A Study of A/R Collection for IC Design Industry in Taiwan Using Fuzzy MCDM Methodology

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Abstract--In this paper, we present a fuzzy multiple criteria decision-making (FMCDM) approach to the evaluation of account receivable (A/R) collection instruments. By considering four collection alternatives, namely: the T/T advance (prepayment), the letter of credit (L/C), the documentary collection (including D/A and D/P), and the open account (O/A), the FMCDM approach is for the first time applied to choose the A/R collection instrument for Taiwanese integrated circuit (IC) design industry. Our results show, when face with new customer, the ranking of preference is the T/T advance, the L/C, the O/A and the documentary collection (D/A, D/P). International collection in modern unpredictable global market could be difficult unless firms have taken appropriate collection strategies. We believe that this study provides an alternative for making critical decisions, as in this case, the selection of A/R collection instruments.

I. INTRODUCTION

Since the last decade, the integrated circuit (IC) industry has played a key role in Taiwan's economic development. Generally speaking, IC industry consisted four phases as of designing, manufacturing, packaging and testing. According to the data of Taiwan Semiconductor Industry Association (TSIA), Taiwan IC Industry has been characterized with the world largest foundry and the world second largest IC design industry. However, they still face the pressure of the worldwide competition. Besides being supported by a solid infrastructure, various investment incentives, intellectual property protection, and integrated resource development from the government, Taiwanese IC firms are pressed by market environment to enhance their competitiveness through research and development (R&D) efforts. Furthermore, the effective working capital management crucial to these firms effort in product innovation and market response. Finance managers in these firms are struggling to find a foothold in the global market. However, the search for profits, market share and shareholder value are rarely risk free. Every transaction involves certain degree of risk. Sources of risk in international trade include the country risk, the credit (or commercial) risk and the foreign exchange risk. The country risk influences levels of risk in the other three categories [1]. Generally, four alternative instruments exist for collecting account receivables (A/R) in practice. Each instrument has its own merits. These alternatives include the payment in advance (prepayment), the letter of credit (L/C), the documentary collection (including documents against acceptance (D/A) and documents against payment (D/P)), and the open account (O/A). Difficulties in international collection nowadays increase significantly. A firm seeking to establish a global presence must search for the most beneficial and cost-effective way to work with their customers when involving international trade.

Firms are concerned with the reliability of payment for their operation overseas and longstanding partnerships with overseas suppliers. However, progress of technology bridges exporters and importers, and also help to establish a sense of trust between trading partners. It is commonly known that the A/R is the principal source of cash flows for a firm, and the management of this asset can have a significant impact on the firm's operations. The L/C has served as the primary international trade finance tool, but it is no longer the optimal possible financing solution in many situations. Intensely competitive pressures are forcing participants throughout the supply chain to improve their efficiency and drive down costs [2]; offering international customers better financing terms plays a crucial role to any sales package. Selling on the O/A is fraught with danger, but favorable in the standpoints of marketing and sales [3-5]. Corporate financial decisions are mostly investigated in the context of optimization. For example, the capital structure theory and the portfolio theory are analyzed in an optimization perspective. As for the individual collection instrument, various studies have discussed the effects of using L/C or O/A [2, 6-15]. Some work explored the international A/R risk [1, 16] and the technique of A/R collections [17]. Some studies focused on trade credit [18-21]; The studies basically were concerned about the buyer/importer' working capital. Unfortunately, these studies emphasized only single objective when they handled A/R problems. A/R problems mainly relate to the management of working capital, involving finance, collection, risk, cost, market shares, etc. Approaches of fuzzy multiple criteria decision-making (FMCDM) have been reported in other decision making problems involving multiple criteria evaluation/selection of alternatives [3-5, 22-25], for example. Multi-criteria decision in solving financial decision problems was discussed [26], but it did involve the A/R issues marginally.

In this paper, we for the first time present a FMCDM approach to the selection of A/R collection instruments. A scientific framework is introduced for the evaluation of A/R collection alternatives. Currently, in practice, decision makers rely on subjective criteria such as safety and convenience, along with other objective criteria such as total assets/sales revenue to conduct the evaluation. In doing so, they usually

depend on their personal wisdom, past experience, professional knowledge, or information that is difficult to define and/or describe exactly. However, considering the fuzziness of subjective judgment and other relative evaluation procedure is essential to promote the decision quality. Linguistic values such as very good, very important or about 100 dollars can be used to convey an evaluation about the importance of criteria and superiority of alternatives. Thus, a fuzzy-based decision model may play an appropriate and effective way than that of traditional precision-based models for international firms. To deal with the qualitative attributes in subjective judgment, we employ fuzzy analytic hierarchy process (AHP) to determine the weights of decision criteria for each expert. Then the FMCDM approach is used to synthesize the group decision. It enables decision makers to formalize and effectively solve the complicated, multi-criteria and fuzzy/vague perception problem of most appropriate A/R collection alternative selection. We apply this approach to investigate the A/R collection for the IC design industry in Taiwan. Based on the results of this study, in the case of facing with new customer, the preferred ranking in the industry is found to be as follow: the prepayment, the L/C, the O/A and the documentary collection. We believe that the current study provides an effective method for making critical decisions in selecting A/R collection instruments.

This paper is organized as follows. In Sec. II, we review the international A/R collection instruments. In Sec. III, we discuss the A/R collection evaluation model. In Sec. IV, we show the results for the IC design industry in Taiwan. Finally, conclusions were drawn from the finding.

II. INTERNATIONAL A/R COLLECTION INSTRUMENT ALTERNATIVES

In general, a seller/exporter and buyer/importer can choose from four methods of payment in international transactions. These options include payment by the T/T advance (prepayment), the L/C, the documentary collection, and the O/A. Different methods means they may face different degree and sources of risk, such as the country risk, the credit (or commercial) risk and the foreign exchange risk etc.

A. Telegraphic Transfer (T/T - Advance)

The T/T is the simplest and cheapest collection instrument for the seller, but it creates the greatest credit risk for the buyer. In such a situation, the buyer forwards payment before the seller ships the goods. If sellers adopt a policy of T/T advance, it usually means that they have stronger bargaining power.

B. Letter of Credit (L/C)

The L/C is a common instrument of "payment on shipment" in international trade. In the L/C transaction, the seller waits to ship until it receives a L/C issued on behalf of the buyer. The buyer then withholds payment until it receives sufficient evidence that the shipment has been made as specified by the documents under the L/C. For the seller, L/C is a protective but expensive and complicated instrument.

C. Documents Against Acceptance (D/A), Documents Against Payment (D/P)

The D/A and D/P are other types of documentary-collection transactions. They belong to the instruments of "deferred payment" D/A and D/P are cheaper but less protective for the seller than the L/C transaction. The seller ships the goods without any previous action by the buyer to effect payment. But a transport document will be transmitted through the banking channel that covers the goods. These collection transactions provide a relatively more secure option than that of an O/A transaction, to be discussed next. Collection transactions (D/A, D/P), however, cost much less than an L/C transaction, with bank fees typically fixed at around 0.5 % of transaction amount, regardless of the size of the transaction.

D. Open Account (O/A)

The O/A is another kind of "deferred payment" instruments. In an O/A transaction, the seller ships the goods without any formal assurance that the buyer will forward the payment when the goods arrive. Thus, in each T/T advance and O/A transaction, one party first fulfills its obligation completely, trusting that the other party will act responsibly. Like in the T/T advance, the O/A is also a simple and cheap instrument that does not involve banking channels.

III. A/R COLLECTION EVALUATION MODEL

A. Evaluation criteria

Multiple criteria evaluation problem examines a set of feasible alternatives and considers more than one criterion to determine a priority ranking for alternative implementation. To formulate the criteria, we have five principles, the completeness, the operational, the decomposable, the non-redundancy, and minimum size are considered. The key dimensions of the criteria for evaluation of A/R collection were derived through comprehensive investigation and consultation with nine experts, including one professor in international trade, one professor in financial, and three senior managers of broadband network equipment manufacturers in Hsinchu Science-Based Industrial Park of Taiwan. These individuals were asked to rate the accuracy, the adequacy and the relevance of the criteria and dimensions, and to verify their content validity in terms of A/R collection. Literatures' review [1, 2, 9-16] and the expert opinions provide the basis for developing the hierarchical structure used in this study.

In this paper, we construct a MCDM model of A/R collection instruments evaluation. There are three dimensions, ten criteria and four alternatives in the model. The hierarchical structure is shown in Fig. 1, where the dimension C_1 is the reduction in transaction risk, the dimension C_2 is the

reduction in transaction costs, and the dimension C_3 is the compliance with firm policy. The criterion C_{11} is the transaction partners' credit risk, the criterion C_{12} is the exchange-rate fluctuation risk, the criterion C_{13} is the political and economic risk, the criterion C_{21} is the financial fees, the criterion C_{22} is the convenience in collection procedures, the criterion C_{23} is the time efficiency of collection, the criterion C_{31} is the sales growth policy, the criterion C_{32} is the financial structure policy, the criterion C_{33} is the A/R period policy, and the criterion C_{34} is the collection method of the industry custom.

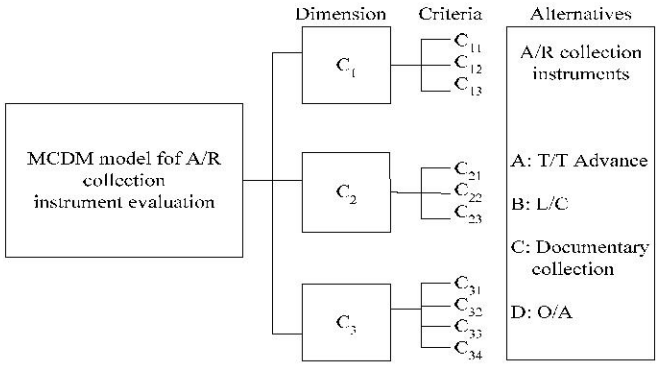

Figure 1. A multiple criteria decision-making model for A/R collection instrument evaluation

B. Analytic hierarchy process

The analytic hierarchy process [27, 28] solves complicated and subjective decision making problems. In AHP, multiple paired comparisons are based on a standardized evaluation scheme (1 =equal importance; 3 = weak importance; 5 = strong importance; 7 =demonstrated importance; 9 = absolute importance). The AHP uses pair-wise comparisons to compare n elements under given condition. Then, we convert vague verbal response into a 9-point linguistic scale. The results of the pair-wise comparisons are used to construct a judgment matrix, and then the normalized eigenvector corresponding to the maximum eigenvalue (λ_{max}) is calculated. The consistency index (C. I.) serves as the indicator of closeness to consistency. C. I. = (λ_{max}-n) / (n-1), with λ_{max} as the eigenvalue for the pair-wise comparison matrix of size n. If the C. I. <0.1, our judgment may be satisfied.

C. Fuzzy set theory

The decision-making method in fuzzy environments is discussed. An increasing number of studies deal with uncertain fuzzy problems by applying fuzzy set theory [29, 30]. Fuzzy numbers are a fuzzy subset of real numbers, and they represent the expansion of the idea of confidence interval. It is very difficult for conventional quantification to express reasonably those situations that are overtly complex or hard define [31-33]; thus, notion of a linguistic variable is necessary in such situations. A linguistic variable is a variable whose values are words or sentences in a natural or artificial language. Here we use this kind of expressions to compare four A/R collection instrument alternatives by five basic linguistic terms. Applications of the fuzzy theory in this study are describe as follows. The procedure is summarized below.

1) Fuzzy number

Fuzzy numbers are a fuzzy subset of real numbers, and they represent the expansion of the idea of confidence interval. According to the definition made by Dubois and Prade [34], Laarhoven and Pedrycz [35], triangular fuzzy number (TFN) should possess the following basic features [34, 35]. A fuzzy number A on $\mathbb{R}$ to be a TFN if its membership function $\mu_{\tilde{A}}(x):\mathbb{R}\to[0,1]$ is equal to

$$\mu_{\tilde{A}}(x)=\begin{cases}\dfrac{x-L}{M-L}, L\le x\le M,\\ \dfrac{U-x}{U-M}, M\le x\le U,\end{cases} \qquad (1)$$

$\mu_{\tilde{A}}(x)$ = 0 otherwise, where L and U stand for the lower and upper bounds of the fuzzy number $\tilde{A}$, respectively, and M is for the modal value, shown in Fig. 2.

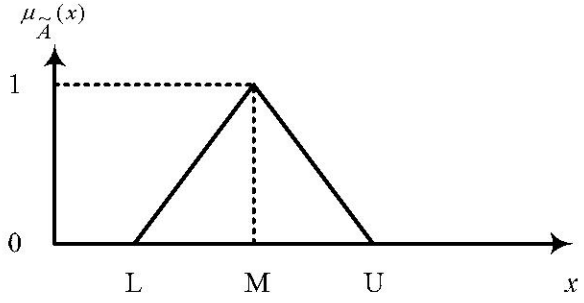

Figure 2. The membership function of the triangular fuzzy number

The TFN is denoted by $\tilde{A}=(L,M,U)$ and the following is the operation laws of two TFNs $\tilde{A}_1=(L_1,M_1,U_1)$ and $\tilde{A}_2=(L_2,M_2,U_2)$, as shown:

Addition of triangular fuzzy number $\oplus$;

$$\widetilde{A}_1 \oplus \widetilde{A}_2 = (L_1, M_1, U_1) \oplus (L_2, M_2, U_2) = (L_1 \oplus L_2, M_1 \oplus M_2, U_1 \oplus U_2) \quad (2)$$

Multiplication of triangular fuzzy number $\otimes$;

$$\widetilde{A}_1 \otimes \widetilde{A}_2 = (L_1, M_1, U_1) \otimes (L_2, M_2, U_2) = (L_1 \otimes L_2, M_1 \otimes M_2, U_1 \otimes U_2) \quad \text{for } L_i \succ 0, M_i \succ 0, U_i \succ 0 \quad (3)$$

Subtraction of triangular fuzzy number Θ; $\widetilde{A}_1 \Theta \widetilde{A}_2 = (L_1, M_1, U_1) \Theta (L_2, M_2, U_2)$

$$= (L_1 - U_2, M_1 - M_2, U_1 - L_2) \quad (4)$$

Division of triangular fuzzy number Ø; $\widetilde{A}_1 Ø \widetilde{A}_2 = (L_1, M_1, U_1) Ø (L_2, M_2, U_2) = (L_1/L_2, M_1M_2, U_1U_2)$

$$\text{for } L_i>0, \quad M_i>0, \; U_i>0 \quad (5)$$

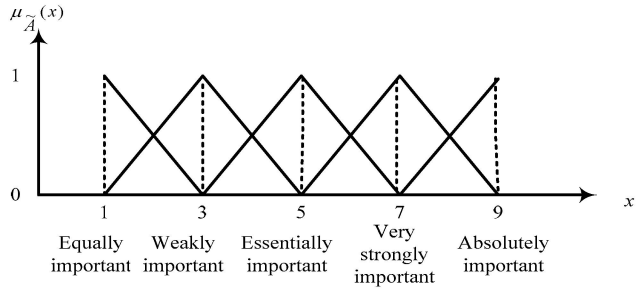

Figure 3. Membership function of linguistics variables for comparing two criteria

2) Linguistic variable

It is very difficult for conventional quantification to express reasonably those situations that are overtly complex or hard define; thus, notion of a linguistic variable is necessary in such situations [31, 32, 33]. A linguistic variable is a variable whose values are words or sentences in a natural or artificial language. Here we use this kind of expressions to compare two A/R collection evaluation criteria by five basic linguistic terms, such as "absolutely important", "very strongly important", "essentially important", "weakly important", and "equally important" with respect to a fuzzy five level scale, shown in Fig. 3.

3) Fuzzy multiple criteria decision-making

a. Alternatives measurement

Using the measurement of linguistic variable to demonstrate the criteria performance (effect-values) by expressions such as "very good", "good", "fair", "poor", "very poor", the evaluators are asked for conducting their subjective judgments, and each linguistic variable is indicated by a TFN within the scale range 0~100, as shown in Fig. 4. In addition, the evaluators can subjectively assign their personal range of linguistic variable that can indicate the membership functions of expression values of evaluator. Take $\widetilde{E}_{ij}^{k}$ to indicate the fuzzy performance value of evaluator *k* towards alternative *i* under criterion *j*, and all of the evaluation criteria will be indicated by $\widetilde{E}_{ij}^{k} = (L\widetilde{E}_{ij}^{k}, M\widetilde{E}_{ij}^{k}, U\widetilde{E}_{ij}^{k})$. Since the perception of each evaluator varies according to the evaluator's experience and knowledge, and the definitions of the linguistic variable vary as well, this study uses the notion of average value to integrate the fuzzy judgment values of *m* evaluators, that is,

$$\widetilde{E}_{ij} = \frac{1}{m} \otimes (\widetilde{E}_{ij}^{1} \oplus \widetilde{E}_{ij}^{2}, \cdots, \oplus \widetilde{E}_{ij}^{m}) \quad (6)$$

The sign $\otimes$ denotes fuzzy multiplication, the sign $\oplus$ denotes fuzzy addition, $\widetilde{E}_{ij}$ shows the average fuzzy number of judgment of the decision-makers, and is expressed by $\widetilde{E}_{ij} = (L\widetilde{E}_{ij}, M\widetilde{E}_{ij}, U\widetilde{E}_{ij})$. The end-point values $L\widetilde{E}_{ij}$, $M\widetilde{E}_{ij}$ and $U\widetilde{E}_{ij}$ are solved by Buckley [36].

$$L\widetilde{E}_{ij} = \frac{1}{m} \otimes (\sum_{k=1}^{m} LE_{ij}^{k}) \;\; ; \;\; M\widetilde{E}_{ij} = \frac{1}{m} \otimes (\sum_{k=1}^{m} ME_{ij}^{k}) ;$$

$$U\widetilde{E}_{ij} = \frac{1}{m} \otimes (\sum_{k=1}^{m} UE_{ij}^{k}) \quad (7)$$

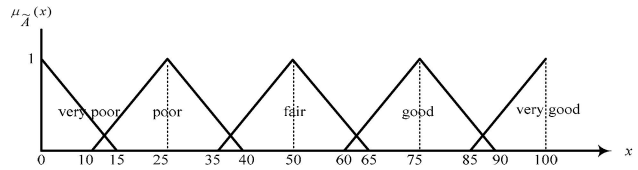

Figure 4. The membership function of linguistics variables for evaluating the collection alternatives

b. Fuzzy synthetic decision

The weights of the each criterion of A/R collection evaluation as well as the fuzzy performance values must be integrated by the calculation of fuzzy numbers, so as to be located at the fuzzy performance value (effect-value) of the integral evaluation. According to the each criterion

weight $\widetilde{w}_j$ derived by FAHP, the criteria weight, $\widetilde{w} = (\widetilde{w}_1, \cdots, \widetilde{w}_j, \cdots, \widetilde{w}_n)^t$, where the fuzzy performance matrix $\widetilde{E}$ of the alternatives is obtained from the fuzzy performance value of each alternative under *n* criteria, $\widetilde{E} = (\widetilde{E}_{ij})$. From the criteria weight vector $\widetilde{w}$ and the fuzzy performance matrix $\widetilde{E}$, the final fuzzy synthetic decision is conducted, and the derived result will be the fuzzy synthetic decision matrix $\widetilde{R}$, that is,

$$\widetilde{R} = \widetilde{E} \circ \widetilde{w}. \quad (8)$$

The sign "$\circ$" indicates the calculation of fuzzy numbers, including fuzzy addition and fuzzy multiplication. Since the calculation of fuzzy multiplication is rather complex, it is usually denoted by the approximate multiplied result of the fuzzy multiplication and the approximate fuzzy number $\widetilde{R}_i$, of the fuzzy synthetic decision of each alternative is given by $\widetilde{R}_i = (LR_i, MR_i, UR_i)$, where LR_i, MR_i **and** UR_i are the lower, middle and upper synthetic performance values of the alternative *i*, that is:

$$LR_i = \sum_{j=1}^{n} LE_{ij} \otimes Lw_j \; ; \; MR_i = \sum_{j=1}^{n} ME_{ij} \otimes Mw_j \; ;$$
$$UR_i = \sum_{j=1}^{n} UE_{ij} \otimes Uw_j \quad (9)$$

c. Ranking the fuzzy number

The result of the fuzzy synthetic decision reached by each alternative is a fuzzy number. Therefore, it is necessary that a nonfuzzy ranking method for fuzzy numbers be employed for comparison of each A/R collection alternative. In other words, the procedure of defuzzification is to locate the Best Nonfuzzy Performance (BNP) value. Methods of such defuzzified fuzzy ranking generally include mean of maximal, center of area (COA), and α–cut. To utilize the COA method to find out the BNP is a simple and practical method, and there is no need to bring in the preferences of any evaluators, so it is used in this study.

The *BNP* value of the fuzzy number $\widetilde{R}_i$ is given by

$$BNP_i = \left[\frac{(UR_i - LR_i) \oplus (MR_i - LR_i)}{3} \right] \oplus LR_i \, , \forall_i \quad (10)$$

According to the value of the derived *BNP* for each of the alternatives, the ranking of the A/R collection of each of the alternatives can then be proceed.

IV. APPLICATIONS TO IC DESIGN INDUSTRY

According to the formulated structure of A/R collection alternatives evaluation, the weights of the dimension hierarchy and criterion hierarchy for the IC design industry is analyzed. Weights and ranking were obtained by using the FAHP method.

A. Basic descriptions

According to Industrial Economics and Knowledge Center of Industrial Technology Research Institute (ITRI) in Taiwan, IC design products generally include consumer products, information products, communication products and IC supporting. Consumer products include toys, DVD/CD player and personal digital assistant (PDA), etc. Information products include printed circuit board (PCB), DVD/CD ROM and NB, etc. Communication products include wireless NIC, switch and cable modem, etc. Recently, Taiwan IC design industry develop quickly, there have excess one hundred IC design firms. About fifty firms are the initial public offerings (IPO) firms. The ranking of world is the second. Among the whole IC design firms in Taiwan, twenty firms, including nine Consumers products firms, seven Information products firms, three Communication products firms, and one Supporting firms, are randomly surveyed in our study. Only one firm is not the IPO firm. The average export rate is 53 %, and the ranking of average proportion export areas are Asian (China, Japan and Korea), U.S.A. and European. All surveyed experts are the senior financial managers with related experience around five-ten years. Generally, the weighting factors and ranking affect A/R collection may be somewhat different in different situation. There are three scenarios when considering A/R collection: new customer, not new customer but with some credit concerned and good risk-rating or reputation customer. In this paper, we focus on the first scenario; facing with the new customer.

B. Weighting factors and ranking of dimensions

According to the formulated structure of A/R collection instrument evaluation, the weighting of dimension hierarchy and criterion hierarchy can be analyzed. After interviews with twenty experts of IC design firms about the importance of evaluation dimensions and criteria, the weighting of each surveyed firm is obtained by Expert Choice [37]. The result is described as follow and listed as Table 1.

TABLE 1. SUBJECT WEIGHTS OBTAINED BY THE AHP METHOD FOR EXPERTS OF IC DESIGN FIRM

Experts/ Weighting Factors of Criteria	C_{11}	C_{12}	C_{13}	C_{21}	C_{22}	C_{23}	C_{31}	C_{32}	C_{33}	C_{34}
01	0.120	0.040	0.040	0.083	0.052	0.065	0.262	0.148	0.095	0.095
02	0.391	0.085	0.149	0.085	0.019	0.033	0.118	0.052	0.032	0.037
03	0.236	0.090	0.103	0.102	0.020	0.020	0.227	0.071	0.044	0.087
04	0.245	0.061	0.122	0.095	0.024	0.024	0.209	0.079	0.050	0.091
05	0.240	0.073	0.132	0.051	0.010	0.051	0.245	0.060	0.060	0.078
06	0.322	0.069	0.075	0.069	0.012	0.020	0.185	0.076	0.101	0.071
07	0.233	0.047	0.047	0.045	0.009	0.016	0.327	0.084	0.069	0.125
08	0.419	0.115	0.127	0.087	0.015	0.029	0.096	0.035	0.019	0.058
09	0.262	0.035	0.055	0.053	0.011	0.025	0.201	0.082	0.052	0.224
10	0.444	0.111	0.111	0.093	0.020	0.053	0.061	0.021	0.039	0.046
11	0.311	0.078	0.078	0.060	0.020	0.020	0.188	0.064	0.131	0.050
12	0.131	0.026	0.016	0.068	0.017	0.017	0.334	0.124	0.202	0.066
13	0.388	0.206	0.073	0.106	0.029	0.032	0.058	0.041	0.033	0.035
14	0.223	0.059	0.094	0.081	0.024	0.044	0.133	0.067	0.113	0.161
15	0.267	0.028	0.046	0.047	0.011	0.007	0.278	0.082	0.058	0.176
16	0.407	0.122	0.049	0.049	0.016	0.016	0.182	0.048	0.074	0.038
17	0.488	0.092	0.086	0.063	0.016	0.032	0.113	0.038	0.046	0.025
18	0.485	0.121	0.061	0.092	0.035	0.040	0.077	0.032	0.031	0.027
19	0.324	0.108	0.108	0.113	0.024	0.026	0.138	0.059	0.059	0.041
20	0.319	0.070	0.183	0.083	0.033	0.026	0.171	0.046	0.046	0.023
Average Weighting	0.313	0.082	0.088	0.076	0.021	0.030	0.180	0.065	0.068	0.078
	$C_{11}+C_{12}+C_{13}=C_1=0.482$			$C_{21}+C_{22}+C_{23}=C_2=0.127$			$C_{31}+C_{32}+C_{33}+C_{34}=C_3=0.391$			

Weighting factors of evaluation criteria across dimensions are:

$$C_{11}= (0.120 + 0.391+ 0.236 + 0.245 + 0.240 + 0.322+ 0.233 + 0.419 + 0.262 + 0.444 + 0.311 + 0.131+ 0.388 + 0.223 + 0.267 + 0.407 + 0.488 + 0.485+ 0.324 + 0.319) / 20 = 0.313, \quad (11)$$

and

$$C_{21} = (0.083 + 0.085 + 0.102 + 0.095 + 0.051 + 0.069+ 0.045 + 0.087 + 0.053 + 0.093 + 0.060 + 0.068+ 0.106+ 0.081 + 0.047 + 0.049 + 0.063 + 0.092+ 0.113 + 0.083)/ 20 = 0.076, \quad (12)$$

and

$$C_{31} = (0.262 + 0.118 + 0.227 + 0.209 + 0.245 + 0.185 + 0.327 + 0.096 + 0.201 + 0.061 + 0.188 + 0.334+ 0.058 + 0.133 + 0.278 + 0.182 + 0.113 + 0.077+ 0.138 + 0.171)/ 20 = 0.180 \quad (13)$$

Weighting factors of dimensions are:

$$C_1 = 0.313 + 0.082 + 0.088 = 0.482, \quad (14)$$

and

$$C_2 = 0.076 + 0.021 + 0.030 = 0.127, \quad (15)$$

and

$$C_3 = 0.180 + 0.065 + 0.068 + 0.078 = 0.391. \quad (16)$$

The weighting factors and ranking of the ten evaluation criteria of IC design firms are listed in Table 2. The weighting factors affecting the dimensions of IC design firms are: (1) reduction in transaction risk (C_1= 0.482); (2) compliance with firm policy (C_3= 0.391); and (3) reduction in transaction costs (C_2=0.127). The priorities of the evaluation criteria used to measure the extent to which reduction in transaction risk are as follows:

(1) The transaction partners' credit risk (C_{11}= 0.313); (2) the exchange-rate fluctuation risk (C_{12}= 0.082); (3) the politics and economy risk (C_{13}= 0.089). The average C. I. of weighting factors of dimensions (C_1, C_2 , C_3) is 0.02; The average C. I. of weighting factors of evaluation criteria across dimensions (C_{11},..,C_{34}) is 0.027. In the dimension of compliance with firm policy, IC design firms place the sales growth policy as the most important. Regarding the dimension of reduction in transaction costs, they place the financial fees as the most important.

TABLE 2. WEIGHTING FACTORS AND RANKING ACCORDING TO SURVEYED IC DESIGN FIRMS

Dimensions and Criteria	Weighting Factors and Ranking of Dimensions	Weighting Factors and Ranking of Criteria
C_1	0.482 (1)	
C_{11}		0.313 (1)
C_{12}		0.082 (4)
C_{13}		0.088 (3)
C_2	0.127 (3)	
C_{21}		0.076 (6)
C_{22}		0.021 (10)
C_{23}		0.030 (9)
C_3	0.391 (2)	
C_{31}		0.180 (2)
C_{32}		0.065 (8)
C_{33}		0.068 (7)
C_{34}		0.078 (5)

C. Ranking of A/R collection alternatives

The five linguistic variables can be expressed in TFNs. The twenty experts of IC design firms assign their subjective

judgments for the four collection instruments. By employing the eq. (6) to eq. (10), we derive the ranking for the four A/R collection instruments. The result is listed in Table 3. The result ranking the T/T advance highest, with the L/C second, the O/A third, and the documentary collection (D/A, D/P) last. This indicates that prepayment is the first choice in view of risk and cost consideration. However, when they are not able to choose the favorite instrument, the next concern is the L/C. IC design firms of Taiwan are remarkable and have strong bargaining power in international transaction. The L/C is helpful to reduce the related risk than the O/A. The reasons that the documentary collection (D/A, D/P) was ranked last could be that the reduction in transaction risk and costs are limited, and the sales growth opportunity offered is smaller than that of the O/A.

TABLE 3. RANKING OF A/R COLLECTION ALTERNATIVES

Alternative	BNP_i	Ranking
T/T Advance	65.06	1
L/C	40.99	2
Documentary collection	27.08	4
O/A	39.15	3

D. Discussion

According to the result, IC design firms care about the dimensions of reduction in transaction risk (C_1= 0.482) first; the dimensions compliance with firm policy (C_3= 0.391) second. Among the ten criteria, they care about the transaction partners' credit risk (C_{11}= 0.313) first, the sales growth policy (C_{31}= 0.180) second and the political and economic risk (C_{13}= 0.088) third. They place the convenience in collection procedures (C_{22}= 0.021) last. This indicates that when face new customer, Taiwan IC design firms care about the risk than the firm policy. Among the ten criteria, they consider the transaction partners' credit risk is the most important factor. As the China market growing, IC design export-oriented firms view transaction partners' credit and the politics and economy risk are the important factors when involving trade collection.

On the other hands, IC design firms most favor the prepayment and least favor the documentary collection (D/A, D/P) to be their choice for A/R collection instruments. Choosing the prepayment as their most favored instrument is an indication that all firms tried to avoid transaction risk and costs. The reasons that the D/A and D/P were ranked last could be that the reduction in transaction risk and costs provided by these instruments is very limited, and the sales growth opportunity provided is smaller than that of the O/A. Besides, IC design firms cared about the related risk because of the diversity customers. The L/C is helpful to the reduction of risk.

V. CONCLUSIONS

In this study, we have constructed a FMCDM model to evaluate four A/R collection instrument alternatives. To deal with the qualitative attributes in subjective judgment, this study employed fuzzy AHP methodology to determine the weights of decision criteria for each expert. Then the FMCDM approach was used to synthesize the group decision. This process enables decision makers to formalize an effective solution. It is capable of solving complicated, multi-criteria and fuzzy / vague perception problem, such as choosing the most appropriate A/R collection alternative. For IC design firms, four collection alternatives were used to exemplify the approach. We believe that it will assist the financial managers in making critical decisions during the selecting of A/R collection alternatives. The paper also revealed the concerns and preferences of those export-oriented firms. The results of this study might be of interest to authorities in the banking sector or government agencies.

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