			Extremely Strong		
	L	M	R	L	M	R	L	M	R	L	M	R	L	M	R
LM_{C1}	0	0	0.25	0.20	0.30	0.40	0.35	0.50	0.65	0.60	0.70	0.80	0.75	1	1
LM_{C2}	0	0	0.30	0.15	0.30	0.45	0.30	0.50	0.70	0.55	0.70	0.85	0.70	1	1
LM_{C3}	0	0	0.55	0.05	0.30	0.6	0.05	0.50	0.95	0.60	0.70	0.95	0.45	1	1

Step 2： Determining the Group Average Fuzzy Assessment Value

If m expert decision-makers evaluate the i^{th} aspect and the j^{th} assessment criteria, apply the calculating method proposed by Dubois and Prade (1987) to aggregate all of the fuzzy linguistic variables of assessment criteria and the fuzzy weighted variables of all the expert decision-makers. The resulting new membership functions from the mean value of all fuzzy linguistic variables of assessment criteria and their fuzzy weighted variables are shown as follows.

$$\bar{\tilde{X}}_{ij} = \left({}_L\bar{\tilde{X}}_{ij},\ {}_M\bar{\tilde{X}}_{ij},\ {}_R\bar{\tilde{X}}_{ij} \right)$$

$$= \left(\sum_{k=1}^{m} {}_L\tilde{X}_{ij}^k / m,\ \sum_{k=1}^{m} {}_M\tilde{X}_{ij}^k / m,\ \sum_{k=1}^{m} {}_R\tilde{X}_{ij}^k / m \right)$$

(3) and

$$\bar{\tilde{g}}_{ij} = \left({}_L\bar{\tilde{g}}_{ij},\ {}_M\bar{\tilde{g}}_{ij},\ {}_R\bar{\tilde{g}}_{ij} \right)$$

$$= \left(\sum_{k=1}^{m} {}_L\tilde{g}_{ij}^k / m,\ \sum_{k=1}^{m} {}_M\tilde{g}_{ij}^k / m,\ \sum_{k=1}^{m} {}_R\tilde{g}_{ij}^k / m \right), (4)$$

where $\bar{\tilde{X}}_{ij}$ represents the mean value of the linguistic variable of the m expert decision-maker in the ith aspect and the jth assessment criteria. $\bar{\tilde{g}}_{ij}$ represents the mean value of weighted variable of m expert decision-maker in the ith aspect and the jth assessment criteria

Step 3： Defuzzification for Calculating the Crisp Values of Assessment Criteria

Many methods are available to complete this step, including mean of maxima, center of sum, center of gravity, and the α -cut method. Chen and Klein's (1997) defuzzifying method is a very sensitive and effective method for discriminating fuzzy ranking based on many simulated experiments and applying various linear or non-linear types of fuzzy numbers and different degrees of fuzzy number overlapping. They utilized a method involving the fuzzy subtraction of a referential rectangle, $\tilde{R}$, fuzzy number which combined with mean value of assessment linguistic variables, $\bar{\tilde{X}}_{ij}$, and mean of value of their weights; the rectangle determined by multiplying the height of the membership function of $\bar{\tilde{X}}_{ij}$ by the distance between the two crisp maximizing and minimizing barriers. Here, $\tilde{R}$ can be regarded as a fuzzy number (see Fig. 2).

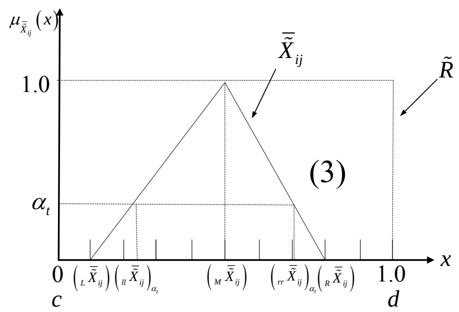

Figure 2 Chen and Klein's Defuzzying Method

(4)

The fuzzy subtraction of the referential rectangle, $\tilde{R}$, from the fuzzy number, $\bar{\tilde{X}}_{ij}$, can be performed at level α_t as follows.

$$\left(\bar{\tilde{X}}_{ij}\right)_{\alpha_t} <-> \tilde{R} = \left[\left({}_{rr}\bar{\tilde{X}}_{ij} \right)_{\alpha_t}, \left({}_{rr}\bar{\tilde{X}}_{ij} \right)_{\alpha_t} \right] [-] [c, d]$$

$$=\left[\left({}_{rr}\bar{\tilde{X}}_{ij}\right)_{\alpha_t}-c,\left({}_{rr}\bar{\tilde{X}}_{ij}\right)_{\alpha_t}-d\right]\quad t=0,1,2,...,\infty. \qquad (5)$$

where $<->$ and $[-]$ represent the fuzzy subtraction and interval subtraction operators, respectively. The crisp value, $D\left(\bar{\tilde{X}}_{ij}\right)$, at the α_t-cut of linguistic variable are obtained as follows (Chen and Klein, 1997).

$$D\left(\bar{\tilde{X}}_{ij}\right)=\frac{\sum_{t=1}^{n}\left[\left({}_{rr}\bar{\tilde{X}}_{ij}\right)_{\alpha_t}-c\right]}{\sum_{t=1}^{n}\left[\left({}_{rr}\bar{\tilde{X}}_{ij}\right)_{\alpha_t}-c\right]-\sum_{t=1}^{n}\left[\left({}_{ll}\bar{\tilde{X}}_{ij}\right)_{\alpha_t}-d\right]},\ n\to\infty;\ i=1,2,\cdots,p;\ j=1,2,\cdots,q; \qquad (6)$$

where n is the number of -cuts. As n approaches ∝, the sum of X is the measured area. The terms $\left({}_{ll}\bar{\tilde{X}}_{ij}\right)_{\alpha_t}$ and $\left({}_{rr}\bar{\tilde{X}}_{ij}\right)_{\alpha_t}$ represent the lower and upper limits, respectively, of the fuzzy number $\bar{\tilde{X}}_{ij}$ under the α_i-cut method. The terms c and d stand for the lower and upper limits, respectively, of the referential rectangle fuzzy number $\tilde{R}$ (see Fig. 2). In Eq. (6), $\sum_{t=1}^{n}\left[\left({}_{rr}\bar{\tilde{X}}_{ij}\right)_{\alpha_t}-c\right]$ is a positive value and $\sum_{t=1}^{n}\left[\left({}_{ll}\bar{\tilde{X}}_{ij}\right)_{\alpha_t}-d\right]$ is a negative value.

Use the α_t-cut method again to calculate the crisp value of defuzzying weighted average value $D\left(\bar{\tilde{g}}_{ij}\right)_{\alpha_t}$, where $\alpha_t=0.5$. According to the inverse function of membership function gained from group decision-making values of each assessment criteria. The mean of the values of each linguistic are calculated using Eq. (3) and its upper and lower membership limits are calculated as $\alpha_t=0.5$; $t=1,2,\cdots,n$. The expressions based on the inverse functions of both left and right sides of the triangular fuzzy number (see Appendix IV) are shown as follows.

$$\begin{cases}\left({}_{ll}\bar{\tilde{X}}_{ij}\right)_{\alpha=0.5}={}_{M}\bar{\tilde{X}}_{ij}-0.5\times\left({}_{M}\bar{\tilde{X}}_{ij}-{}_{L}\bar{\tilde{X}}_{ij}\right) & ,{}_{L}\bar{\tilde{X}}_{ij}\le\left({}_{ll}\bar{\tilde{X}}_{ij}\right)_{\alpha_t}\le{}_{M}\bar{\tilde{X}}_{ij}\\ \left({}_{rr}\bar{\tilde{X}}_{ij}\right)_{\alpha=0.5}={}_{M}\bar{\tilde{X}}_{ij}+0.5\times\left({}_{R}\bar{\tilde{X}}_{ij}-{}_{M}\bar{\tilde{X}}_{ij}\right) & ,{}_{M}\bar{\tilde{X}}_{ij}\le\left({}_{rr}\bar{\tilde{X}}_{ij}\right)_{\alpha_t}\le{}_{R}\bar{\tilde{X}}_{ij}\end{cases} \qquad (7)$$

where $i=1,2,\cdots,p$; $j=1,2,\cdots,q$.

Plug Eq. (7) into Eq. (6) to determine the aggregated m expert decision-maker fuzzy assessment value, $\bar{\tilde{X}}_{ij}$, and then calculate the crisp value of $D\left(\bar{\tilde{X}}_{ij}\right)$, $i=1,2,\cdots,p;\ j=1,2,\cdots,q$. Similarly, use the same algorithm to calculate the lower limit, ${}_{ll}\bar{\tilde{g}}_{ij}$, and upper limit, ${}_{rr}\bar{\tilde{g}}_{ij}$, of the weighted average of criteria while $\alpha_t=0.5$ for m expert decision-makers in the ith aspect and the jth assessment criteria.

Step 4：λ-Fuzzy Measure （Sugeno, 1974; 1977）— λ Value in λ-Fuzzy Measure Determined by Genetic Algorithm

The fuzzy measure can be used to determine the degrees of weighted values and interactive relationship among assessment criteria that belong to the sets of each other. In the fuzzy measure model, the constrained parameter λ in the λ-fuzzy measure represents the additive degree and interactive relationships among the assessment criteria. Therefore, this study applies the λ-fuzzy measure to determine the weight values within the additive degree and interactive relationships among the assessment criteria. The parameter, λ, and the weighted values, $\bar{\tilde{g}}_{ij}$, of each assessment criteria are defined as follows:

If $\bar{\tilde{X}}_i = \left\{ \bar{\tilde{X}}_{i1}, \bar{\tilde{X}}_{i2}, \ldots, \bar{\tilde{X}}_{ij} \right\}$, $i = 1, 2, \cdots, p$; $j = 1, 2, \cdots, q,$ is a finite set of assessment criteria in the ith aspect, $P\left(\bar{\tilde{X}}_{ij}\right)$ is the power set of $\bar{\tilde{X}}_{ij}$. If $g_\lambda(\bar{\tilde{X}}_{i1}) = g_\lambda\left(\left\{\bar{\tilde{X}}_{i1}\right\}\right)$ is the fuzzy density of singular element of $\bar{\tilde{X}}_{i1}$, then the fuzzy measure, $g_\lambda\left(\bar{\tilde{X}}_i\right) = g_\lambda\left(\left\{\bar{\tilde{X}}_{i1}, \bar{\tilde{X}}_{i2}, \ldots, \bar{\tilde{X}}_{ij}\right\}\right)$, of the finite set, $\bar{\tilde{X}}_i$, can be expressed as follows (Keeney and Raiffa, 1976; Leszcznski et al., 1985).

$$g_\lambda\left(\bar{\tilde{X}}_i\right) = g_\lambda\left(\left\{\bar{\tilde{X}}_{i1}, \bar{\tilde{X}}_{i2}, \ldots, \bar{\tilde{X}}_{ij}\right\}\right) \quad (8)$$

$$= \sum_{j=1}^{q} g_{ij} + \lambda \sum_{j_1=1}^{q-1} \sum_{j_2=j_1+1}^{q} g_{ij_1} g_{ij_2} + \ldots + \lambda^{q-1} g_{i1} g_{i2} \ldots .. g_{iq}$$

$$= \frac{1}{\lambda} \left| \prod_{j=1}^{q} \left(1 + \lambda g_{ij}\right) - 1 \right|,$$

where $i = 1, 2, \cdots, p$, $g_{ij} = g_\lambda\left(\left\{\bar{\tilde{X}}_{ij}\right\}, i = 1, 2, \cdots, p;\ j = 1, 2, \cdots, q\right)$

When $\lambda \in [-1, \infty]$ and $g_\lambda\left(\tilde{X}_i\right) = 1$, Eq. (8) can be simplified as

$$\lambda + 1 = \prod_{j=1}^{q} \left(1 + \lambda g_{ij}\right), \quad (9)$$

where $i = 1, 2, \cdots, p$.

In this study, if $\bar{\tilde{X}}_i = \left\{ \bar{\tilde{X}}_{i1}, \bar{\tilde{X}}_{i2}, \ldots, \bar{\tilde{X}}_{ij} \right\}$ is the finite set of assessment criteria, the crisp value of defuzzifying $D\left(\bar{\tilde{g}}_{ij}\right) = \hat{g}_{ij}$, $i = 1, 2, \cdots, p$; $j = 1, 2, \cdots, q$ can be put into the formula, $\lambda + 1 = \prod_{j=1}^{q}\left(1 + \lambda g_{ij}\right)$, to determine the λ value in the fuzzy measure. The fitness function and constrained condition of λ value are as follows:

$$\min_{\lambda} \quad \prod_{j=1}^{n} \left(1 + \lambda \hat{g}_{ij}\right) - \left(\lambda + 1\right), \quad i = 1, \cdots, p \quad (10)$$

s. t. $-1 < \lambda < \infty$.

In defining the λ-fuzzy measure, the decision-maker must determine both the unconsidered additive degree and the interactive relationship weighted value, g_{ij}, $i = 1, 2, \cdots, p$; $j = 1, 2, \cdots, q$, in the assessment criteria and the λ value. In this study, the weighted value, g_{ij}, can be obtained from the second-stage questionnaire. However, there are many ways to determine the λ value for each decision-maker. Thus, it is very difficult to obtain consistent results for group decisions. Therefore, this study uses the GA program MatlabR2007a to compute the λ value to simulate the human assessment values. Following Lee and Leekwang (1995), Eq. (10) can be used to compute the λ value using the GA and setting the reproduction number (or population size), the crossover rate, and the mutation rate.

First set the crisp value, $D\left(\bar{\tilde{X}}_{ij}\right)$, $i = 1, \cdots, p$; $j = 1, \cdots, q$, rearrange the order of $D\left(\bar{\tilde{X}}_{ij}\right)$, and renumber the assessment criteria. Set up $D\left(\tilde{\bar{X}}_{ij}\right)=h\left(\tilde{\bar{X}}_{ij}\right)$ to satisfy $h\left(\tilde{\bar{X}}_{i1}\right)\le h\left(\tilde{\bar{X}}_{i2}\right)\le\cdots\le h\left(\tilde{\bar{X}}_{ij}\right)\le\cdots\le h\left(\tilde{\bar{X}}_{iq}\right)$, and then put the λ value into the objective function in Eq. (10) to calculate and obtain the estimated values, $g_\lambda\left(\tilde{\bar{X}}_{ij}\right)$, of each assessment criteria. Repeat this procedure to calculate the weight measurement in each assessment aspect.

Step 5： Calculating the Choquet Integral for the Assessment Value and Its Weighted Values

The fuzzy integral was developed and based on the concept of the fuzzy measure. It is not necessary to assume dependence among the assessment criteria to use the fuzzy integral, but it must meet the monotonic property requirement (Chen and Wang, 2001). The fuzzy integral is a useful tool to calculate the aggregated weight of X. A decision-maker can select the assessment criteria with the relative property and then apply the fuzzy integral to obtain the aggregated performance value for each alternative. The ranking order of each alternative is based on the aggregated performance value.

Murofushi and Sugeno (1989) indicated that the Choquet Integral represents the non-additive multiple attribute utility function, and offers good performance that is suitable for applying to decision problems with multiple criteria. The degree of importance for each assessment criterion can be determined individually, and X reveals the relationships among the assessment criteria. This is why this study adopts the Choquet Integral. This study also employs the λ -fuzzy measure of the Choquet Integral computer program designed by Takahagi (2000; 2005) to calculate the λ value and all the Choquet Integral values. Equation (11) calculates the fuzzy integral value of each criterion for each aspect.

Takahagi's (2000; 2005) computer program uses $\phi_{\lambda+1}$ to normalize g_λ. Let u_{ij} be the normalized weight, that is, $u_{ij}=\bar{\tilde{g}}_{ij}/\sum_{i=1}^{p}\sum_{j=1}^{q}\bar{\tilde{g}}_{ij}$,

$\phi_{\lambda+1}:[0,\ 1]\rightarrow[0,\ 1]$, $\lambda+1\in[0,\ +\infty]$,

$$\phi_{\lambda+1}(u_{ij})=\begin{cases}\langle u_{ij}\rangle, & if\quad \lambda+1=0\\ u_{ij}, & if\quad \lambda+1=1\\ 1-\langle 1-u_{ij}\rangle, & if\quad \lambda+1=+\infty\\ \left((\lambda+1)^{u_{ij}}-1\right)\Big/(\lambda+1-1), & otherwise\end{cases}$$

and $$\langle u_{ij}\rangle=\begin{cases}1, & if\quad 0<u_{ij}\le 1\\ 0, & if\quad u_{ij}=0\end{cases} \qquad (11)$$

where $u_\lambda(A)=\phi_{\lambda+1}\left(\sum_{i\in A}u_{ij}\right)$, $A\in\beta(\tilde{\bar{X}}_{ij})$ in a space of the fuzzy measure, ($\tilde{\bar{X}}_{ij}$, β, u_{ij}) (Lee and Leekwang, 1995).

Let h be a measurable function for $\tilde{\bar{X}}_{ij}$ and $h\left(\tilde{\bar{X}}_{i1}\right)\le h\left(\tilde{\bar{X}}_{i2}\right)\le\cdots\quad\le h\left(\tilde{\bar{X}}_{ij}\right)\le\cdots\le h\left(\tilde{\bar{X}}_{iq}\right)$. Therefore, the function of the Choquet Integral, $h:\tilde{\bar{X}}\rightarrow[0,1]$, in the fuzzy measure $g_\lambda\left(\tilde{\bar{X}}_{ij}\right)$ of the ith aspect can be defined as:

$$(C)\int hdg=h\left(\tilde{\bar{X}}_{i1}\right)g_\lambda\left(\tilde{\bar{X}}_{i1}\right)+\left[h(\tilde{\bar{X}}_{i2})-h(\tilde{\bar{X}}_{i1})\right]g_\lambda\left(\tilde{\bar{X}}_{i2}\right) \qquad (12)$$

$$+\cdots+\left[h(\tilde{\bar{X}}_{iq})-h(\tilde{\bar{X}}_{i(q-1)})\right]g_\lambda\left(\tilde{\bar{X}}_{iq}\right),$$

where $h(\tilde{\bar{X}}_{i0})=0$,

$$g_\lambda\left(\bar{\tilde{X}}_{ij}\right) = g_\lambda\left(\left\{\bar{\tilde{X}}_{i1}, \bar{\tilde{X}}_{i2}, \ldots, \bar{\tilde{X}}_{ij}, \ldots, \bar{\tilde{X}}_{iq}\right\}\right).$$

Let the Choquet Integral be, $(C)\int hdg = F$, and let F be the aggregated evaluation value after calculated. Repeat Steps 1 through 5 above to calculate the linguistic variable values (or assessment criteria) for each aspect.

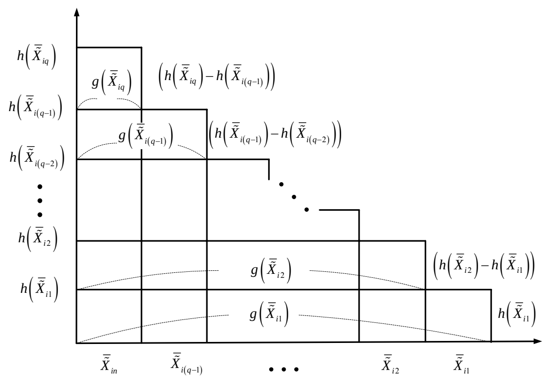

Figure 3 Illustration of the Choquet Integral, $(c)\int hdg$

Step 6：Calculating the Aggregated Evaluation Value

Steps 4 and 5 can also be used to calculate the linguistic variable values and the weighted values of each aspect. This X rearranges the alternative ranking order depending on the aggregated values calculated by the Choquet Integral.

This study uses the hierarchical Choquet Integral to select bio-tech firm's foreign entry mode procedures. Figure 4 depicts this approach.

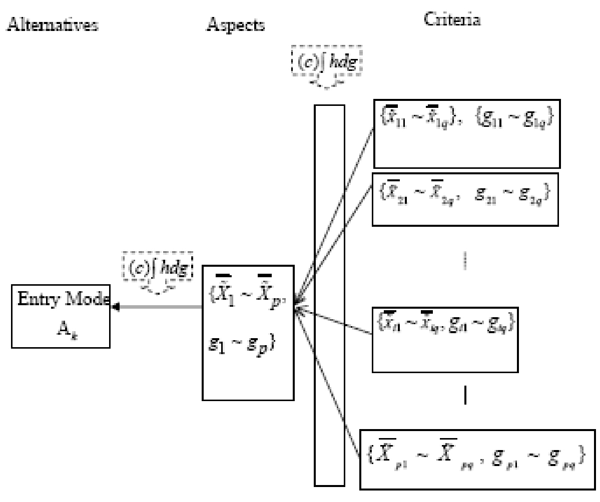

Figure 4 The Hierarchical Choquet Integral Process for Selecting Bio-tech Firm's Foreign Entry Mode

III. Case Implementation

3.1 Constructing the Hierarchical Selection of FI Entry Modes for Taiwanese Bio-tech Firms

This study uses the Delphi Technique, which includes a literature review. to screen and categorize the assessment criteria. Questionnaires were issued to specialists in bio-tech and related fields, and with name on Collection of Taiwan bio-tech Industry (2007). A total of 200 questionnaires were distributed and 155 valid samples were returned, for a valid questionnaire rate of 77.5%. These respondents included 41 expert decision-makers who actually have experience in making FI policy decisions, and 144 persons who have FI experience but did not make FI decisions. Results suggest that whether or not respondents have FI decision-making experience, they did not show a significant difference in recognition and importance of the 31 assessment criteria. At the same time, the results show that different X affect the selection of assessment criteria. Almost of possible principles should be involved, thus there is unnecessary to omit the criteria. The Kaiser-Meyer-Olkin's measure of adequacy based on the sampling size reached 0.892. This indicates that 31 assessment criteria are suitable for factor analysis (see Appendix II).

Based on these results, this study does not reduce any assessment criteria or preset any factor structure situations. The orthogonal rotation of principal axis factors was used to analyze factors, while oblique rotation revealed the relationship among all factors. Finally, this study selects the same components of variation and excludes the errors of measure effects from 31 assessment criteria to find and name the significant possibility of the six-divided-factor. This study also establishes factor structures for the assessment criteria. Based on the adjusted results of factor analysis from each assessment criteria, this study establishes the assessment hierarchy of FI entry modes for Taiwanese bio-tech firms as shown in

Figure 5.

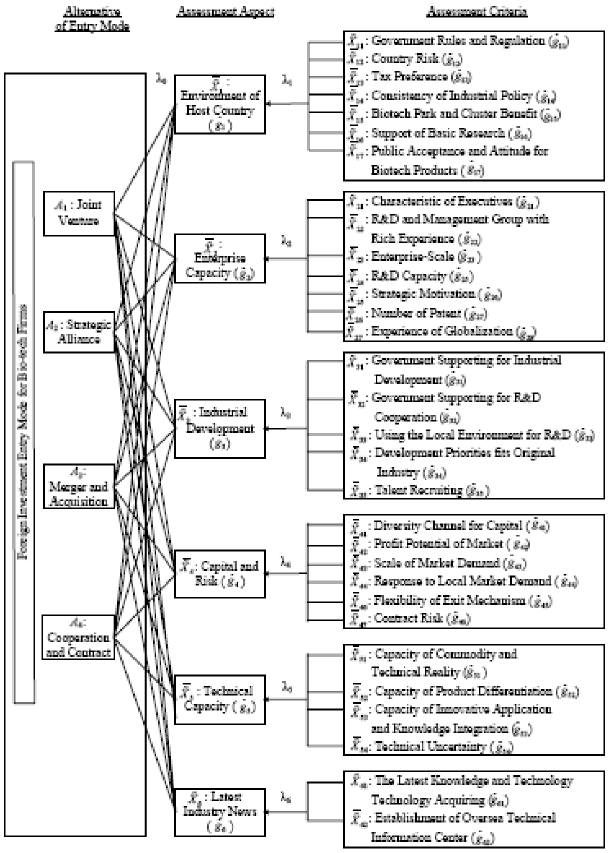

Figure 5 Hierarchical Evaluation Structure of Fuzzy Integral for FI Entry Modes for Taiwanese Bio-tech Firms

3.2 Evaluation of FI Entry Mode for Taiwanese Bio-tech Firms

Following Section 3.1, this study evaluates the importance and the effect of making the decision for four major FI entry modes of bio-tech firms based on each assessment aspect and criterion. Bio-tech industry investment experts filled out the questionnaire and its assessment scale from 1 to 5. This questionnaire was issued for 10 firms on the Collection of Taiwan Biotech Industry 2007. A total of 13 questionnaires were delivered, and 10 valid sample counts were recovered, for a valid questionnaire rate of 79.92%.

This study according to each expert who has experience in bio-tech fields, familiar with bio-tech industry, has influence of making decision and all respondents determine what they belong to the linguistic models to decide the triangular fuzzy numbers while they fill out the questionnaires (see Table 3).

Table 3 Linguistic Models for the Experts

	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Expert 7	Expert 8	Expert 9	Expert 10
Assessment Linguistic Model	LM_{C1}	LM_{C1}	LM_{C2}	LM_{C3}	LM_{C3}	LM_{C1}	LM_{C2}	LM_{C2}	LM_{C2}	LM_{C1}
Weight Linguistic Model	LM_{G1}	LM_{G1}	LM_{G3}	LM_{G4}	LM_{G4}	LM_{G1}	LM_{G2}	LM_{G3}	LM_{G3}	LM_{G1}

Under different alternatives, this study calculates the aggregated assessment values of criteria and weighted values of assessment criteria in each evaluative aspect for all expert decision-makers. The results of the "$\bar{\tilde{X}}_5$: Technical Competence" for the entry mode of "A_1: Joint Venture" are as follows:

$$\bar{\tilde{X}}_{51}=\left(\frac{1}{10}\right)\otimes\begin{pmatrix}(0.35,0.5,0.65)\oplus(0.2,0.3,0.4)\oplus(0.55,0.7,0.85)\\ \oplus(0.05,0.3,0.6)\oplus(0.05,0.3,0.6)\oplus(0.6,0.7,0.8)\\ \oplus(0.55,0.7,0.85)\oplus(0.7,1,1)\oplus(0.7,1,0.1)\oplus(0.6,0.7,0.8)\end{pmatrix}=(0.435,0.62,0.755)$$

,

$\bar{\tilde{X}}_{52}=(0.515,0.68,0.81)$; $\bar{\tilde{X}}_{53}=(0.395,0.57,0.73)$; $\bar{\tilde{X}}_{54}=(0.37,0.57,0.745)$;

$\bar{\tilde{g}}_{51}=(0.485,0.72,0.835)$; $\bar{\tilde{g}}_{52}=(0.485,0.71,0.86)$; $\bar{\tilde{g}}_{53}=(0.355,0.55,0.73)$; $\bar{\tilde{g}}_{54}=(0.385,0.57,0.73)$.

Using Eq. (7), the upper and lower limit of the mean linguistic variable values and fuzzy weights are calculated at $\alpha_i=0.5$.

$$\bar{\tilde{X}}_{51(\alpha=0.5)}=\begin{pmatrix}[0.62-0.5\times(0.62-0.5275)],\\ [0.62+0.5\times(0.755-0.62)]\end{pmatrix}=(0.57375,0.6875)$$,

$\bar{\tilde{g}}_{51(\alpha=0.5)}=(0.6025,0.7775)$; $\bar{\tilde{g}}_{52(\alpha=0.5)}=(0.5975,0.785)$; $\bar{\tilde{g}}_{5}$

$\bar{\tilde{g}}_{54(\alpha=0.5)}=(0.4775,0.65)$,

Defuzzify the fuzzy number of the assessment linguistic variable (or criterion) by Eq. (6) and calculate the crisp value of the fuzzy number, which combines the mean value of linguistic variable and fuzzy weighted number, at $\alpha_t = 0.5$.

$D\left(\bar{\tilde{X}}_{51}\right) = \frac{(0.6875-0)+(0.62-0)}{\left[(0.6875-0)+(0.62-0)\right]-\left[(0.62-1)+(0.57375-1)\right]} = 0.6053;\ D\left(\bar{\tilde{X}}_{52}\right) = 0.6636;$

$D\left(\bar{\tilde{X}}_{53}\right) = 0.5629;\ D\left(\bar{\tilde{X}}_{54}\right) = 0.5611;\ D\left(\bar{\tilde{g}}_{51}\right) = 0.6885;\ D\left(\bar{\tilde{g}}_{52}\right) = 0.6834;\ D\left(\bar{\tilde{g}}_{53}\right) = 0.5440;\ D\left(\bar{\tilde{g}}_{54}\right)$ $= 0.5616$.

Defuzzify the fuzzy weighted number to a crisp value, $D\left(\bar{\tilde{g}}_{ij}\right)_{(\alpha_t=0.5)} = \hat{g}_{ij}$, and then substitute it into Eq. (10). Calculate the λ value of the fuzzy measure using a GA computer program. That is,

$$\min_{\lambda}\ (1+0.6885\lambda)\times(1+0.6834\lambda)\times(1+0.5440\lambda)\times(1+0.5616\lambda)-(\lambda+1)$$

Subject to $-1 < \lambda < \infty$.

The related values of the "$\bar{\tilde{X}}_5$: Technical Competence" aspect based on the assessment criteria, $\lambda_5 = -0.4224$ were obtained after 54 iterative operations of GA. This study rearranges the defuzzied assessment value of each criterion in the following order:

$$D\left(\bar{\tilde{X}}_{54}\right)=0.5611<D\left(\bar{\tilde{X}}_{53}\right)=0.5629<D\left(\bar{\tilde{X}}_{51}\right)=0.6053<D\left(\bar{\tilde{X}}_{52}\right)=0.6636.$$

To obtain the fuzzy measure of weight, calculate the λ value and weighted crisp value, $D\left(\bar{\tilde{g}}_{5j}\right)$, which was defuzzied and normalized according to the Eq. (11):

$$\lambda+1=-0.4224+1=0.5776;\ \sum_{i=1}^{4} D\left(\bar{\tilde{g}}_{5j}\right) = 0.6885+0.6834+0.5440+0.5616$$

$$=2.4775;\ g_\lambda\left(\left\{\bar{\tilde{X}}_{51}\right\}\right) = \frac{(0.5776)^{\frac{0.6885}{2.4775}}-1}{0.5776-1} = 0.3349;\ g_\lambda\left(\left\{\bar{\tilde{X}}_{52}\right\}\right) = 0.3326;$$

$$g_\lambda\left(\left\{\bar{\tilde{X}}_{53}\right\}\right) = 0.2688;\ g_\lambda\left(\left\{\bar{\tilde{X}}_{54}\right\}\right) = 0.2769;\ g_\lambda\left(\left\{\bar{\tilde{X}}_{51}, \bar{\tilde{X}}_{52}\right\}\right) = \frac{(0.5776)^{\frac{0.6885+0.6834}{2.4775}}-1}{0.5776-1}$$

$$=0.6205;\ g_\lambda\left(\left\{\bar{\tilde{X}}_{51}, \bar{\tilde{X}}_{52}, \bar{\tilde{X}}_{53}\right\}\right) = 0.8188;\ g_\lambda\left(\left\{\bar{\tilde{X}}_{51}, \bar{\tilde{X}}_{52}, \bar{\tilde{X}}_{53}, \bar{\tilde{X}}_{54}\right\}\right) = 1.$$

Use Eq. (12) to calculate the Choquet Integral, $(C)\int hdg$, of the "$\bar{\tilde{X}}_5$: Technical Competence" aspect based on each assessment criteria contented in this aspect (see Table 4). The $(C)\int hdg$ of the "$\bar{\tilde{X}}_5$: Technical Competence" can also be a value (= 0.6083) for calculating the aggregated evaluation of "A_1 : Joint Venture Entry Mode" (see Table 4). Repeat the steps above to calculate each linguistic and weighted value for the four different entry modes.

Table 4 Aggregated Assessment Results of the "$\bar{\tilde{X}}_5$: Technical Competence" Aspect for The Alternative of "A_1 : Joint Venture" Entry Mode

Assessment Criteria	$h\left(\bar{X}_{ij}\right)$	$h\left(\bar{X}_{ij}\right)-h\left(\bar{X}_{i(j-1)}\right)$	$g_\lambda\left(\{\bar{X}_{ij}\}\right)$		$\left[h\left(\bar{X}_{ij}\right)-h\left(\bar{X}_{i(j-1)}\right)\right] g_\lambda\left(\{\bar{X}_{ij}\}\right)$	Ranking Order
$\bar{X}_{52}$	0.6636	0.0583	$g_\lambda\left(\{\bar{X}_{52}\}\right)$	0.3326	0.0194	3
$\bar{X}_{51}$	0.6053	0.0424	$g_\lambda\left(\{\bar{X}_{51}, \bar{X}_{52}\}\right)$	0.6205	0.0263	2
$\bar{X}_{53}$	0.5	0.0018	$g_\lambda\left(\{\bar{X}_{51}, \bar{X}_{52}, \bar{X}_{53}\}\right)$	0.8188	0.0015	4
$\bar{X}_{54}$	0.5611	0.5611	$g_\lambda\left(\{\bar{X}_{51}, \bar{X}_{52}, \bar{X}_{53}, \bar{X}_{54}\}\right)$	1	0.5611	1
				$(C)\int hdg =$	0.6083	

Tables A5.1 to A5.5 in Appendix V show the other aggregated assessment results of $h\left(X_{ij}\right)$, g_λ, and $(C)\int hdg$ for to each criterion and aspect for the four different kinds of entry modes. Tables 5, 6, and 7 show the ranking orders of each aggregated assessment criterion and aspect obtained from the four different kinds of entry modes. These values are reorganized according to each assessment criterion, aspect, and alternative. These results indicate the relative importance of each assessment criterion and aspect in making decisions under the four different kinds of entry modes. See Tables A5.1

to A5.5 in Appendix V and Tables 5 to 7.

IV. Conclusions

The results of this study show that different assessment criteria affect the decisions of Taiwanese bio-tech firms which plan to invest, or have already invested, in Mainland China. The following section summarizes some key points.

For "$\tilde{\bar{X}}_1$: Environment of Host Country," the "$\tilde{\bar{X}}_{13}$: Tax Preference" is a very important factor for choosing the models "A_1: Joint Venture," "A_2: Strategy Alliance," and "A_4: Acquisition and Merger." This shows that if there a country has a tax preference, it is a significant attraction for bio-tech firms investment. The "$\tilde{\bar{X}}_{17}$: Public Acceptance and Attitude for Bio-tech Products" factor is important in considering the models "A_3: Acquisition and Merger," and "A_4: Cooperative Contract." This result implies that if bio-tech products are accepted by local customers, they fill a niche market that in turn improves the cooperation with local manufacturers. The factors of "$\tilde{\bar{X}}_{12}$: Country Risk" and "$\tilde{\bar{X}}_{14}$: Consistency of Industry Policy" are of medium and equal importance. For this reason, we can presume that some countries that support the improvement of the bio-tech industry are almost developed or developing countries with a basic foundation in politics, economy, society, regulation, and conducting policy. Thus, this fact has medium importance bio-tech investment decisions. Other assessment criteria like "$\tilde{\bar{X}}_{11}$: Governmental Rules and Regulation," "$\tilde{\bar{X}}_{15}$: Bio-tech Park and Cluster Benefit" and "$\tilde{\bar{X}}_{16}$: Support of Basic Research" create different effects depending on the kind of entry mode selected, and have inconsistent importance for decision making.

Based on seven assessment criteria, the "$\tilde{\bar{X}}_2$: Enterprise Competence" factor exhibits significant differences depending on the kind of entry mode selected. For "A_1: Joint Venture," the following factors are ranked in terms of importance: "$\tilde{\bar{X}}_{23}$: Enterprise-Scale," "$\tilde{\bar{X}}_{21}$: Characteristics of Executive Manger," "$\tilde{\bar{X}}_{26}$: Number of Patent," "$\tilde{\bar{X}}_{24}$: R&D Competence," "$\tilde{\bar{X}}_{22}$: R&D Management Groups with Rich Experience," and "$\tilde{\bar{X}}_{25}$: Strategic Motivation." This shows that a bio-tech firm have competence in the input resource if they want to obtain more holdings; in general, large-scale firms are usually competent enough to support R&D activities with long-term and high cost investment. The factors "$\tilde{\bar{X}}_{21}$: Characteristics of Executive" and "$\tilde{\bar{X}}_{22}$: R&D Management Groups with Rich Experience" can help a company cooperate with partners in "A_1: joint venture." Patents are an important factor in the success of bio-tech products. If the bio-tech firm develops or obtains patents, it increases their willingness to cooperate with partners. For "A_2: Strategic Alliance," the factors "$\tilde{\bar{X}}_{26}$: Number of Patents" and "$\tilde{\bar{X}}_{24}$: R&D Competence" are most important for decision making. Currently, bio-tech firms have difficulty acquiring patents quickly due to the strict regulations established by many countries. Therefore, if a bio-tech firm can form a strategic alliance with manufacturers in the host country, it will help that company acquire patent and R&D competence quickly. For " A_3: Acquisition and Merger," the factors " $\tilde{\bar{X}}_{24}$: R&D Competence," " $\tilde{\bar{X}}_{21}$: Characteristics of Executive Manger" and " $\tilde{\bar{X}}_{22}$: R&D Management Group with Rich Experience" are for the most important to policy-making. As a rule, a business will experience some reorganization after conducting " A_3: Acquisition and Merger." This highlights the necessity of competence in leadership, team management, and executives. For " A_4 : Cooperative Contract," policy consideration is primarily based on the factors " $\tilde{\bar{X}}_{23}$: Enterprise-Scale," " $\tilde{\bar{X}}_{26}$: Number of Patent" and " $\tilde{\bar{X}}_{25}$: Strategic Motivation." For medium and small scale bio-tech firms, the main reason to conduct foreign investment is based on a consideration of overall strategies, including acquiring the foreign market, developing the R&D technology, building a base for future development, or attacking global competitors to obtain an overall competitive advantage. Consequently, a cooperative contract is a good way for bio-tech firms to reduce the risk of entering a host market.

For " $\tilde{\bar{X}}_3$: Industrial Development," each assessment criterion has a significantly different effect on decision-making; however under different modes. In general, however, the factor " $\tilde{\bar{X}}_{32}$: Development Priorities Fits Original Industrial" is a vital consideration in the modes of " A_2 : Strategic Alliance and " A_3: Acquisition and Merger." The factor " $\tilde{\bar{X}}_{34}$: Using the Local Environment for R&D" is also very important in all four entry modes when a company makes consideration for its policy. Therefore, each country should follow a clear direction in developing their bio-technology industry, and must plan a complete infrastructure including water and electricity, medical treatment, education, and transportation to achieve better quality of life and advanced R&D facilities. In addition, the " $\tilde{\bar{X}}_{31}$: Government Supporting for R&D Cooperation" and " $\tilde{\bar{X}}_{33}$: Government Supporting for Industrial Development" factors do not have a significant influence on decision-making processes since many countries have high respect to this industry in present. Thus, many enterprises will disregard these factors when selecting their entry modes.

For " $\tilde{\bar{X}}_4$: Capital and Risk," the factor " $\tilde{\bar{X}}_{41}$: Diversity Channel for Capital" has the most significant influence on the models " A_1 : Joint Venture," " A_2 : Strategic Alliance" and " A_4 : Cooperative Contract." These results indicate that a company that selects the entry mode with no or minimal holdings is more likely to consider using capital. Hence, a country can attract the investment of many bio-tech enterprises by establishing a complete financial system and capital market that makes it easy for bio-tech firms to obtain long-term capital from diversity number of different channels. The results of this research also show that " $\tilde{\bar{X}}_{41}$: Diversity Channel of Capital" has the lowest influence on the mode " A_3 : Acquisition and Merger" but the " $\tilde{\bar{X}}_{45}$: Flexibility of

Exit Mechanism" factor has the greatest influence. These results show that an investment model with high holdings must input much more capital than usual, and a strong capital foundation is necessary. Therefore, " $\tilde{\bar{X}}_{45}$: Flexibility of Exit Mechanism" and quick returns on capital are vital in this situation.

For " $\tilde{\bar{X}}_{5}$: Technical Competence," the factors " $\tilde{\bar{X}}_{54}$: Technical Uncertainty," " $\tilde{\bar{X}}_{51}$: Competence of Technical and Commodity Reality" and " $\tilde{\bar{X}}_{52}$: Competence of Product Differentiation" have high and consistent importance in the four kinds of entry modes. For this reason, regardless of which model is selected, a bio-tech firm can earn high profits by acquiring stable technology and competence in X.

For " $\tilde{\bar{X}}_{6}$: Latest Industry News," there has consistent idea between the criteria of " $\tilde{\bar{X}}_{62}$: Establishment of Overseas Technical Information Center" and " $\tilde{\bar{X}}_{61}$: The Advanced Knowledge and Technology Acquiring" when a company selects its preferred entry mode. Although knowledge acquisition has become easier in the information era, each country has their priority development for bio-tech industry and have more protection and management for the technology and resource they have. Therefore, it is crucial that the host country collect information to encourage a company to conduct foreign investment.

For the assessment aspects in Table 6, different entry modes create different priorities. For " A_1 : Joint Venture," the factors " $\tilde{\bar{X}}_{6}$: Latest Industry News," " $\tilde{\bar{X}}_{5}$: Technical Competence" and " $\tilde{\bar{X}}_{2}$: Enterprise Competence" are the most important. These results show that the industrial knowledge, technology, and operation ability are vital to bio-tech firms conducting foreign investment with the host country partners. For " A_2 : Strategic Alliance," of the most important factors are " $\tilde{\bar{X}}_{3}$: Industrial Development," " $\tilde{\bar{X}}_{1}$: Environment of Host Country," and " $\tilde{\bar{X}}_{2}$: Enterprise Competence." Currently, many developed countries have already developed their bio-tech industries, environment, and infrastructure. Therefore, the " A_1 : Joint Venture" is a good way to rapidly develop a technology or product. The consideration of " A_3 : Acquisition and Merger" focuses on the aspects of " $\tilde{\bar{X}}_{5}$: Technical Competence," " $\tilde{\bar{X}}_{4}$: Capital and Risk" and " $\tilde{\bar{X}}_{1}$: Environment of Host Country.". This shows that although technical competence can be an assurance of making high profits in the future, the risk of politics, society, regulation, and operation are higher than previously thought. Consequently, a bio-tech firm conducting foreign investment must face many risks, thus only making the well risk prevention, solution and avoidance can declined the influence of investment risk. This study shows that the " A_4 : Cooperative Contract" focuses on the aspects of " $\tilde{\bar{X}}_{2}$: Enterprise Competence," " $\tilde{\bar{X}}_{5}$: Technical Competence" and " $\tilde{\bar{X}}_{6}$: Latest Industry News." These results show that a bio-tech firm must carefully consider its partner's abilities and competency, as well as of its level of contract control. Bio-tech firms should cooperate with local partners to enhance their overall competitive abilities with complementing resources or cooperating with each other.

Finally, this study conducts an order ranking of all assessment values for the four kinds of entry modes (see Table 7) The results indicate that the appropriate order of entry modes for Taiwanese bio-tech firms who want to invest in the Chinese market is "A_3: Acquisition and Merger," "A_2: Strategic Alliance," "A_1: Joint Venture" and "A_4: Cooperative Contract." This also indicates that Taiwanese bio-tech firms prefer the entry mode with high holdings. This prediction is consistent with actual the development modes of some foreign bio-tech companies, who usually adopt "A_3: Acquisition and Merger" or "A_2: Strategic Alliance" (see Table A1 in Appendix I).

For "A_3: Acquisition and Merger," there are still some problems that must be solved in the Chinese market despite the fact that the Chinese bio-tech industry is gradually catching up with more advanced countries. For example, the vertical stream can not be effectively integrated, fakes flooding, serious repeat of R&D and many small-scale companies has mushroomed all over the market but with less competition. Therefore, if a company wants to get ahead in the market and effectively integrate its production, selling, and R&D and expand its influence in the market, acquiring and merging with local bio-tech firms is actually viable option. However, the entry mode of "A_3: Acquisition and Merger" is not a commonly-used method in the Chinese market. This is because regulations are not complete, the market system is not mature enough, and a comprehensive capital market is not yet fully formed. For these reasons, the optimal approach for Taiwanese bio-tech firms is to select the entry mode with high holdings. The reason why the mode "A_1: Joint Venture" and "A_4: Cooperative Contract" is not very important is easy to determine. Despite the fact that Chinese investment regulations the "A_1: Joint Venture" must be the Sino-foreign type, endless financial disputes still arise from many Taiwanese investment cases. In addition, Chinese partners often intentionally deceive the firm, mis-appropriate funds or escape with cash, quarrel with the local government, and share profit unequally. These and other industrial disputes are problems which are difficult to solve immediately. Therefore, only carefully choosing the cooperative partner or joint objective can bio-tech firms reduce their risk of investment.

Table 5 Assessment Criteria Ranking Under Four Different Kinds of Entry Modes

Assessment Aspect	Assessment Criteria	A_1: Joint Venture	A_2: Strategic Alliance	A_3: Acquisition and Merger	A_4: Cooperation Contract
		Ranking Order	Ranking Order	Ranking Order	Ranking Order
$\bar{\tilde{X}}_1$: Environment of Host Country	$\bar{\tilde{X}}_{11}$: Governmental Rules and Regulations	7	4	6	3
	$\bar{\tilde{X}}_{12}$: Country Risk	5	5	5	4
	$\bar{\tilde{X}}_{13}$: Tax Preference	2	2	4	2
	$\bar{\tilde{X}}_{14}$: Consistency of Industrial Policy	4	3	3	5
	$\bar{\tilde{X}}_{15}$: Bio-tech Park and Cluster Benefit	6	1	2	7
	$\bar{\tilde{X}}_{16}$: Support of Basic Research	1	6	7	6
	$\bar{\tilde{X}}_{17}$: Public Attitude and Acceptance for Bio-tech Products	3	7	1	1
$\bar{\tilde{X}}_2$: Enterprise Competence	$\bar{\tilde{X}}_{21}$: Characteristics of Executive Manager	2	5	2	6
	$\bar{\tilde{X}}_{22}$: R&D and Management Groups with Rich Experience	5	7	3	5
	$\bar{\tilde{X}}_{23}$: Enterprise Scale	1	3	6	1
	$\bar{\tilde{X}}_{24}$: R&D Competence	4	2	1	7
	$\bar{\tilde{X}}_{25}$: Strategic Motivation	6	6	4	3
	$\bar{\tilde{X}}_{26}$: Number of Patent	3	1	5	2
	$\bar{\tilde{X}}_{27}$: Experience of Globalization	7	4	7	4
$\bar{\tilde{X}}_3$: Industrial Development	$\bar{\tilde{X}}_{31}$: Government Supporting for R&D Cooperation	5	3	4	3
	$\bar{\tilde{X}}_{32}$: Development Priorities Fits Original Industry	4	1	1	4
	$\bar{\tilde{X}}_{33}$: Government Supporting for Industrial Development	3	4	2	5
	$\bar{\tilde{X}}_{34}$: Using the Local Environment for R&D	1	2	3	2
	$\bar{\tilde{X}}_{35}$: Talent Recruiting	2	5	5	1
$\bar{\tilde{X}}_4$: Capital and Risk	$\bar{\tilde{X}}_{41}$: Diversity Channel for Capital	1	1	6	1
	$\bar{\tilde{X}}_{42}$: Potential Profit of Market	2	5	3	5
	$\bar{\tilde{X}}_{45}$: Scale of Market Demand	3	2	2	4
	$\bar{\tilde{X}}_{44}$: Response to Local Market Demand	6	3	4	6
	$\bar{\tilde{X}}_{45}$: Flexibility of Exit Mechanism	5	4	1	2
	$\bar{\tilde{X}}_{46}$: Contract Risk	4	6	5	3
$\bar{\tilde{X}}_5$: Technical Competence	$\bar{\tilde{X}}_{51}$: Competence of Technical and Commodity Reality	2	2	2	2
	$\bar{\tilde{X}}_{52}$: Competence of Product Differentiation	3	3	4	3
	$\bar{\tilde{X}}_{53}$: Competence of Innovative Application and Knowledge Integration	4	1	3	4
	$\bar{\tilde{X}}_{54}$: Technical Uncertainty	1	4	1	1
X_6 : Latest Industry News	$\bar{\tilde{X}}_{61}$: The Advanced Knowledge and Technology Acquiring	2	2	2	2

	$\tilde{\bar{X}}_{62}$: Establishment of Overseas Technical Information Center	1	1	1	1

Table 6 Assessment Aspect Ranking Under Different Kinds of Entry Modes

Assessment Aspect	A_1 : Joint Venture	A_2 : Strategic Alliance	A_3 : Acquisition and Merger	A_4 : Cooperation Contract
	Ranking Order	Ranking Order	Ranking Order	Ranking Order
$\tilde{\bar{X}}_1$: Environment of Host Country	5	2	3	6
$\tilde{\bar{X}}_2$: Enterprise Competence	3	3	5	1
$\tilde{\bar{X}}_3$: Industrial Development	6	1	6	5
$\tilde{\bar{X}}_4$: Capital & Risk	4	4	2	4
$\tilde{\bar{X}}_5$: Technical Competence	2	5	1	2
$\tilde{\bar{X}}_6$: Latest Industry News	1	6	4	3

Table 7 Summary of $h(X_{ij})$, g_λ, and $(C)\int hdg$ for Assessment Criteria Ranking Under Four Different Kinds of Entry Modes

Altern-ative	Aspect	$h(X_{ij})$	g_{ij}	g_λ		$(C)\int hdg$ (λ Value)	Ranking Order
A_1	$\tilde{\bar{X}}_1$	0.6697	0.6572	$\{X_1\}$	0.2014	0.6279 (-0.3666)	**3**
	$\tilde{\bar{X}}_1$	0.6449	0.7471	$\{X_1, X_4\}$	0.4124		
	$\tilde{\bar{X}}_3$	0.6307	0.5964	$\{X_1, X_3, X_4\}$	0.5681		
	$\tilde{\bar{X}}_2$	0.6275	0.6209	$\{X_1, X_2, X_3, X_4\}$	0.7192		
	$\tilde{\bar{X}}_5$	0.6083	0.7286	$\{X_1, X_2, X_3, X_4, X_5\}$	0.8829		
	$\tilde{\bar{X}}_6$	0.5493	0.5615	$\{X_1, X_2, X_3, X_4, X_5, X_6\}$	1.0000		
A_2	$\tilde{\bar{X}}_4$	0.7178	0.8424	$\{X_4\}$	0.2372	0.6464 (-0.3566)	**2**
	$\tilde{\bar{X}}_5$	0.6577	0.7526	$\{X_4, X_5\}$	0.4321		
	$\tilde{\bar{X}}_2$	0.6445	0.6991	$\{X_2, X_4, X_5\}$	0.5999		
	$\tilde{\bar{X}}_1$	0.6191	0.6547	$\{X_1, X_2, X_4, X_5\}$	0.7462		
	$\tilde{\bar{X}}_6$	0.5893	0.6313	$\{X_1, X_2, X_4, X_5, X_6\}$	0.8781		
	$\tilde{\bar{X}}_3$	0.5862	0.6230	$\{X_1, X_2, X_3, X_4, X_5, X_6\}$	1.0000		
A_3	$\tilde{\bar{X}}_1$	0.7376	0.7667	$\{X_1\}$	0.2054	0.6838 (-0.3490)	**1**
	$\tilde{\bar{X}}_4$	0.7178	0.7596	$\{X_1, X_4\}$	0.3944		
	$\tilde{\bar{X}}_3$	0.6578	0.7245	$\{X_1, X_3, X_4\}$	0.5621		
	$\tilde{\bar{X}}_6$	0.6571	0.6663	$\{X_1, X_3, X_4, X_6\}$	0.7063		
	$\tilde{\bar{X}}_2$	0.6530	0.7900	$\{X_1, X_2, X_3, X_4, X_6\}$	0.8656		

Altern-ative	Aspect	$h\left(X_{ij}\right)$	g_{ij}	g_{λ}		$(C)\int hdg$ (λ Value)	Ranking Order
	$\bar{\bar{\tilde{X}}}_5$	0.6516	0.7169	$\{X_1, X_2, X_3, X_4, X_5, X_6\}$	1.0000		
A_4	$\bar{\bar{\tilde{X}}}_4$	0.6559	0.6181	$\{X_4\}$	0.2061	0.6186 (-0.3765)	4
	$\bar{\bar{\tilde{X}}}_1$	0.6342	0.6250	$\{X_1, X_4\}$	0.3983		
	$\bar{\bar{\tilde{X}}}_5$	0.6260	0.6280	$\{X_1, X_4, X_5\}$	0.5762		
	$\bar{\bar{\tilde{X}}}_6$	0.5986	0.6112	$\{X_1, X_4, X_5, X_6\}$	0.7359		
	$\bar{\bar{\tilde{X}}}_3$	0.5876	0.5426	$\{X_1, X_3, X_4, X_5, X_6\}$	0.8673		
	$\bar{\bar{\tilde{X}}}_2$	0.5833	0.5896	$\{X_1, X_2, X_3, X_4, X_5, X_6\}$	1.0000		

Note： A_1 represents "Joint Venture"; A_2 represents "Strategic Alliance"; A_3 represents "Acquisition and Merger" ; and A_4 represents "Cooperation Contract"

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Appendix I

Table A1 Important Case of Acquisition and Merger or Strategic Alliance for International Leading Manufacturers

Manufacturer	Important Case of Acquisition and Merger or Strategic Alliance
Badische Anilin- and Soda-Fabrik （BASF）（German）	● Technology authorizing a Crop Design bio-tech firm in Belgium to improve the production of genetically modified crops and reform its ability to endure droughts. ● Acquiring the Orgamol chemical company of Switzerland to enhance product diversity and increase market competitiveness. Acquiring and merging with U.S. Mine Safety Appliances to add sales items and services of non-organization chemical composition for BASF.
DuPont（U.S.）	● Conducting a joint venture with Tate and Lyle in the U.K., a manufacturer of renewable food and industrial ingredients, to build a factory and up the production of biological material commodities. ● Cooperating with Syngenta agribusiness in Switzerland to establish the branch company Leaf Genetic with 50% holdings, exchange each other's agri-products, seed property, and relative technology.
Roche (Switzerland）	● Obtaining the non-exclusive authorization for the Alnylam technical platform from Alnylam Pharmaceuticals and developing the RNAi method. ● Cooperating and interacting with Genentech to discover new drugs. ● Making a strategic alliance with Affymetrix to obtain technology on microchip diagnostic. ● Acquiring and merging with Disetronic to expand its service items from diabetic care to insulin injection products.
Abbott Laboratories (U.S.）	● Acquiring the Guidant firm's endovascular intervention business of Vascular Intervention (VI) and Endovascular Solution (ES), which allows the rapidly-growing Vascular department in Abbott Laboratories to obtain more complete product lines and advanced technology in the market of solving pathological changes in blood vessels. ● Cooperating with Celera Diagnostics to obtain the related genetic technology to expand the product lines of molecule examination products. ● Acquiring MediSense and entering the fast-growing market of self monitoring blood glucose products.
Bayer（German）	● Acquiring Visible Genetics and enlarging the product line of molecule examination products, including the examination of virus genetic type. ● Acquiring and merging with Oncogene Science Diagnostics and to obtain the material technology for plasma identification of breast cancer. ● Obtaining authorization from Sontra Medical and gaining the technology of non-invasive blood glucose monitoring.
BD（German）	● Making a strategic alliance with Medtronic MiniMed and Eli Lill to build marketing channels and enter the market of blood glucose monitoring.
BioMérieux （French）	● Acquiring and merging with Organon Teknika to cross over from the market of molecule examination products to blood coagulation.
Johnson and Johnson （J & J LifeScan） （U. S.）	● Acquiring and merging with Inverness Medical to beomce the leading brand in the market of blood glucose monitoring.

Appendix II

Table A.2 The Definition of Influential Factors (or Assessment Criteria) of Foreign Investment and Their Related Literatures

Influential Factors (or Assessment Criteria)	Definition and Related Literature
1. Strategic Motivation (X_{25})	The main reasons for a business to conduct foreign investment are based on its consideration of overall strategies, including entering a foreign market, developing R&D technology, building a base for future global development, or obtaining a competitive advantage in advance (Kim and Hwang, 1992; Appiah-Adu and Ranchhod, 1998; Pearce and Papanastassiou, 1996; Shan and Song, 1997).
2. R&D and Management Groups with Rich Experience (X_{22})	A team of R&D and management personnel with extensive experience in overseas investing, operations, and R&D technology for a business (Lee et al., 2007, Hu et al, 2005).
3. Characteristics of Executive Manager (X_{21})	An executive manager with a positive and active attitude toward the company conducting the foreign investment (Dalton and Serapio, 1999; Tsai and Erickson, 2006).
4. Number of Patent (X_{26})	The number of patents that create profits for a bio-tech firm (Deeds et al., 1997; Shan and Song, 1997).
5. R&D Competence (X_{24})	The degree to which a company possesses technology, knowledge, or experience for developing bio-tech products or technology platforms (Cho and Yu, 2000).
6. Enterprise Scale (X_{23})	The enterprise scale depends on the comparison with main competitor in host country (Ekeledo and Sivakumar, 2004; Coombs et al., 2006).
7. Experience of Globalization (X_{27})	The degree of familiarity with the customs and business behaviors of the host country, or the use of professional technology and bio-tech awareness (Gomes-Casseres , 1989; Agarwal and Ramaswami, 1992; Shih, 2006).
8. Government Supporting for R&D Cooperation (X_{31})	The degree of government support for R&D cooperation with domestic and overseas businesses, academic or research institutions in the host country (Agarwal and Ramaswami, 1992; Kim and Hwang, 1992; Cho and Yu, 2000).
9. Development Priorities Fits Original Industry (X_{32})	The development priorities and product portfolios in the host country fit the investment purposes of original industry (Richards and DeCarolis, 2003).
10. Government Supporting for Industrial Development (X_{33})	The host country has a positive attitude toward, and all-out support for, bio-tech industry development (Dalton and Serapio, 1999; Yiu and Makino, 2002; Shenkar and Luo, 2004).
11. Talent Recruiting (X_{35})	The high quality of education system in the host country can improve the opportunity to recruit or make great integration for professional talent with R&D or management competence (Dalton and Serapio, 1999).
12. Using the Local Environment for R&D (X_{34})	The host country possesses complete infrastructures, such as water and electricity, medical treatment, education, transportation, etc, excellent quality of life, and advanced R&D facilities (Dalton and Serapio, 1999).
13. The Advanced Knowledge and Technology Acquiring (X_{61})	The host country possesses advanced knowledge and technology in the bio-tech industry (Dalton and Serapio,

	1999).
14. Establishment of Overseas Technical Information Center (X_{62})	X can make a company easily pursue technology development by establishing an overseas technical information center (Dalton and Serapio, 1999).
15. Bio-tech Park and Cluster Benefit (X_{15})	A bio-tech park uses business, academic, and research institutions to provide and obtain professionalized services. Examples include bio-tech service businesses, accountants, lawyers, and supporting services. This cluster benefit gathers professionals from various fields to combine relevant industry information (Deeds et al., 2000; Rosenfeld, 1996).
16. Country Risk (X_{12})	The degree of political, economic, and social stability in the host country (Richards and DeCarolis, 2003; Agarwal and Ramaswami, 1992; Kim and Hwang, 1992; Cho and Yu, 2000).
17. Governmental Rules and Regulations (X_{11})	Governmental rules and regulations on import and export control, work and resident visas, and patent and trademark policies in the host country (Dalton and Serapio, 1999; Davis et al., 2000; Yiu and Makino, 2002; Shenkar and Luo, 2004).
18. Tax Preference (X_{13})	The rewards and rules benefiting a business that invests in the host country, such as free import row material, tax burden deduction, deferred tax, tax holiday, or government compensations (Dalton and Serapio, 1999; Yiu and Makino, 2002; Shenkar and Luo, 2004；Brouthers, 2002; Meyer, 2001; Shih, 2006; Czinkota and Ronkainen, 2002).
19. Consistency of Industrial Policy (X_{14})	The host government has a consistent and stable industrial policy for the bio-tech industry (Agarwal and Ramaswami, 1992; Kim and Hwang, 1992; Cho and Yu, 2000).
20. Support of Basic Research (X_{16})	The level of basic research provided by the host government in support of high risk and long-term bio-tech industry development (Dalton and Serapio, 1999; Yiu and Makino, 2002; Shenkar and Luo, 2004).
21. Scale of Market Demand (X_{43})	The market demand for bio-tech products in host country market (Agarwal and Ramaswami, 1992; Kim and Hwang, 1992; Cho and Yu, 2000).
22. Potential Profit of Market (X_{42})	The host country is competent in maintaining the long-term development of market scale and profit growth; Potential for a business (Agarwal and Ramaswami, 1992; Robertson and Gatignon, 1998; Czinkota and Ronkainen, 2002).
23. Public Attitude and Acceptance for Bio-tech Products (X_{17})	Public attitude and acceptance for bio-tech products in the host country (Allansdottir, et al., 2002).
24. Response to Local Market Demand (X_{44})	Directly contact the local market, understand consumer needs, improve product quality, and offer good sales service (Dalton and Serapio, 1999).
25. Diversity Channel for Capital (X_{41})	A bio-tech firm can obtain sufficient long-term operational capital from diverse channels, including initial public offerings (IPOs), venture capital (VC), or cash flow from selling the product (Greetham, 1998; Stuart and Sorenson, 2003; Folta et al., 2006; Stuart, Hoang and Hybels, 1999).
26. Flexibility of Exit Mechanism (X_{45})	The host country has a complete financial system and capital market to assist the exit mechanism flexibility for a company (Stuart and Sorenson, 2003; Folta et al, 2006).
27. Contract Risk (X_{46})	The potential cost of searching for a new partner, researching rules, negotiation, and trade conducting, or the professional technology and know-how diffusion caused by cooperation, or less control of the quality and quantity of

	products and services (Hill, 1990; Agarwal and Ramaswami, 1992; Kim and Hwang, 1992).
28. Technical Uncertainty (X_{54})	The know-how or technology spillover caused by cooperating with suppliers or other organizations (Cho and Yu, 2000; Pisano, 1990; Robertson and Gatignon, 1998).
29. Competence of Product Differentiation (X_{52})	A company with competency in delivering products that are different, finishing prototype experiments, and legal selling in advanced (Deeds and Hill, 1996; Deeds et al., 1998; Hall and Bagchi-Sen, 2002; Greetham, 1998).
30. Competence of Technical and Commodity Reality (X_{51})	A business with competency in technical reality and product packaging, channel developing, and advertisting (Hu et al., 2005).
31. Competence of Innovative Application and Knowledge Integration (X_{53})	A business with competency in integrating technology and knowledge across fields can use this advantage to innovative application (Lee, et al., 2007).

Appendix III　Linguistic Models

1. Linguistic Model for for the Grade of Importance of Foreign Investment Influence Factor (or Criteria)

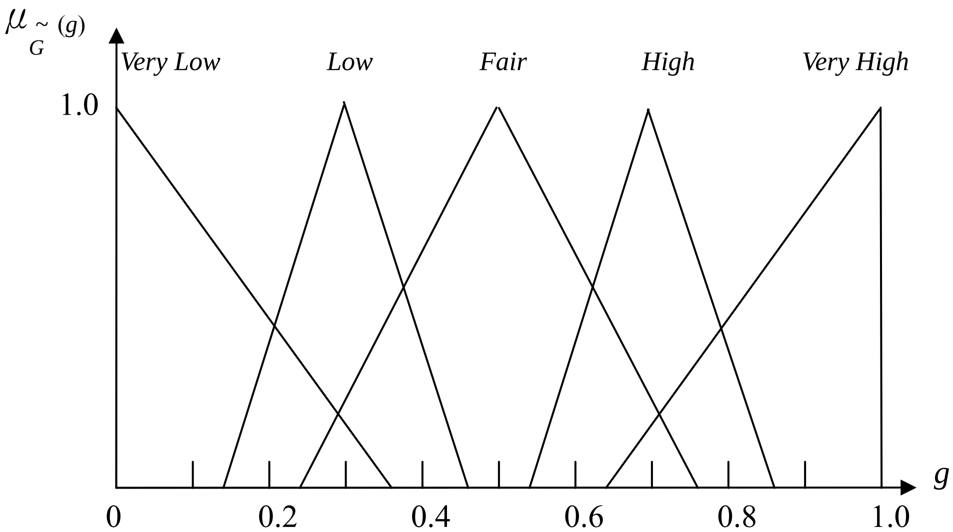

Figure A3.1 Linguistic Model, LMG3, for the Grade of Importance of Foreign Investment Influence Factor (or Criteria)

Table A3.1 Five Possible Fuzzy Ratings and Meanings for Model LMG3

Verbal Expression	Membership Function
Very Low	$\mu_{Very\ \ Low}(g)=\begin{cases}0; & g\le 0,\\ (0.35-g)/0.35; & 0\le g\le 0.35,\\ 0; & g\ge 0.35.\end{cases}$
Low	$\mu_{Low}(g)=\begin{cases}0; & g\le 0.15,\\ (g-0.15/0.15; & 0.15\le g\le 0.3,\\ (0.45-g)/0.15; & 0.3\le g\le 0.45,\\ 0; & g\ge 0.45.\end{cases}$
Fair	$\mu_{Fair}(g)=\begin{cases}0; & g\le 0.25,\\ (g-0.25/0.25; & 0.25\le g\le 0.5,\\ (0.75-g)/0.25; & 0.5\le g\le 0.75,\\ 0; & g\ge 0.75.\end{cases}$
High	$\mu_{High}(g)=\begin{cases}0; & g\le 0.55,\\ (g-0.55/0.15; & 0.55\le g\le 0.7,\\ (0.85-g)/0.15; & 0.7\le g\le 0.85,\\ 0; & g\ge 0.85.\end{cases}$
Very High	$\mu_{Very\ \ High}(g)=\begin{cases}0; & g\le 0.65,\\ (g-0.65/0.35; & 0.65\le g\le 1.0,\\ 1; & g=1.0.\end{cases}$

2. Linguistic Model for the Effectiveness of Foreign Investment Influence Factor (or Criteria)

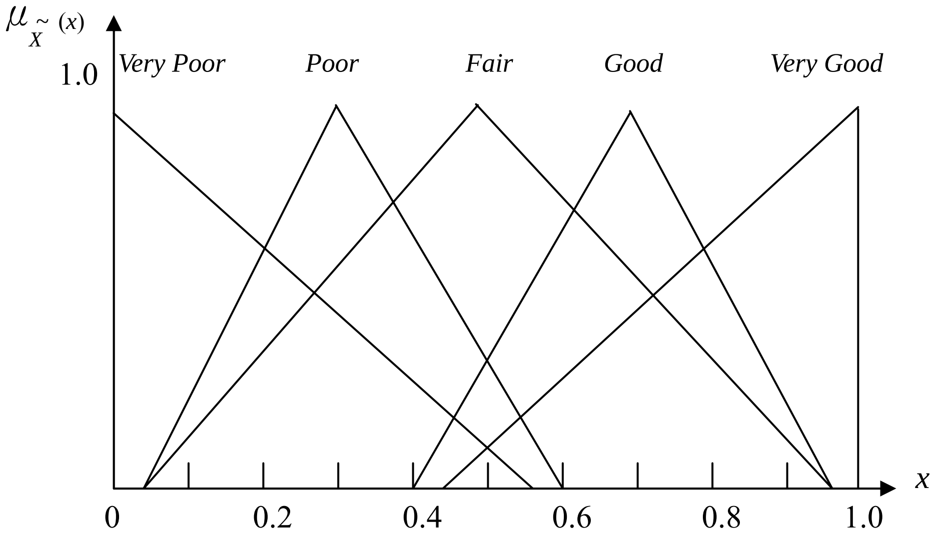

Figure A3.2 Linguistic Model, LMC3, for the Effectiveness of Foreign Investment Influence Factor (or Criteria)

Table A3.2 Five Possible Fuzzy Ratings and Meanings for Model LMC3

Verbal Expression	**Membership Function**
Very Poor	$\mu_{Very\ \ Poor}(x) = \begin{cases} 0; & x \le 0, \\ (0.55 - x)/0.55; & 0 \le x \le 0.55, \\ 0; & x \ge 0.55. \end{cases}$
Poor	$\mu_{Poor}(x) = \begin{cases} 0; & x \le 0.05, \\ (x - 0.05/0.25; & 0.05 \le x \le 0.3, \\ (0.6 - x)/0.3; & 0.3 \le x \le 0.6, \\ 0; & x \ge 0.6. \end{cases}$
Fair	$\mu_{Fair}(x) = \begin{cases} 0; & x \le 0.05, \\ (x - 0.5/0.45; & 0.05 \le x \le 0.5, \\ (0.95 - x)/0.45; & 0.5 \le x \le 0.95, \\ 0; & x \ge 0.95. \end{cases}$
Good	$\mu_{Good}(x) = \begin{cases} 0; & x \le 0.6, \\ (x - 0.4/0.3; & 0.4 \le x \le 0.7, \\ (0.95 - x)/0.25; & 0.7 \le x \le 0.95, \\ 0; & x \ge 0.95. \end{cases}$
Very Good	$\mu_{Very\ \ Good}(x) = \begin{cases} 0; & x \le 0.45, \\ (x - 0.45/0.55; & 0.45 \le x \le 1.0, \\ 1; & x = 1.0. \end{cases}$

Appendix IV

The following procedure is an example of how to determine the left and right spreads of the L-R fuzzy number at the -level. Other fuzzy numbers can use similar procedures to determine their left and right spreads (Chen, 1994).

Suppose an L-R fuzzy number is defined as:

$\forall x \in R:$

$$\mu_{\tilde{X}}(x) = \begin{cases} 0, & a_{\tilde{X}} \le 0, \\ F_L[(m_{\tilde{X}} - x)/(m_{\tilde{X}} - a_{\tilde{X}})], & a_{\tilde{X}} \le x \le m_{\tilde{X}}, \\ F_R[(x - m_{\tilde{X}})/(b_{\tilde{X}} - m_{\tilde{X}})], & m_{\tilde{X}} \le x \le b_{\tilde{X}}, \\ 0, & x \ge b_{\tilde{X}}. \end{cases} \quad \text{(A4.1)}$$

with scales $m_{\tilde{X}} - a_{\tilde{X}} > 0$, $b_{\tilde{X}} - m_{\tilde{X}} > 0$. The height of $\tilde{X}$ at $m_{\tilde{X}}$ in the x-axis is a real number, and $a_{\tilde{X}}$, $b_{\tilde{X}}$ are called the left and right spreads at the -level (. = 0), respectively. Figure A4.1 shows the fuzzy number of Eq. (A4.1) and its left and right spreads at an arbitrary ˜ level.

In Fig. A4.1, an arbitrary ˜ level of FL can be written as

$$F_L\left(\frac{m_{\tilde{X}} - x}{m_{\tilde{X}} - a_{\tilde{X}}}\right) = \alpha, \quad \alpha \in [0, \ 1]. \quad \text{(A4.2)}$$

Taking the inverse of this function leads to

$$\frac{m_{\tilde{X}} - x}{m_{\tilde{X}} - a_{\tilde{X}}} = F_L^{-1}(\alpha),$$

$$\text{or} \quad x = m_{\tilde{X}} - F_L^{-1}(\alpha)(m_{\tilde{X}} - a_{\tilde{X}}).$$

Similarly, for F_R,

$$F_R\left(\frac{x - m_{\tilde{X}}}{b_{\tilde{X}} - m_{\tilde{X}}}\right) = \alpha, \qquad \alpha = [0, \ 1].$$

Taking the inverse of this function leads to

$$\frac{x - m_{\tilde{X}}}{b_{\tilde{X}} - m_{\tilde{X}}} = F_R^{-1}(\alpha),$$

$$\text{or} \quad x = m_{\tilde{X}} + F_R^{-1}(\alpha)(b_{\tilde{X}} - m_{\tilde{X}}). \quad \text{(A4.3)}$$

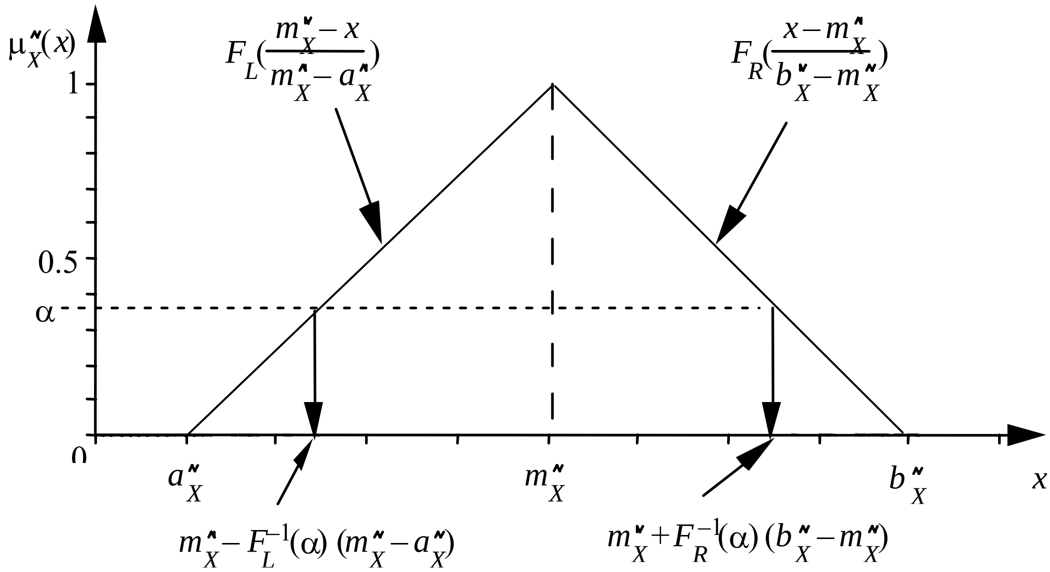

Figure A4.1 The left and right spreads of fuzzy number $\widetilde{X}$ at the -level

Hence, the interval of $\widetilde{X}$ at the ˜ level is given by

$$\widetilde{X}_\alpha = [a_{\widetilde{X}}(\alpha),\ \ b_{\widetilde{X}}(\alpha)]$$

$$= [m_{\widetilde{X}} - F_L^{-1}(\alpha)(m_{\widetilde{X}} - a_{\widetilde{X}}),\ \ m_{\widetilde{X}} + F_R^{-1}(\alpha)(b_{\widetilde{X}} - m_{\widetilde{X}})] . \quad \text{(A4.4)}$$

Appendix V

Table A5.1 Summary of $h(X_{ij})$, g_λ, and $(C)\int hdg$ for A_2: Joint Venture

lternative	Aspect	Criteria	$h(\bar{\tilde{X}}_{ij})$	$\hat{g}_{ij}$	g_λ		$(C)\int hdg$ (λ Value)
A_1	$\bar{\tilde{X}}_1$	$\bar{\tilde{X}}_{11}$	0.7710	0.8222	$\{\bar{\tilde{X}}_{11}\}$	0.2019	0.6697 (-0.3385)
		$\bar{\tilde{X}}_{12}$	0.7709	0.8134	$\{\bar{\tilde{X}}_{11}, \bar{\tilde{X}}_{12}\}$	0.3880	
		$\bar{\tilde{X}}_{14}$	0.7079	0.7068	$\{\bar{\tilde{X}}_{11}, \bar{\tilde{X}}_{12}, \bar{\tilde{X}}_{14}\}$	0.5395	
		$\bar{\tilde{X}}_{13}$	0.6387	0.6759	$\{\bar{\tilde{X}}_{11}, \bar{\tilde{X}}_{12}, \bar{\tilde{X}}_{13}, \bar{\tilde{X}}_{14}\}$	0.6760	
		$\bar{\tilde{X}}_{15}$	0.5680	0.6257	$\{\bar{\tilde{X}}_{11}, \bar{\tilde{X}}_{12}, \bar{\tilde{X}}_{13}, \bar{\tilde{X}}_{14}, \bar{\tilde{X}}_{15}\}$	0.7955	
		$\bar{\tilde{X}}_{17}$	0.5508	0.5672	$\{\bar{\tilde{X}}_{11}, \bar{\tilde{X}}_{12}, \bar{\tilde{X}}_{13}, \bar{\tilde{X}}_{14}, \bar{\tilde{X}}_{15}, \bar{\tilde{X}}_{17}\}$	0.8984	
		$\bar{\tilde{X}}_{16}$	0.5075	0.5889	$\{\bar{\tilde{X}}_{11}, \bar{\tilde{X}}_{12}, \bar{\tilde{X}}_{13}, \bar{\tilde{X}}_{14}, \bar{\tilde{X}}_{15}, \bar{\tilde{X}}_{16}, \bar{\tilde{X}}_{17}\}$	1.0000	
	$\bar{\tilde{X}}_4$	$\bar{\tilde{X}}_{43}$	0.7838	0.6815	$\{\bar{\tilde{X}}_{43}\}$	0.2005	0.6449 (-0.3612)
		$\bar{\tilde{X}}_{42}$	0.7027	0.7569	$\{\bar{\tilde{X}}_{42}, \bar{\tilde{X}}_{43}\}$	0.4062	
		$\bar{\tilde{X}}_{45}$	0.6002	0.6820	$\{\bar{\tilde{X}}_{42}, \bar{\tilde{X}}_{43}, \bar{\tilde{X}}_{45}\}$	0.5773	
		$\bar{\tilde{X}}_{44}$	0.5801	0.5837	$\{\bar{\tilde{X}}_{42}, \bar{\tilde{X}}_{43}, \bar{\tilde{X}}_{44}, \bar{\tilde{X}}_{45}\}$	0.7140	
		$\bar{\tilde{X}}_{46}$	0.5703	0.6800	$\{\bar{\tilde{X}}_{42}, \bar{\tilde{X}}_{43}, \bar{\tilde{X}}_{44}, \bar{\tilde{X}}_{45}, \bar{\tilde{X}}_{46}\}$	0.8624	
		$\bar{\tilde{X}}_{41}$	0.5567	0.6793	$\{\bar{\tilde{X}}_{41}, \bar{\tilde{X}}_{42}, \bar{\tilde{X}}_{43}, \bar{\tilde{X}}_{44}, \bar{\tilde{X}}_{45}, \bar{\tilde{X}}_{46}\}$	1.0000	
	$\bar{\tilde{X}}_3$	$\bar{\tilde{X}}_{31}$	0.6655	0.7298	$\{\bar{\tilde{X}}_{31}\}$	0.2835	0.6307 (-0.3981)
		$\bar{\tilde{X}}_{32}$	0.6594	0.5805	$\{\bar{\tilde{X}}_{31}, \bar{\tilde{X}}_{32}\}$	0.4860	
		$\bar{\tilde{X}}_{33}$	0.6486	0.6397	$\{\bar{\tilde{X}}_{31}, \bar{\tilde{X}}_{32}, \bar{\tilde{X}}_{33}\}$	0.6879	
		$\bar{\tilde{X}}_{35}$	0.6244	0.6026	$\{\bar{\tilde{X}}_{31}, \bar{\tilde{X}}_{32}, \bar{\tilde{X}}_{33}, \bar{\tilde{X}}_{35}\}$	0.8597	
		$\bar{\tilde{X}}_{34}$	0.5006	0.5409	$\{\bar{\tilde{X}}_{31}, \bar{\tilde{X}}_{32}, \bar{\tilde{X}}_{33}, \bar{\tilde{X}}_{34}, \bar{\tilde{X}}_{35}\}$	1.0000	
	$\bar{\tilde{X}}_2$	$\bar{\tilde{X}}_{22}$	0.7361	0.8143	$\{\bar{\tilde{X}}_{22}\}$	0.2104	0.6275 (-0.3426)
		$\bar{\tilde{X}}_{24}$	0.6701	0.7323	$\{\bar{\tilde{X}}_{22}, \bar{\tilde{X}}_{24},\}$	0.3866	
		$\bar{\tilde{X}}_{25}$	0.6279	0.6348	$\{\bar{\tilde{X}}_{22}, \bar{\tilde{X}}_{24}, \bar{\tilde{X}}_{25}\}$	0.5301	
		$\bar{\tilde{X}}_{26}$	0.6100	0.6030	$\{\bar{\tilde{X}}_{22}, \bar{\tilde{X}}_{24}, \bar{\tilde{X}}_{25}, \bar{\tilde{X}}_{26}\}$	0.6588	
		$\bar{\tilde{X}}_{27}$	0.5815	0.6164	$\{\bar{\tilde{X}}_{22}, \bar{\tilde{X}}_{24}, \bar{\tilde{X}}_{25}, \bar{\tilde{X}}_{26}, \bar{\tilde{X}}_{27}\}$	0.7832	
		$\bar{\tilde{X}}_{21}$	0.5797	0.6811	$\{\bar{\tilde{X}}_{21}, \bar{\tilde{X}}_{22}, \bar{\tilde{X}}_{24}, \bar{\tilde{X}}_{25}, \bar{\tilde{X}}_{26}, \bar{\tilde{X}}_{27}\}$	0.9128	
		$\bar{\tilde{X}}_{23}$	0.4406	0.4838	$\{\bar{\tilde{X}}_{21}, \bar{\tilde{X}}_{22}, \bar{\tilde{X}}_{23}, \bar{\tilde{X}}_{24}, \bar{\tilde{X}}_{25}, \bar{\tilde{X}}_{26}, \bar{\tilde{X}}_{27}\}$	1.0000	

Appendix V

Table A5.1 Summary of $h(X_{ij})$, g_{λ}, and $(C)\int hdg$ for A_2: Joint Venture

lltern-ative	Aspect	Criteria	$h(\tilde{\bar{X}}_{ij})$	$\hat{g}_{ij}$	g_{λ}		$(C)\int hdg$ (λ Value)
	$\tilde{\bar{X}}_5$	$\tilde{\bar{X}}_{52}$	0.6636	0.683 4	$\{\tilde{\bar{X}}_{52}\}$	0.3326	0.6083 (-0.4224)
		$\tilde{\bar{X}}_{51}$	0.6053	0.6885	$\{\tilde{\bar{X}}_{51},\tilde{\bar{X}}_{52}\}$	0.6205	
		$\tilde{\bar{X}}_{53}$	0.5629	0.5440	$\{\tilde{\bar{X}}_{51},\tilde{\bar{X}}_{52},\tilde{\bar{X}}_{53}\}$	0.8188	
		$\tilde{\bar{X}}_{54}$	0.5611	0.5616	$\{\tilde{\bar{X}}_{51},\tilde{\bar{X}}_{52},\tilde{\bar{X}}_{53},\tilde{\bar{X}}_{54}\}$	1.0000	
	$\tilde{\bar{X}}_6$	$\tilde{\bar{X}}_{61}$	0.5830	0.6336	$\{\tilde{\bar{X}}_{61}\}$	0.5876	0.5493 (-0.2121)
		$\tilde{\bar{X}}_{62}$	0.5011	0.5011	$\{\tilde{\bar{X}}_{61},\tilde{\bar{X}}_{62}\}$	1.0000	

Note： A_1 represents Joint Venture; A_2 represents Strategic Alliance; A_3 represents Merger and Acquisition; A_4 represents Cooperation Contract

Table A5.2 Summary of $h(X_{ij})$, g_{λ}, and $(C)\int hdg$ for A_2: Strategic Alliance

Altern-ative	Aspect	Criteria	$h(\tilde{\bar{X}}_{ij})$	$\hat{g}_{ij}$	g_{λ}		$(C)\int hdg$ (λ Value)
A_2	$\tilde{\bar{X}}_4$	$\tilde{\bar{X}}_{42}$	0.7590	0.7823	$\{\tilde{\bar{X}}_{42}\}$	0.2193	0.7178 (-0.3555)
		$\tilde{\bar{X}}_{44}$	0.7457	0.7272	$\{\tilde{\bar{X}}_{42},\tilde{\bar{X}}_{46}\}$	0.4079	
		$\tilde{\bar{X}}_{43}$	0.7398	0.7431	$\{\tilde{\bar{X}}_{42},\tilde{\bar{X}}_{45},\tilde{\bar{X}}_{46}\}$	0.5864	
		$\tilde{\bar{X}}_{43}$	0.7320	0.6974	$\{\tilde{\bar{X}}_{42},\tilde{\bar{X}}_{43},\tilde{\bar{X}}_{45},\tilde{\bar{X}}_{46}\}$	0.7418	
		$\tilde{\bar{X}}_{44}$	0.6636	0.6846	$\{\tilde{\bar{X}}_{42},\tilde{\bar{X}}_{43},\tilde{\bar{X}}_{44},\tilde{\bar{X}}_{45},\tilde{\bar{X}}_{46}\}$	0.8838	
		$\tilde{\bar{X}}_{41}$	0.6079	0.5984	$\{\tilde{\bar{X}}_{41},\tilde{\bar{X}}_{42},\tilde{\bar{X}}_{43},\tilde{\bar{X}}_{44},\tilde{\bar{X}}_{45},\tilde{\bar{X}}_{46}\}$	1.0000	
	$\tilde{\bar{X}}_5$	$\tilde{\bar{X}}_{52}$	0.6879	0.7319	$\{\tilde{\bar{X}}_{52}\}$	0.3081	0.6577 (-0.4132)
		$\tilde{\bar{X}}_{54}$	0.6513	0.6709	$\{\tilde{\bar{X}}_{52},\tilde{\bar{X}}_{54}\}$	0.5559	
		$\tilde{\bar{X}}_{51}$	0.6502	0.7480	$\{\tilde{\bar{X}}_{51},\tilde{\bar{X}}_{52},\tilde{\bar{X}}_{54}\}$	0.7980	
		$\tilde{\bar{X}}_{53}$	0.6287	0.7149	$\{\tilde{\bar{X}}_{51},\tilde{\bar{X}}_{52},\tilde{\bar{X}}_{53},\tilde{\bar{X}}_{54}\}$	1.0000	
	$\tilde{\bar{X}}_2$	$\tilde{\bar{X}}_{22}$	0.7515	0.7322	$\{\tilde{\bar{X}}_{22}\}$	0.1967	0.6445 (-0.3491)
		$\tilde{\bar{X}}_{25}$	0.7150	0.7296	$\{\tilde{\bar{X}}_{22},\tilde{\bar{X}}_{25},\}$	0.3792	
		$\tilde{\bar{X}}_{21}$	0.6937	0.6694	$\{\tilde{\bar{X}}_{21},\tilde{\bar{X}}_{22},\tilde{\bar{X}}_{25}\}$	0.5357	

		$\bar{\tilde{X}}_{24}$	0.6606	0.6771	$\{\bar{\tilde{X}}_{21},\bar{\tilde{X}}_{22},\bar{\tilde{X}}_{24},\bar{\tilde{X}}_{25}\}$	0.6840	
		$\bar{\tilde{X}}_{27}$	0.5582	0.5922	$\{\bar{\tilde{X}}_{21},\bar{\tilde{X}}_{22},\bar{\tilde{X}}_{24},\bar{\tilde{X}}_{25},\bar{\tilde{X}}_{27}\}$	0.8059	
		$\bar{\tilde{X}}_{23}$	0.5006	0.4821	$\{\bar{\tilde{X}}_{21},\bar{\tilde{X}}_{22},\bar{\tilde{X}}_{23},\bar{\tilde{X}}_{24},\bar{\tilde{X}}_{25},\bar{\tilde{X}}_{27}\}$	0.9001	
		$\bar{\tilde{X}}_{26}$	0.4456	0.5372	$\{\bar{\tilde{X}}_{21},\bar{\tilde{X}}_{22},\bar{\tilde{X}}_{23},\bar{\tilde{X}}_{24},\bar{\tilde{X}}_{25},\bar{\tilde{X}}_{26},\bar{\tilde{X}}_{27}\}$	1.0000	
	$\bar{\tilde{X}}_{1}$	$\bar{\tilde{X}}_{12}$	0.7638	0.7098	$\{\bar{\tilde{X}}_{12}\}$	0.1950	0.6191 (-0.3520)
		$\bar{\tilde{X}}_{11}$	0.7131	0.7117	$\{\bar{\tilde{X}}_{11},\bar{\tilde{X}}_{12}\}$	0.3771	
		X_{16}	0.6226	0.6125	$\{\bar{\tilde{X}}_{11},\bar{\tilde{X}}_{12},\bar{\tilde{X}}_{16}\}$	0.5237	
		$\bar{\tilde{X}}_{14}$	0.6214	0.6181	$\{\bar{\tilde{X}}_{11},\bar{\tilde{X}}_{12},\bar{\tilde{X}}_{14},\bar{\tilde{X}}_{16}\}$	0.6628	
		$\bar{\tilde{X}}_{13}$	0.5403	0.6176	$\{\bar{\tilde{X}}_{11},\bar{\tilde{X}}_{12},\bar{\tilde{X}}_{13},\bar{\tilde{X}}_{14},\bar{\tilde{X}}_{16}\}$	0.7935	
		$\bar{\tilde{X}}_{17}$	0.4456	0.5615	$\{\bar{\tilde{X}}_{11},\bar{\tilde{X}}_{12},\bar{\tilde{X}}_{13},\bar{\tilde{X}}_{14},\bar{\tilde{X}}_{16},\bar{\tilde{X}}_{17}\}$	0.9054	
		$\bar{\tilde{X}}_{15}$	0.4456	0.5000	$\{\bar{\tilde{X}}_{11},\bar{\tilde{X}}_{12},\bar{\tilde{X}}_{13},\bar{\tilde{X}}_{14},\bar{\tilde{X}}_{15},\bar{\tilde{X}}_{16},\bar{\tilde{X}}_{17}\}$	1.0000	
	$\bar{\tilde{X}}_{6}$	$\bar{\tilde{X}}_{61}$	0.6231	0.6640	$\{\bar{\tilde{X}}_{61}\}$	0.5746	0.5893 (-0.3326)
		$\bar{\tilde{X}}_{62}$	0.5435	0.6019	$\{\bar{\tilde{X}}_{61},\bar{\tilde{X}}_{62}\}$	1.0000	
	$\bar{\tilde{X}}_{3}$	$\bar{\tilde{X}}_{31}$	0.6214	0.6214	$\{\bar{\tilde{X}}_{31}\}$	0.2402	0.5862 (-0.3964)
		$\bar{\tilde{X}}_{32}$	0.6057	0.6494	$\{\bar{\tilde{X}}_{31},\bar{\tilde{X}}_{32}\}$	0.4668	
		$\bar{\tilde{X}}_{33}$	0.5810	0.6359	$\{\bar{\tilde{X}}_{31},\bar{\tilde{X}}_{32},\bar{\tilde{X}}_{33}\}$	0.6669	
		$\bar{\tilde{X}}_{35}$	0.5751	0.5964	$\{\bar{\tilde{X}}_{31},\bar{\tilde{X}}_{32},\bar{\tilde{X}}_{33},\bar{\tilde{X}}_{35}\}$	0.8368	
		$\bar{\tilde{X}}_{34}$	0.5254	0.6322	$\{\bar{\tilde{X}}_{31},\bar{\tilde{X}}_{32},\bar{\tilde{X}}_{33},\bar{\tilde{X}}_{34},\bar{\tilde{X}}_{35}\}$	1.0000	

Note： A_1 represents Joint Venture; A_2 represents Strategic Alliance; A_3 represents Merger and Acquisition; A_4 represents Cooperation Contract

Table A5.3 Summary of $h(X_{ij})$, g_λ, and $(C)\int hdg$ for A_3: Merger and Acquisition

Altern-ative	Aspect	Criteria	$h(\bar{\tilde{X}}_{ij})$	$\hat{g}_{ij}$	g_λ		$(C)\int hdg$ (λ Value)
A_3	$\bar{\tilde{X}}_{1}$	$\bar{\tilde{X}}_{11}$	0.8148	0.8409	$\{\bar{\tilde{X}}_{11}\}$	0.1907	0.7376 (-0.3273)
		$\bar{\tilde{X}}_{12}$	0.7951	0.7900	$\{\bar{\tilde{X}}_{11},\bar{\tilde{X}}_{12}\}$	0.3590	
		$\bar{\tilde{X}}_{14}$	0.7752	0.8164	$\{\bar{\tilde{X}}_{11},\bar{\tilde{X}}_{12},\bar{\tilde{X}}_{14}\}$	0.5225	
		$\bar{\tilde{X}}_{16}$	0.7055	0.6670	$\{\bar{\tilde{X}}_{11},\bar{\tilde{X}}_{12},\bar{\tilde{X}}_{14},\bar{\tilde{X}}_{16}\}$	0.6488	
		$\bar{\tilde{X}}_{13}$	0.7045	0.7167	$\{\bar{\tilde{X}}_{11},\bar{\tilde{X}}_{12},\bar{\tilde{X}}_{13},\bar{\tilde{X}}_{14},\bar{\tilde{X}}_{16}\}$	0.7774	
		$\bar{\tilde{X}}_{15}$	0.6874	0.7041	$\{\bar{\tilde{X}}_{11},\bar{\tilde{X}}_{12},\bar{\tilde{X}}_{13},\bar{\tilde{X}}_{14},\bar{\tilde{X}}_{15},\bar{\tilde{X}}_{16}\}$	0.8971	

	$\bar{\tilde{X}}_{17}$	0.5800	0.6375	$\{\bar{\tilde{X}}_{11},\bar{\tilde{X}}_{12},\bar{\tilde{X}}_{13},\bar{\tilde{X}}_{14},\bar{\tilde{X}}_{15},\bar{\tilde{X}}_{16},\bar{\tilde{X}}_{17}\}$	1.0000	
$\bar{\tilde{X}}_4$	$\bar{\tilde{X}}_{44}$	0.7889	0.7645	$\{\bar{\tilde{X}}_{46}\}$	0.2112	0.7178 (-0.3533)
	$\bar{\tilde{X}}_{42}$	0.7744	0.8164	$\{\bar{\tilde{X}}_{42},\bar{\tilde{X}}_{46}\}$	0.4194	
	$\bar{\tilde{X}}_{44}$	0.7006	0.6628	$\{\bar{\tilde{X}}_{42},\bar{\tilde{X}}_{44},\bar{\tilde{X}}_{46}\}$	0.5762	
	$\bar{\tilde{X}}_{41}$	0.6854	0.7332	$\{\bar{\tilde{X}}_{41},\bar{\tilde{X}}_{42},\bar{\tilde{X}}_{44},\bar{\tilde{X}}_{46}\}$	0.7378	
	$\bar{\tilde{X}}_{43}$	0.6838	0.6576	$\{\bar{\tilde{X}}_{41},\bar{\tilde{X}}_{42},\bar{\tilde{X}}_{43},\bar{\tilde{X}}_{44},\bar{\tilde{X}}_{46}\}$	0.8728	
	$\bar{\tilde{X}}_{45}$	0.6053	0.6621	$\{\bar{\tilde{X}}_{41},\bar{\tilde{X}}_{42},\bar{\tilde{X}}_{43},\bar{\tilde{X}}_{44},\bar{\tilde{X}}_{45},\bar{\tilde{X}}_{46}\}$	1.0000	
$\bar{\tilde{X}}_3$	$\bar{\tilde{X}}_{35}$	0.6875	0.7480	$\{\bar{\tilde{X}}_{35}\}$	0.2583	0.6578 (-0.3852)
	$\bar{\tilde{X}}_{34}$	0.6835	0.7043	$\{\bar{\tilde{X}}_{34},\bar{\tilde{X}}_{35}\}$	0.4779	
	$\bar{\tilde{X}}_{31}$	0.6451	0.7039	$\{\bar{\tilde{X}}_{31},\bar{\tilde{X}}_{34},\bar{\tilde{X}}_{35}\}$	0.6768	
	$\bar{\tilde{X}}_{33}$	0.6428	0.6404	$\{\bar{\tilde{X}}_{31},\bar{\tilde{X}}_{33},\bar{\tilde{X}}_{34},\bar{\tilde{X}}_{35}\}$	0.8415	
	$\bar{\tilde{X}}_{32}$	0.6053	0.6758	$\{\bar{\tilde{X}}_{31},\bar{\tilde{X}}_{32},\bar{\tilde{X}}_{33},\bar{\tilde{X}}_{34},\bar{\tilde{X}}_{35}\}$	1.0000	
$\bar{\tilde{X}}_6$	$\bar{\tilde{X}}_{61}$	0.6398	0.6834	$\{\bar{\tilde{X}}_{61}\}$	0.5788	0.6571 (-0.3580)
	$\bar{\tilde{X}}_{62}$	0.6019	0.6209	$\{\bar{\tilde{X}}_{61},\bar{\tilde{X}}_{62}\}$	1.0000	
$\bar{\tilde{X}}_2$	$\bar{\tilde{X}}_{27}$	0.7141	0.7323	$\{\bar{\tilde{X}}_{27}\}$	0.1766	0.6530 (-0.3333)
	$\bar{\tilde{X}}_{22}$	0.7118	0.7293	$\{\bar{\tilde{X}}_{22},\bar{\tilde{X}}_{27}\}$	0.3421	
	$\bar{\tilde{X}}_{21}$	0.6651	0.7051	$\{\bar{\tilde{X}}_{21},\bar{\tilde{X}}_{22},\bar{\tilde{X}}_{27}\}$	0.4929	
	$\bar{\tilde{X}}_{25}$	0.6325	0.6693	$\{\bar{\tilde{X}}_{21},\bar{\tilde{X}}_{22},\bar{\tilde{X}}_{25},\bar{\tilde{X}}_{27}\}$	0.6281	
	$\bar{\tilde{X}}_{26}$	0.6101	0.6897	$\{\bar{\tilde{X}}_{21},\bar{\tilde{X}}_{22},\bar{\tilde{X}}_{25},\bar{\tilde{X}}_{26},\bar{\tilde{X}}_{27}\}$	0.7598	
	$\bar{\tilde{X}}_{23}$	0.5982	0.6556	$\{\bar{\tilde{X}}_{21},\bar{\tilde{X}}_{22},\bar{\tilde{X}}_{23},\bar{\tilde{X}}_{25},\bar{\tilde{X}}_{26},\bar{\tilde{X}}_{27}\}$	0.8782	
	$\bar{\tilde{X}}_{24}$	0.5915	0.7135	$\{\bar{\tilde{X}}_{21},\bar{\tilde{X}}_{22},\bar{\tilde{X}}_{23},\bar{\tilde{X}}_{24},\bar{\tilde{X}}_{25},\bar{\tilde{X}}_{26},\bar{\tilde{X}}_{27}\}$	1.0000	
$\bar{\tilde{X}}_5$	$\bar{\tilde{X}}_{53}$	0.7079	0.7306	$\{\bar{\tilde{X}}_{53}\}$	0.3127	0.6516 (-0.4150)
	$\bar{\tilde{X}}_{52}$	0.6486	0.7351	$\{\bar{\tilde{X}}_{52},\bar{\tilde{X}}_{53}\}$	0.5863	
	$\bar{\tilde{X}}_{51}$	0.6411	0.7488	$\{\bar{\tilde{X}}_{51},\bar{\tilde{X}}_{52},\bar{\tilde{X}}_{53}\}$	0.8284	
	$\bar{\tilde{X}}_{54}$	0.5685	0.6039	$\{\bar{\tilde{X}}_{51},\bar{\tilde{X}}_{52},\bar{\tilde{X}}_{53},\bar{\tilde{X}}_{54}\}$	1.0000	

Note： A_1 represents Joint Venture; A_2 represents Strategic Alliance; A_3 represents Merger and Acquisition; A_4 represents Cooperation Contract

Table A5.4 Summary of $h(X_{ij})$, g_λ, and $(C)\int hdg$ for A_4: Cooperation Contract

Altern-ative	Aspect	Criteria	$h\left(\bar{\tilde{X}}_{ij}\right)$	$\hat{g}_{ij}$	g_{λ}		$(C)\int hdg$ (λ Value)
A_4	$\bar{\tilde{X}}_4$	$\bar{\tilde{X}}_{42}$	0.7108	0.5974	$\{\bar{\tilde{X}}_{42}\}$	0.2152	0.6559 (-0.3652)
		$\bar{\tilde{X}}_{43}$	0.6819	0.6991	$\{\bar{\tilde{X}}_{42},\bar{\tilde{X}}_{43}\}$	0.4104	
		$\bar{\tilde{X}}_{44}$	0.6671	0.6509	$\{\bar{\tilde{X}}_{42},\bar{\tilde{X}}_{43},\bar{\tilde{X}}_{44}\}$	0.5785	
		$\bar{\tilde{X}}_{46}$	0.6633	0.6682	$\{\bar{\tilde{X}}_{42},\bar{\tilde{X}}_{43},\bar{\tilde{X}}_{44},\bar{\tilde{X}}_{46}\}$	0.7384	
		$\bar{\tilde{X}}_{46}$	0.6287	0.6199	$\{\bar{\tilde{X}}_{42},\bar{\tilde{X}}_{43},\bar{\tilde{X}}_{44},\bar{\tilde{X}}_{45},\bar{\tilde{X}}_{46}\}$	0.8762	
		$\bar{\tilde{X}}_{41}$	0.5573	0.5974	$\{\bar{\tilde{X}}_{41},\bar{\tilde{X}}_{42},\bar{\tilde{X}}_{43},\bar{\tilde{X}}_{44},\bar{\tilde{X}}_{45},\bar{\tilde{X}}_{46}\}$	1.0000	
	$\bar{\tilde{X}}_1$	$\bar{\tilde{X}}_{12}$	0.7454	0.6678	$\{\bar{\tilde{X}}_{12}\}$	0.1911	0.6342 (-0.3573)
		$\bar{\tilde{X}}_{11}$	0.6814	0.7104	$\{\bar{\tilde{X}}_{11},\bar{\tilde{X}}_{12}\}$	0.3801	
		$\bar{\tilde{X}}_{14}$	0.6058	0.5493	$\{\bar{\tilde{X}}_{11},\bar{\tilde{X}}_{12},\bar{\tilde{X}}_{14}\}$	0.5168	
		$\bar{\tilde{X}}_{16}$	0.5966	0.6209	$\{\bar{\tilde{X}}_{11},\bar{\tilde{X}}_{12},\bar{\tilde{X}}_{14},\bar{\tilde{X}}_{16}\}$	0.6620	
		$\bar{\tilde{X}}_{15}$	0.5949	0.5444	$\{\bar{\tilde{X}}_{11},\bar{\tilde{X}}_{12},\bar{\tilde{X}}_{14},\bar{\tilde{X}}_{15},\bar{\tilde{X}}_{16}\}$	0.7817	
		$\bar{\tilde{X}}_{13}$	0.5943	0.5403	$\{\bar{\tilde{X}}_{11},\bar{\tilde{X}}_{12},\bar{\tilde{X}}_{13},\bar{\tilde{X}}_{14},\bar{\tilde{X}}_{15},\bar{\tilde{X}}_{16}\}$	0.8939	
		$\bar{\tilde{X}}_{17}$	0.5246	0.5412	$\{\bar{\tilde{X}}_{11},\bar{\tilde{X}}_{12},\bar{\tilde{X}}_{13},\bar{\tilde{X}}_{14},\bar{\tilde{X}}_{15},\bar{\tilde{X}}_{16},\bar{\tilde{X}}_{17}\}$	1.0000	
	$\bar{\tilde{X}}_5$	$\bar{\tilde{X}}_{53}$	0.6505	0.6399	$\{\bar{\tilde{X}}_{53}\}$	0.3019	0.6260 (-0.4202)
		$\bar{\tilde{X}}_{52}$	0.6418	0.6469	$\{\bar{\tilde{X}}_{52},\bar{\tilde{X}}_{53}\}$	0.5682	
		$\bar{\tilde{X}}_{51}$	0.6231	0.6713	$\{\bar{\tilde{X}}_{51},\bar{\tilde{X}}_{52},\bar{\tilde{X}}_{53}\}$	0.8085	
		$\bar{\tilde{X}}_{54}$	0.5690	0.6129	$\{\bar{\tilde{X}}_{51},\bar{\tilde{X}}_{52},\bar{\tilde{X}}_{53},\bar{\tilde{X}}_{54}\}$	1.0000	
	$\bar{\tilde{X}}_6$	$\bar{\tilde{X}}_{61}$	0.6316	0.5612	$\{\bar{\tilde{X}}_{61}\}$	0.5275	0.5986 (-0.1920)
		$\bar{\tilde{X}}_{62}$	0.5616	0.5593	$\{\bar{\tilde{X}}_{61},\bar{\tilde{X}}_{62}\}$	1.0000	
	$\bar{\tilde{X}}_3$	$\bar{\tilde{X}}_{31}$	0.6429	0.6866	$\{\bar{\tilde{X}}_{31}\}$	0.2534	0.5876 (-0.3924)
		$\bar{\tilde{X}}_{34}$	0.6019	0.7052	$\{\bar{\tilde{X}}_{31},\bar{\tilde{X}}_{34}\}$	0.4875	
		$\bar{\tilde{X}}_{33}$	0.5616	0.6217	$\{\bar{\tilde{X}}_{31},\bar{\tilde{X}}_{33},\bar{\tilde{X}}_{34}\}$	0.6740	
		$\bar{\tilde{X}}_{32}$	0.5556	0.5621	$\{\bar{\tilde{X}}_{31},\bar{\tilde{X}}_{32},\bar{\tilde{X}}_{33},\bar{\tilde{X}}_{34}\}$	0.8281	
		$\bar{\tilde{X}}_{35}$	0.5435	0.6903	$\{\bar{\tilde{X}}_{31},\bar{\tilde{X}}_{32},\bar{\tilde{X}}_{33},\bar{\tilde{X}}_{34},\bar{\tilde{X}}_{35}\}$	1.0000	
	$\bar{\tilde{X}}_2$	$\bar{\tilde{X}}_{22}$	0.6647	0.6663	$\{\bar{\tilde{X}}_{22}\}$	0.1893	0.5833 (-0.3556)
		$\bar{\tilde{X}}_{21}$	0.6227	0.6217	$\{\bar{\tilde{X}}_{21},\bar{\tilde{X}}_{22}\}$	0.3544	
		$\bar{\tilde{X}}_{25}$	0.6018	0.6023	$\{\bar{\tilde{X}}_{21},\bar{\tilde{X}}_{22},\bar{\tilde{X}}_{25}\}$	0.5045	

		$\bar{\tilde{X}}_{27}$	0.5614	0.5629	$\{\bar{\tilde{X}}_{21},\bar{\tilde{X}}_{22},\bar{\tilde{X}}_{25},\bar{\tilde{X}}_{27}\}$	0.6365
		$\bar{\tilde{X}}_{24}$	0.5445	0.6312	$\{\bar{\tilde{X}}_{21},\bar{\tilde{X}}_{22},\bar{\tilde{X}}_{24},\bar{\tilde{X}}_{25},\bar{\tilde{X}}_{27}\}$	0.7755
		$\bar{\tilde{X}}_{26}$	0.5372	0.6027	$\{\bar{\tilde{X}}_{21},\bar{\tilde{X}}_{22},\bar{\tilde{X}}_{24},\bar{\tilde{X}}_{25},\bar{\tilde{X}}_{26},\bar{\tilde{X}}_{27}\}$	0.8999
		$\bar{\tilde{X}}_{23}$	0.4764	0.5140	$\{\bar{\tilde{X}}_{21},\bar{\tilde{X}}_{22},\bar{\tilde{X}}_{23},\bar{\tilde{X}}_{24},\bar{\tilde{X}}_{25},\bar{\tilde{X}}_{26},\bar{\tilde{X}}_{27}\}$	1.0000

Note： A_1 represents Joint Venture; A_2 represents Strategic Alliance; A_3 represents Merger and Acquisition; A_4 represents Cooperation Contract

Table A5.5 Summary of $h(X_{ij})$, g_λ, and $(C)\int hdg$ for Four Kinds of Entry Modes

lternative	Aspect	$h(\bar{\tilde{X}}_{ij})$	$\hat{g}_{ij}$	g_λ		$(C)\int hdg$ （λ Value）	Ranking Order
A_1	$\bar{\tilde{X}}_1$	0.6697	0.6572	$\{\bar{\tilde{X}}_1\}$	0.2014	0.6279 （-0.3666）	**3**
	$\bar{\tilde{X}}_4$	0.6449	0.7471	$\{\bar{\tilde{X}}_1,\bar{\tilde{X}}_4\}$	0.4124		
	$\bar{\tilde{X}}_3$	0.6307	0.5964	$\{\bar{\tilde{X}}_1,\bar{\tilde{X}}_3,\bar{\tilde{X}}_4\}$	0.5681		
	$\bar{\tilde{X}}_2$	0.6275	0.6209	$\{\bar{\tilde{X}}_1,\bar{\tilde{X}}_2,\bar{\tilde{X}}_3,\bar{\tilde{X}}_4\}$	0.7192		
	$\bar{\tilde{X}}_5$	0.6083	0.7286	$\{\bar{\tilde{X}}_1,\bar{\tilde{X}}_2,\bar{\tilde{X}}_3,\bar{\tilde{X}}_4,\bar{\tilde{X}}_5\}$	0.8829		
	$\bar{\tilde{X}}_6$	0.5493	0.5615	$\{\bar{\tilde{X}}_1,\bar{\tilde{X}}_2,\bar{\tilde{X}}_3,\bar{\tilde{X}}_4,\bar{\tilde{X}}_5,\bar{\tilde{X}}_6\}$	1.0000		
A_2	$\bar{\tilde{X}}_4$	0.7178	0.8424	$\{\bar{\tilde{X}}_4\}$	0.2372	0.6464 （-0.3566）	**2**
	$\bar{\tilde{X}}_5$	0.6577	0.7526	$\{\bar{\tilde{X}}_4,\bar{\tilde{X}}_5\}$	0.4321		
	$\bar{\tilde{X}}_2$	0.6445	0.6991	$\{\bar{\tilde{X}}_2,\bar{\tilde{X}}_4,\bar{\tilde{X}}_5\}$	0.5999		
	$\bar{\tilde{X}}_1$	0.6191	0.6547	$\{\bar{\tilde{X}}_1,\bar{\tilde{X}}_2,\bar{\tilde{X}}_4,\bar{\tilde{X}}_5\}$	0.7462		
	$\bar{\tilde{X}}_6$	0.5893	0.6313	$\{\bar{\tilde{X}}_1,\bar{\tilde{X}}_2,\bar{\tilde{X}}_4,\bar{\tilde{X}}_5,\bar{\tilde{X}}_6\}$	0.8781		
	$\bar{\tilde{X}}_3$	0.5862	0.6230	$\{\bar{\tilde{X}}_1,\bar{\tilde{X}}_2,\bar{\tilde{X}}_3,\bar{\tilde{X}}_4,\bar{\tilde{X}}_5,\bar{\tilde{X}}_6\}$	1.0000		
A_3	$\bar{\tilde{X}}_1$	0.7376	0.7667	$\{\bar{\tilde{X}}_1\}$	0.2054	0.6838 （-0.3490）	**1**
	$\bar{\tilde{X}}_4$	0.7178	0.7596	$\{\bar{\tilde{X}}_1,\bar{\tilde{X}}_4\}$	0.3944		
	$\bar{\tilde{X}}_3$	0.6578	0.7245	$\{\bar{\tilde{X}}_1,\bar{\tilde{X}}_3,\bar{\tilde{X}}_4\}$	0.5621		
	$\bar{\tilde{X}}_6$	0.6571	0.6663	$\{\bar{\tilde{X}}_1,\bar{\tilde{X}}_3,\bar{\tilde{X}}_4,\bar{\tilde{X}}_6\}$	0.7063		
	$\bar{\tilde{X}}_2$	0.6530	0.7900	$\{\bar{\tilde{X}}_1,\bar{\tilde{X}}_2,\bar{\tilde{X}}_3,\bar{\tilde{X}}_4,\bar{\tilde{X}}_6\}$	0.8656		
	$\bar{\tilde{X}}_5$	0.6516	0.7169	$\{\bar{\tilde{X}}_1,\bar{\tilde{X}}_2,\bar{\tilde{X}}_3,\bar{\tilde{X}}_4,\bar{\tilde{X}}_5,\bar{\tilde{X}}_6\}$	1.0000		
A_4	$\bar{\tilde{X}}_4$	0.6559	0.6181	$\{\bar{\tilde{X}}_4\}$	0.2061	0.6186 （-0.3765）	**4**
	$\bar{\tilde{X}}_1$	0.6342	0.6250	$\{\bar{\tilde{X}}_1,\bar{\tilde{X}}_4\}$	0.3983		

Table A5.5 Summary of $h\left(X_{ij}\right)$, g_{λ}, and $(C)\int hdg$ for Four Kinds of Entry Modes

lternative	Aspect	$h\left(\tilde{\bar{X}}_{ij}\right)$	$\hat{g}_{ij}$	g_{λ}		$(C)\int hdg$ (λ Value)	Ranking Order
	$\tilde{\bar{X}}_5$	0.6260	0.6280	$\left\{\tilde{\bar{X}}_1, \tilde{\bar{X}}_4, \tilde{\bar{X}}_5\right\}$	0.5762		
	$\tilde{\bar{X}}_6$	0.5986	0.6112	$\left\{\tilde{\bar{X}}_1, \tilde{\bar{X}}_4, \tilde{\bar{X}}_5, \tilde{\bar{X}}_6\right\}$	0.7359		
	$\tilde{\bar{X}}_3$	0.5876	0.5426	$\left\{\tilde{\bar{X}}_1, \tilde{\bar{X}}_3, \tilde{\bar{X}}_4, \tilde{\bar{X}}_5, \tilde{\bar{X}}_6\right\}$	0.8673		
	$\tilde{\bar{X}}_2$	0.5833	0.5896	$\left\{\tilde{\bar{X}}_1, \tilde{\bar{X}}_2, \tilde{\bar{X}}_3, \tilde{\bar{X}}_4, \tilde{\bar{X}}_5, \tilde{\bar{X}}_6\right\}$	1.0000		

Note： A_1 represents Joint Venture; A_2 represents Strategic Alliance; A_3 represents Merger and Acquisition; A_4 represents Cooperation Contract