Evaluation of Account Receivable Collection Alternatives with Fuzzy MCDM Methodology

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Abstract— In this paper, we present a fuzzy multiple criteria decision-making (FMCDM) approach to evaluation of account receivable (A/R) collection instruments. By considering the pre-payment, the letter of credit (L/C), the documentary collection (including D/A and D/P), and the open account (O/A), the FM-CDM approach is for the first time applied to investigate the A/R collection for the microelectronics and optoelectronics industries in Taiwan. According to our results, difference of the ranking preference between the two industries is observed. The ranking in the microelectronics industry is the prepayment, the L/C, the O/A and the documentary collection (D/A,D/P). The preference in the optoelectronics industry is the prepayment, the O/A, the L/C, and the documentary collection (D/A,D/P), respectively. International collection in modern unpredictable global market could be difficult unless firms have taken appropriate collection strategies. We believe that our study provides an alternative for making critical decisions during selecting A/R collection instruments.

Keywords: Account Receivable, FAHP, Fuzzy MCDM, Quantitative Method, Microelectronics, Optoelectronics, Global market, International collection.

I. INTRODUCTION

Finance managers in many firms are struggling to find a foothold in global market, where the search for profits, market share and shareholder value are rarely risk free. Every transaction involves a degree of risk. Sources of risk in international trade include the country risk, the credit (or commercial) risk, the foreign exchange risk, and the property 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 operation. 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). International collection nowadays increases difficulties significantly unless firms take appropriate collection strategies. 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.

Evolution of technology bridges exporters and importers, and establishes a measure of trust with one's trading partner. Firms are concerning about the reliability of payment for their operations overseas and longstanding partnerships with overseas suppliers. Then, they gain a familiarity with overseas markets and financial institutions that further enhance trust between trading partners. It is known that the A/R is the principal source of cash flow, and the better (or worse) management of this asset can have a significant impact on a firm's business operations. The L/C has served as the primary international trade finance tool, but it is no longer the best possible financing solution in every situation. 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 it is favorable to standpoints of marketing and sales[3]. The financial decisions of a firm are usually considered in the context of optimization. The financial theories, such as the theory of capital cost, the option theory, and the portfolio theory analyze these decisions always from an optimization perspective. For the L/C and factoring [2], [4], [5], [6], [7], [8], [9], [10], [11], [12], [13], many studies have discussed effects of using L/C or O/A. Some work explored the international A/R risk [1], [14] and the technique of A/R collections [15]. Unfortunately, they emphasize single objective when they handle A/R problem. 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 have been reported in decision making problems involving multiple criteria evaluation/selection of alternatives [16], [17], for example. Multi-criteria decision in solving financial decision problems was discussed [18], but it did involve the A/R issues marginally.

In this paper, we for the first time present a fuzzy multiple criteria decision making (FMCDM) approach to evaluation of A/R collection instruments. A scientific framework is introduced for the evaluation of A/R collection alternatives. In current methods of A/R collection instruments selection, decision makers rely on subjective criteria such as safety and convenience, together with objective criteria such as total assets/sales revenue to perform the evaluation. In doing so, they usually depend on their wisdom, experience, professional knowledge, and information that is difficult to define and/or describe exactly. However, considering the fuzziness of sub-

jective 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 microelectronics and optoelectronics industries in Taiwan. According to our results, difference of the ranking preference between the two industries is observed. The ranking in the microelectronics industry is the prepayment, the L/C, the O/A and the documentary collection. The preference in the optoelectronics industry is the prepayment, the O/A, the L/C, and the documentary collection, respectively. We believe that our study provides an alternative for making critical decisions during selecting A/R collection instruments.

This paper is organized as follows. In Sec. II, we discuss the A/R collection evaluation model and the solution methodology. In Sec. III, we show the examined results for the microelectronics and optoelectronics industries in Taiwan. Finally we draw conclusions.

II. THE A/R COLLECTION EVALUATION MODEL

A. An evaluation criteria

MCDM problems are classified into two categories, the multiple objective programming and the multiple criteria evaluation. To focus on the evaluation problems, the second category is emphasized. A typical 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, five principles, the completeness, the operational, the decomposable, the non-redundancy, and minimum size are considered. Criteria used to evaluate the A/R collection instruments are adopted from literature reviews and consultation with experts. The factors affecting the performance of A/R collection instruments are classified into three dimensions and twelve criteria. The hierarchical structure is shown in Fig.1, where C_1 is the reduction in transaction risk, C_2 is the reduction in transaction costs, and C_3 is the compliance with firm policy. The C_{11} is the reduction in transaction partners' credit risk, the C_{12} is the reduction in interest-rate fluctuation risk, the C_{13} is the reduction in exchange-rate fluctuation risk, the C_{14} is the reduction in politics and economy risk, the C_{21} is the reduction in transaction fees, the C_{22} is the convenience in collection procedures, the C_{23} is the time efficiency of collection, the C_{24} is the reduction in financial costs of collection, the C_{31} is the sales growth policy, the C_{32} is the financial structure policy, the C_{33} is the A/R period policy, and the C_{34} is the collection method of the industry custom.
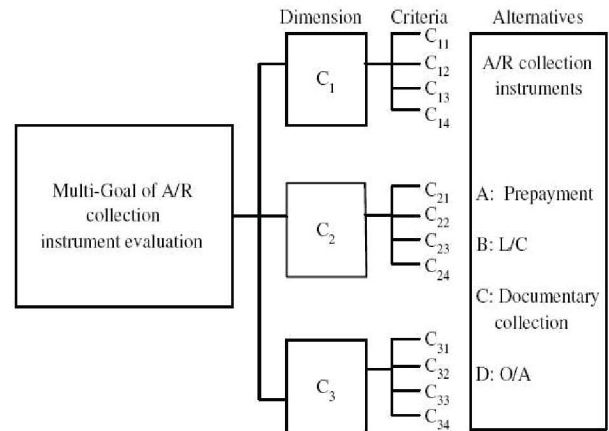

Fig. 1. A multi-criteria decision making model for A/R collection evaluation.

The key dimensions of the criteria for evaluation of A/R collection were derived through comprehensive investigation and consultation with nine experts, including two professors in international trade, two professors in financial, five senior managers of microelectronics and optoelectronics firms in Hsinchu science-based industrial park, 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], [4], [5], [6], [7], [9], [10], [11], [12], [13], [14], [15] and the expert opinions provide the basis for developing the hierarchical structure used in this study.

B. Analytic hierarchy process

The analytic hierarchy process [19], [20] 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}) can be 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 multiple criteria decision making

The decision making method in fuzzy environments is discussed. An increasing number of studies deals with uncertain fuzzy problems by applying fuzzy set theory [21], [22]. 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 [23], [24], [25]; 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 is describe as follows. The procedure is described as follow.

1) Alternatives measurement: Using the measurement of linguistic variable to demonstrate the criteria performance (effect-values) by expressions such as very good, good, fair, poor, and very poor, the evaluators are asked for conduct their subjective judgments, and each linguistic variable can be indicated by a triangular fuzzy number (TFN) within the scale range 0-100. In addition, the evaluators can subjectively assign their personal range of linguistic variable that can indicate the membership functions of expression values of evaluator.

2) 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 each criterion weight derived by FAHP, can be obtained. Whereas the fuzzy performance matrix of the alternatives cam also be obtained from the fuzzy performance value of each alternative under four criteria. From the criteria weight vector and the fuzzy performance matrix, the final fuzzy synthetic decision can be conducted.

3) 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 are employed for comparison of each A/R collection alternative. In other words, the procedure of defuzzification is to locate the best nonfuzzy performance value (BNP). To utilize the center of area (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. The BNP value of the fuzzy number can be found. 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 proceed.

III. APPLICATIONS TO MICROELECTRONICS AND OPTOELECTRONICS INDUSTRIES

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

A. Microelectronics industry

A distribution of the surveyed firms for the microelectronics industry is shown in Fig. 2. In our investigation, 9 integrated circuit (IC) manufacturing firms, 5 IC designing firms, 3 IC packaging firms, and 3 IC testing firms are randomly surveyed.

1) Weighting factors and ranking of dimensions : The weighting factors affecting the dimensions of microelectronics firms are: (1) compliance with firm policy (0.487); (2) reduction in transaction risk (0.313); and (3) reduction in
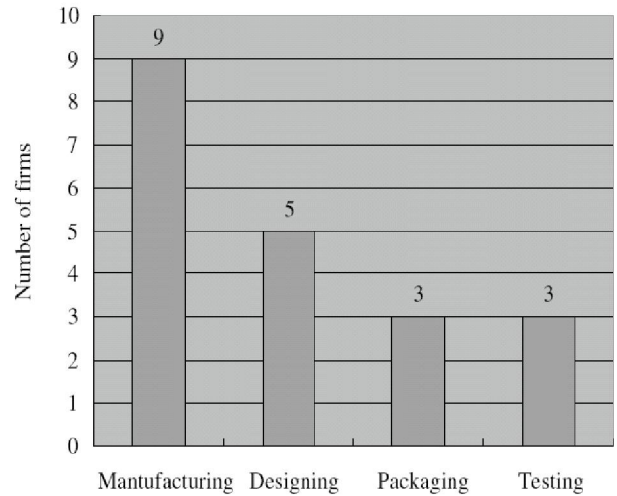
Fig. 2. A distribution of the surveyed firms for the microelectronics industry.

transaction costs (0.199). The importance of compliance with firm policy was 2.4 times higher than that of reduction in transaction costs. The priorities of the evaluation criteria used to measure the extent to which compliance with firm policy are as follows: (1) sales growth policy (0.143); (2) financial structure policy (0.124); (3) A/R period policy (0.118); and (4) collection method of the industry custom (0.102). The weighting factors and ranking of the twelve evaluation criteria of microelectronics firms are listed in Table I. In the dimension of reduction in transaction risk, microelectronics firms place the reduction in transaction risk as the most important. Regarding the dimension of reduction in transaction costs, they place time efficiency of collection as most important.

2) Ranking of A/R collection alternatives : The five linguistic variables can be expressed in TFNs. By averaging the numbers of the four collection instruments by all survey subjects in microelectronics firms experts, we derive the ranking for all of the A/R collection instruments and are listed in Table III. The result rating prepayment the highest, with L/C second, O/A third, and 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 L/C. Microelectronics firms of Taiwan, especially manufacturers, are remarkable and have strong bargaining power in international transaction. L/C is helpful to reduce the related risk than O/A. The reasons that 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 O/A.

B. Optoelectronics industry

A distribution of the surveyed firms for the optoelectronics industry is shown in Fig. 3. The distribution includes 2 liquid crystal display (LCD) firms and 15 light emitting diodes (LED) firms which cover up, middle, and downstream industries. The LED upstream covers the single crystal and and Epi-wafer
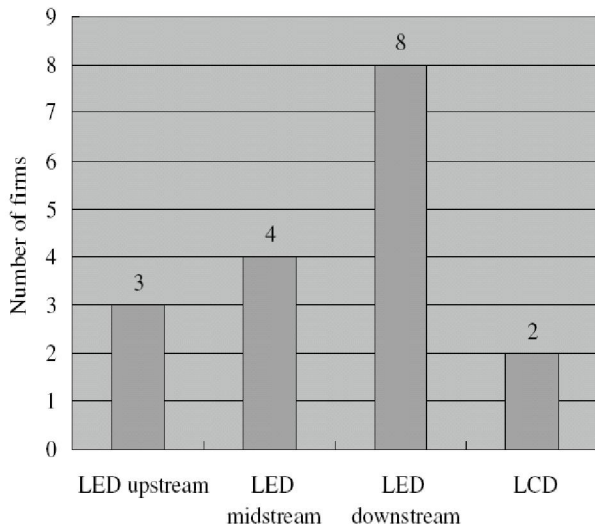
Fig. 3. A distribution of the surveyed firms for the optoelectronics industry.

manufacturing, the LED midstream means chips manufacturing, and the LED downstream consists of the packaging and testing.

1) Weighting factors and ranking of dimensions : The weighting factors of the optoelectronics firms are: (1) compliance with firm policy (0.495); (2) reduction in transaction risk (0.306); and (3) reduction in transaction costs (0.199). The importance of compliance with firm policy was 2.4 times higher than that of reducing transaction costs. The priorities of the evaluation criteria used to measure the extent to which compliance with firm policy are as follows: (1) sales growth policy (0.198); (2) financial structure policy (0.116); (3) A/R period policy (0.101); and (4) collection method of the industry custom (0.080). The weighting factors and ranking of the twelve evaluation criteria for optoelectronics firms are listed in Table II. In the dimension of reduction in transaction risk, optoelectronics firms place reduction the transaction partners' credit risk as the most important. Regarding reaching the dimension of reduction in transaction costs, they place the financial cost of collection as the most important.

2) Ranking of A/R collection alternatives : The ranking for the A/R collection instruments of optoelectronics firms and are listed in Table III. Again, the result rating prepayment the highest, with O/A second, L/C third, and documentary collection (D/A, D/P) last. This means that when optoelectronics industry firms are not able to reduce the related risk, the next concern then becomes the sales growth. O/A is helpful to sales growth. In other words, LED firms are less concerned about credit risk. One possible reason for this result could be that LED firms of Taiwan in general have longer histories. Their relationship with customers is relatively permanent and close. Presumably, they are well versed in their customers' creditworthiness. The reasons that documentary collection (D/A, D/P) was ranked last could be the same with the microelectronics firms.

IV. DISCUSSION

According to the result, there exists some consensus of the ranking preference between the two industries. The rank preferred by them is as follows: (1) compliance with firm policy; (2) reduction in transaction risk; and (3) reduction in transaction costs. The first priority among the twelve evaluation criteria is the sales growth policy. The convenience of collection procedures under the category of the reduction in transaction costs is considered the least important. The results clearly indicate that the convenience of collection procedures is not as relevant an objective for A/R collection instruments.

On the other hands, the two groups 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. In other words, the time efficiency of collection is the exporters' main concern. The reasons that 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 O/A. However, there is somewhat difference between microelectronics and optoelectronics group concerning about the second best, microelectronics group have stronger bargaining power than optoelectronics group. On the other hand, microelectronics group cared about the related risk because of the diversity customers. L/C is helpful to the reduction of risk. The optoelectronics group concerned about sales growth than credit reduction, because their stable relationship with customers. The selection of A/R collection instruments really has profound impact on not only sellers/exporters and buyers/importers, but also the revenue of the banking industry. With L/C and documentary collection volumes declining, some banks have devoted time to developing new activities - Factoring. For example, in Taiwan, Commercial Bank, Taishin Commercial Bank, and Bank SinoPac, etc. They adjust their credit policy and convince their customs of accepting the new concept. The market of factoring in Taiwan has been growing at substantial rates and most banking institutions are now actively exists.

V. CONCLUSIONS

In this study, we have constructed a FMCDM model to evaluate four A/R collection instrument alternatives. Although judging the quality of the A/R collection may be subjective, evaluation of the A/R alternative is even more so. To deal with the qualitative attributes in subjective judgment, this work employed fuzzy AHP 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 formalized an effectively solve the complicated, multi-criteria and fuzzy / vague perception problem of most appropriate A/R collection alternative selection. For microelectronics and optoelectronics firms, four collection alternatives were used to exemplify the approach. The underlying concepts were intelligible to the DM groups, and the computation is straightforward and simple. We believe that it will assist the

TABLE I

WEIGHTING FACTORS AND RANKING ACCORDING TO EXPLORED
MICROELECTRONIC FIRMS

Dimension	Weighting factors and ranking of dimensions	Weighting factors and ranking of criteria
C_1	0.313 (2)	
C_{11}		0.111(4)
C_{12}		0.062(9)
C_{13}		0.077(6)
C_{14}		0.063(8)
C_2	0.199 (3)	
C_{21}		0.040(11)
C_{22}		0.031(12)
C_{23}		0.072(7)
C_{24}		0.056(10)
C_3	0.487 (1)	
C_{31}		0.143(1)
C_{32}		0.124(2)
C_{33}		0.118(3)
C_{34}		0.102(5)

TABLE II

WEIGHTING FACTORS AND RANKING ACCORDING TO EXPLORED
OPTOELECTRONIC FIRMS

Dimension	Weighting factors and ranking of dimensions	Weighting factors and ranking of criteria
C_1	0.306 (2)	
C_{11}		0.136(2)
C_{12}		0.057(9)
C_{13}		0.051(6)
C_{14}		0.062(8)
C_2	0.199 (3)	
C_{21}		0.041(11)
C_{22}		0.040(12)
C_{23}		0.055(9)
C_{24}		0.063(6)
C_3	0.495 (1)	
C_{31}		0.198(1)
C_{32}		0.116(3)
C_{33}		0.101(4)
C_{34}		0.080(5)

TABLE III

RANKING OF A/R COLLECTION ALTERNATIVES

Alternative	Microelectronic firms		Optoelectronic firms	
	BNPi	Ranking	BNPi	Ranking
Prepayment	62.32	1	65.79	1
L/C	48.39	2	44.13	3
Documentary collection	34.66	4	35.50	4
O/A	45.36	3	49.92	2

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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