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TFT-LCD 製造之彩色濾光片供應及管理策略
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TFT-LCD 製造之彩色濾光片供應及管理策略

SUPPLY STRATEGY AND MANAGEMENT OF COLOR FILTERS FOR TFT-LCD MANUFACTURING

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中文摘要：TFT-LCD產業已處於高度競爭環境，好的供應關係為TFT-LCD製造商能夠生存和獲利的基礎。彩色濾光片佔TFT-LCD原料成本極高之比例，因此TFT-LCD製造商和彩色濾光片製造商之間的配合度便顯得非常重要。隨著全球產業的不斷進化，供應關係以及存貨管理在現今已成為熱門的研究主題之一，唯獨在TFT-LCD製造商和彩色濾光片製造商之間的合作策略目前仍尚未有相關之研究。TFT-LCD產業為全球快速發展之新興產業，且是台灣兩兆雙星之重點產業，因此TFT-LCD製造商和彩色濾光片製造商之間的關係會影響TFT-LCD廠是否能生存進而獲利之重要因素。TFT-LCD製造商面對彩色濾光片廠商必須選擇一個最佳之供應關係，以求維持及提升合作的關係。計畫內容主要是應用模糊階級程序分析（FAHP）來評估彩色濾光片製造商與TFT-LCD製造商之間買賣的供應關係。評估的準則是經過專家意見得到一致結果，研究的方法是將多項因素透過模糊階層分析而得到買賣雙方的供應關係模式。其結果將提供TFT-LCD廠商來選擇適合的彩色濾光片供應商合作模式。

關鍵詞：供應鏈關係，策略聯盟，TFT-LCD，彩色濾光片，模糊階級分析。

ABSTRACT

The TFT-LCD industry is extremely competitive, and therefore a good buyer-supply relationship is essential in order for a TFT-LCD manufacturer to survive and be profitable. Because color filters consist of the highest percentage of raw material cost, a good management of color filters is essential for the firm to attain the highest possible profit. Even though buyer-supplier relationship is a popular research topic, no research has been done on the relationship between TFT-LCD manufacturer and color filter manufacturer. Since the TFT-LCD is one of the most brilliant industries in Taiwan and is a major focus of the “Two Trillion and Twin Star” program commenced by The Ministry of Economic Affairs of Taiwan, this research is very important. To be successful, a TFT-LCD manufacturer needs to select the best form of buyer-seller relationship with color filter manufacturer and to maintain a good relationship. A fuzzy analytic hierarchy process (FAHP) model is developed to help in the evaluation of the effectiveness of different forms of buyer-seller relationships. Multiple factors that may affect the success are analyzed by incorporating experts’ opinion on their importance, and a performance ranking of the buyer-supplier types is obtained. The results can provide guidance in selecting the most appropriate form of the relationship between TFT-LCD and color filter manufacturer.

KEY WORDS
Buyer supplier relationship, Strategic alliance, TFT-LCD, Color filter, Fuzzy analytic hierarchy process.

1. Introduction

Strategic alliances are defined as inter-firm cooperative arrangements aimed at pursuing mutual strategic objectives (Das and Teng 2003). There are various types of alliances, including joint ventures, joint R&D, contracted R&D, joint production, product bundling, joint bidding, co-marketing, licensing, and code-sharing. Strategic alliances are becoming an increasingly popular strategy, particularly in high-tech industries, in which the pace of new technology and product development is remarkably high and the lifecycle of products is short (Vilkamo and Keil 2003). A dramatic increase in strategic alliances is observed in the past two decades. The trend is attributed to the firm's strategic responses to the rapid environmental changes, such as sharing risk and resources, gaining knowledge, accelerating technology advancements, building new sources of competitive advantage, concentrating on the firm's core competencies, increasing capital requirements, increasing importance of customer relationships, obtaining access to new markets, and the globalization of markets (Dacin and Hitt 1997, Chen 2003, Townsend 2003, Yasuda and Iijima 2005).

Despite the popularity of developing alliances among firms, strategic alliances often fail, and the failure rate was reported to be as high as 70% (Das and Teng 2000, Murray *et al.* 2005). Although the basic concept of alliances is well known, there are relatively few guidelines for implementing and developing strategic alliances. Therefore, in order to achieve the eventual success of the buyer-supplier relationship, a formal purchasing strategy development process, a supplier assessment and selection process, followed by the evaluation and selection of the type of collaborations are necessary.

In the digital era, thin film transistor-liquid crystal displays (TFT-LCD) are quickly becoming the preferred choice in many applications of human-machine interface. However, the profit margin of TFT-LCD is decreasing as the manufacturers enter into the mass production phase. In the fabrication of TFT-LCD panels, color filter substrate is the key component for the display to perform at its brightest, most vivid and colorful potential. However, it is one of the most expensive raw materials. The cost ratio for TFT-LCD components is quite high, and the cost of color filters is around 25% of total material cost. Color filters are usually purchased from color filter manufacturers, and each TFT-LCD panel requires a piece of color filter. Therefore, sufficient amount of color filters must be available in the plant to maintain a smooth production flow. To summarize, in order to reduce cost and ensure product availability, a good buyer-supplier relationship is especially important in TFT-LCD manufacturing.

This report is organized as follows. Section 2 reviews the theories of buyer-supplier relationships. Section 3 goes over the key concepts of benefits, opportunities, costs and risks (BOCR) methods. A fuzzy analytic hierarchy process (FAHP) model is constructed to evaluate the forms of buyer-supplier relationship in section 4. Section 5 provides a numerical example, and the proposed model is applied to evaluate the efficiency under different types of buyer-supplier relationships between a TFT-LCD manufacturer and a color filter manufacturer. Some concluding remarks are made in the last section.

2. Buyer-supplier relationships

The proliferation of strategic alliances has been increasing at an amazing rate in the past two decades across all business sectors. Strategic alliance is attractive in today's global environment because firms often lack the resources, such as skills, technology, capital and market access, to achieve a sustainable competitive advantage on their own. Whereas an alliance offers the means to obtain the benefits of vertical integration without the investment in physical and human resources associated with actual ownership (Whipple and Frankel 2000, Zineldin and Bredenlöw 2003). Between 1987 and 1992, over 20,000 new alliances were formed, with a growth rate of 25 percent a year (Harbison and Pekar 1994). According to Zineldin and Bredenlöw (2003), the number of strategic alliances has almost doubled in the past ten years and is expected to increase even more in the future. The collaboration among firms through strategic alliances, corporate mergers and acquisitions appears to have become indispensable means for firms to carry out business strategy and may even determine a firm's potential for future growth. Various types of collaborations have grown rapidly in the last decade, and collaborations will grow continuously into the twenty-first century and is very likely to be a significant trend in the industrial corporate world (Wheelen and Hungar 2000, Zineldin and Jonsson 2000, Zineldin and Bredenlöw 2003).

Even though many firms enter into some kind of inter-organizational relationship, few firms succeed eventually (Malott 1992, Michelet and Remacle 1992, Soursac 1996, Elmuti and Kathawala 2001, Zineldin and Bredenlöw 2003). Research estimated that two-thirds of the strategic alliances formed between 1992 and 1995 were dissolved (The Economist 1999, Cravens *et al.* 2000). The failure rate of strategic alliance strategies to meet partner expectations and of termination of alliances is projected to be as high as 70 percent (Kalmbach and Roussel 1999, Whipple and Frankel 2000). In spite of the fact that strategic alliance is attractive in today's global environment, it is not easy to create, develop, implement and support an alliance (Whipple and Frankel 2000, Zineldin and Bredenlöw 2003). One of the most cited reasons for alliance failure is the incompatibility of partners (Dacin and Hitt 1997). The choice of the right partner and right type of collaboration can yield important competitive benefits that lead to the success of the relationship, whereas the failure to establish compatible objectives, or to communicate effectively, can lead to detrimental problems (Dacin and Hitt 1997).

To summarize, the selection of an appropriate supplier and a right type of buyer-supplier relationship is an important factor affecting the performance of the relationship. Although the literatures on supplier selection methods and the reviews of the different forms of inter-firm links are abundant, there are very few mathematical models for evaluating the forms of relationship that is most appropriate for a firm to enter into with its supplier.

3. BOCR

One of the general theories of the analytic network process (ANP), which was also proposed by Saaty (1996), enables one to deal with the benefits, opportunities, costs, and risks (the BOCR merits) of a decision. A network can consist of four sub-networks: benefits, opportunities, costs, and risks. We can first combine the weights of the alternatives according to the weights of the criteria, which are set by experts, for each subnet. Then the weights of the alternatives under B, O, C and R are further combined to get a single outcome for each alternative. Saaty (2003) proposed five ways to combine the scores of each alternative under B, O, C and R:

1. *Additive*
   Relative priority for alternatives =
   $bB+oO+c(1/C)+r(1/R)$
   where B, O, C and R represent the synthesized results and b, o, c and r are normalized weights of B, O, C and R subnets, respectively.
2. *Probabilistic additive*
   Relative priority for alternatives =
   $bB+oO+c(1-C)_{\text{Normalized}}+r(1-R)_{\text{Normalized}}$
3. *Subtractive*
   Relative priority for alternatives =
   $bB+oO-cC-rR$
4. *Multiplicative priority powers*
   Relative priority for alternatives =
   $B^b O^o [(1/C)_{\text{Normalized}}]^c [(1/R)_{\text{Normalized}}]^r$
5. *Multiplicative*
   Relative priority for alternatives = BO/CR

The BOCR concept can also by applied by the AHP, and each subnet of the four merits is replaced by a hierarchy. The major drawback of ANP is that the questionnaire is too cumbersome, and experts may not have patience to fill it out, not to say that the consistency of judgment can be met. Therefore, in this paper we will only adopt the BOCR concept, and propose a fuzzy AHP model with two phases, as shown in Figure 1.

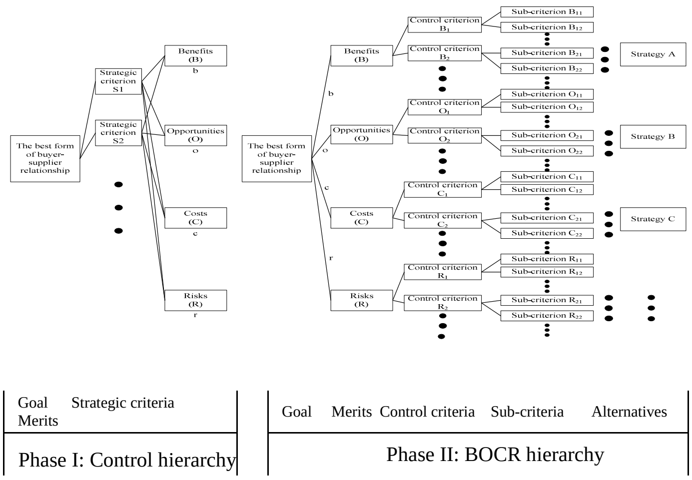

Figure 1. The framework.

4. Methodology and algorithm

A systematic fuzzy AHP model for evaluating the forms of buyer-supplier relationship is proposed in this section. The steps are summarized as follows:

Step 1. Form a committee of experts in the industry and define the buyer-supplier relationship problem. Different forms of collaboration have different impacts on a manufacturer, and the selection of an appropriate relationship is essential to be competitive in the market.

Step 2. Decompose the problem hierarchically. Two hierarchies, in the form as in Figure 1, are constructed based on literature review and experts' opinions.

Step 3. Formulate a questionnaire based on the proposed structure, and experts in the field are asked to fill out the questionnaire. There are basically two types of questions. The first type of questions is to pairwise compare the importance of strategic criteria with respect to the goal. The second type of questions is to give a rating of the importance of each merit on each strategic criterion, the importance of each control criterion on each merit, the importance of each sub-criterion on each control criterion, and the performance of each strategy on each sub-criterion (Cheng, 1996, Chen and Cheng, 2005, Lee *et al.* 2006, Kang and Lee 2006, Saaty 2005, Saaty and Ozdemir 2003).

Step 4 Phase I calculations. Calculate the relative weights, b, o, c and r, for the four merits B, O, C and R.

Step 4.1 From experts' questionnaire results, obtain pairwise comparison results of the importance of strategic criteria toward achieving the overall objective. A five-point scale is used to express preferences among strategic criteria *p* and *q* by experts, η_{pqt}, as equally (1), moderately (3), strongly (5), very strongly (7), or extremely preferred (9), and the reciprocal of the value is used to express less preference. For example, if strategic criterion S1 is strongly important than strategic criterion S2 under the evaluation of expert 1, then $\eta_{121} = 5/1 = 5$. On the other hand, if S2 is strongly important than S1, then $\eta_{121} = 1/5$. The consistency property of each expert's comparison results is examined. If an inconsistency is found in an expert's result, the expert is asked to revise the questionnaire until a consistency is met.

Step 4.2 Combine experts' opinions on the importance weight for each strategic criterion. For a number of ***S*** experts, the synthetic set representing the relative importance level between strategic criteria *p* and *q* can be generated by geometric average as (Kuo *et al.* 2002; Lee *et al.* 2006):

$$\bar{\eta}_{pq} = \left(\prod_{t=1}^{s} \eta_{pqt} \right)^{\frac{1}{s}}, \forall \quad t = 1, 2, ..., s. \qquad (4)$$

$$\beta = \begin{bmatrix} \bar{\eta}_{11} & \bar{\eta}_{12} & \cdots & \bar{\eta}_{1n} \\ \bar{\eta}_{21} & \bar{\eta}_{22} & \cdots & \bar{\eta}_{2n} \\ \vdots & \vdots & \bar{\eta}_{pq} & \vdots \\ \bar{\eta}_{n1} & \bar{\eta}_{n2} & \cdots & \bar{\eta}_{nn} \end{bmatrix} \qquad (5)$$

where $\bar{\eta}_{qp} = \begin{cases} \bar{\eta}_{pq}^{-1}, & if \quad p \neq q \\ 1 \quad , & if \quad p = q \end{cases}$

$$\alpha_p = \sum_{q=1}^{n} \bar{\eta}_{pq}, \forall \quad p = 1,2,...,n \qquad (6)$$

$$Z_p = \alpha_p \Big/ \sum_{p=1}^{n} \alpha_p, \forall \quad p = 1,2,...,n. \qquad (7)$$

Step 4.3 Establish fuzzy importance weight for each strategic criterion. By synthesizing experts' opinions, the weights of strategic criteria can be represented by a weight vector, $\tilde{\mathbf{w}}$ (Mon *et al.* 1994, Cheng *et al.* 1999, Lee *et al.* 2006):

$$\tilde{\mathbf{w}} = \begin{bmatrix} \tilde{w}_1 \\ \tilde{w}_2 \\ . \\ \tilde{w}_p \\ . \\ \tilde{w}_n \end{bmatrix} \qquad (8)$$

where $\tilde{w}_p = \tilde{1},\tilde{3},\tilde{5},\tilde{7},\tilde{9}$, and are defined as in Table 1.

Table 1. Characteristic function of the fuzzy numbers.

Fuzzy number	Characteristic (Membership) function
$\tilde{1}$	(1, 1, 3)
$\tilde{\mathbf{x}}$	(***x*** –2, ***x***, ***x***+2) for ***x*** =3,5,7
$\tilde{9}$	(7, 9, 9)

Step 4.4 Calculate fuzzy importance (impact) of each merit on each strategic criterion. Obtain experts' opinions on the importance (impact) of the merit (B, O, C and R) on each strategic criterion by a five-point scale (from very unimportant (1) to very important (9)). The approach is not a pairwise comparison of two merits with respect to each strategic criterion, but is based on the approach proposed by Satty (2005) and Saaty and Ozdemir (2003). A rating is given by each expert on the level of benefit (opportunity, cost or risk) on that strategic criterion. A triangular fuzzy number $\tilde{D}_{ep}$ is obtained by combining the experts' opinions.

$$\tilde{D}_{ep} = (l_{ep}, m_{ep}, u_{ep}) \qquad (9)$$

where $l_{ep} = \min(k_{ept}), \forall \quad t = 1, 2, ..., s \qquad (10)$

$$u_{ep} = \max(k_{ept}), \forall \quad t = 1, 2, ..., s \qquad (11)$$

$$m_{ep} = \left(\frac{\prod_{t=1}^{s} k_{ept}}{l_{ep} \times u_{ep}} \right)^{\frac{1}{(s-2)}}, \forall \quad t = 1, 2, ..., s. \qquad (12)$$

and k_{ept} is the importance weight of merit *e* (benefits, costs, opportunities, risks) on strategic criterion *p* from expert *t*.

Step 4.5 Prioritize the relative importance of the four merits by considering their ratings on the strategic criteria. The fuzzy priority of a merit is obtained by summing up the multiplication of the fuzzy importance weight for each strategic criterion from Step 4.3 and the fuzzy importance (impact) of the merit on each strategic criterion from Step 4.4. The resulted fuzzy priority of each merit is assumed to be a triangular fuzzy number (Kaufmann and Gupta 1991, Chen 1996, Cheng *et al.* 1996). By applying the centroid method, a defuzzified priority for each merit is obtained. The deffuzified priorities for the four merits are normalized into b, o, c and r.

Step 5 Phase II calculations. Calculate the fuzzy ranking of alternatives under each merit (B, O, C and R).

Step 5.1 Obtain the importance weight of each control criterion (and sub-criterion) by a similar step as Step 4.4.

Step 5.2 Calculate the integrated normalized priority of each sub-criterion under each merit. A fuzzy integrated priority of each sub-criterion is calculated by multiplying the importance weight of the sub-criterion with the importance weight of its upper-level control criterion. The fuzzy integrated priority of each sub-criterion is defuzzified into an integrated defuzzified priority by the centroid method. The integrated defuzzified priorities under the same merit are normalized into normalized integrated priorities.

Step 5.3 Obtain the performances of each alternative under each quantitative sub-criterion by experts' forecasting. Normalize the value into a number between zero and one:

- For direct sub-criterion j :

$$\rho_{ij} = (r_{ij} - R_j^-)/(R_j^+ - R_j^-) \quad (13)$$

- For inverse sub-criterion j :

$$\rho_{ij} = (r_{ij} - R_j^+)/(R_j^- - R_j^+) \quad (14)$$

where $R_j^+ = \max_i \{r_{ij}\}$, $R_j^- = \min_i \{r_{ij}\}$, $0 \le \rho_{ij} \le 1$, and r_{ij} is the value of sub-criterion j in evaluating alternative i.

Step 5.4 Obtain the performances of each alternative under each qualitative sub-criterion. The performances of alternatives under each qualitative sub-criterion are generated through expert's evaluations since these data may not be quantified. Five levels of evaluation are used here and their linguistic values are as in Table 2. Experts' opinions are collected through questionnaire, and the same procedure as Step 4.4 is applied here.

Table 2. Linguistic value table.

Language	Quantitative value
Very good	1
Good	0.75
Fair	0.5
Poor	0.25
Very poor	0.1

Step 5.5 Determine the relative performance of alternatives with respect to each control criterion by forming a matrix for each control criterion. Use the data generated from Step 5.3 and 5.4, the performances of alternatives in each sub-criterion under the same control criterion are entered in the matrix.

Step 5.6 Synthesize and establish the fuzzy ranking of alternatives under each merit (B, O, C and R) by combining the results from Step 5.2 and 5.5.

Step 6 Calculate overall priorities of alternatives by combining BOCR priorities of each alternative from Step 5.6 with corresponding normalized weights b, o, c and r from Step 4.5. As stated in section 3.3, there are five ways to combine the scores of each alternative under B, O, C and R.

5. Application of the model on a TFT-LCD manufacturer

Since color filters is one of the most critical and the most expensive components in TFT-LCD manufacturing; therefore, in this paper, we propose to build a model for selecting the most appropriate buyer-supplier relationship between TFT-LCD manufacturer and color filter manufacturer. A committee of experts in the TFT-LCD industry is formed to define the buyer-supplier relationship problem between TFT-LCD manufacturers and color filter manufacturers. The research scope is on TFT-LCD plants with fifth generation or lower. With a comprehensive review of literature, consultation with domain experts and consideration of data accessibility, the hierarchy and the factors for determining the efficiency of a TFT-LCD manufacturer in terms of a buyer-supplier relationship form is organized. Four forms of buyer-supplier relationships, which are currently possible and are highly recommended to form with the target color filter manufacturer, are considered here: contractual alliance (I), minority equity ownership (II), joint venture (III) and acquisition (IV).

The final ranking of the alternatives are calculated by the five methods to combine the scores of each alternative under B, O, C and R. Under all the five methods of synthesizing the scores of alternatives, minority equity ownership (II) ranks the first. Contractual alliance (I) ranks the second under all the methods except probabilistic additive method and subtractive method. Under probabilistic additive method, joint venture (III) ranks the second with a score of 0.46998 and contractual alliance (I) ranks the third with 0.46680 (an insignificant difference of 0.00318). Under subtractive method, acquisition (IV) ranks the second with a score of 0.05494 and contractual alliance (I) ranks the third with 0.03380. The major reason for minority equity ownership (II) being the best alternative is that it is the least risky and rather costless alternative. Even though minority equity ownership (II) performs the worst in the benefits and opportunities merits, but the difference from the performance of other alternatives are not tremendous. On the other hand, it is the second best in the costs merit, with an insignificant performance difference from the best alternative, contractual alliance (I). The most important thing is that it performs best in the risks merit, with the lowest normalized priority of 0.11023, which is two times better than the second best alternative, joint venture (III), and 3.5 times better than the worst alternative, acquisition (IV). Therefore, minority equity ownership (II) is the best alternative with experts' overall consideration of benefits, opportunities, costs and risks.

6. Conclusions

In this report, a fuzzy analytic hierarchy process (AHP) model is constructed to evaluate the forms of buyer-supplier relationship. Even though there are many supplier selection models available, the models usually only consider the criteria that are required by the buyers, but not the opportunities, costs and risks that need to be faced by the buyers if they select a specific supplier. In addition, in author's knowledge, there is no mathematical model that can help a firm to evaluate the various types of buyer-supplier relationship. Therefore, the proposed model can help decision makers in the buyer-supplier relationship selection process by considering the benefits, opportunities, costs and risks (BOCR) perspectives. Because human decision making process involves ambiguity and uncertainty, fuzzy theory is also incorporated into the model.

By applying the proposed model, decision makers in the TFT-LCD manufacturer can base on the results to examine the expected performance of each relationship form on various criteria and sub-criteria, and can select the most appropriate form of relationship with its color filter manufacturer. The model can also be modified as required by a firm in any other industry to help it selecting the best form of buyer-supplier relationship.

References

Chen, C.J., The effects of environment and partner characteristics on the choice of alliance forms. *International Journal of Project Management*, 2003, **21**, 115-124.

Chen, L.S. and Cheng, C.H., Selecting IS personnel use fuzzy GDSS based on metric distance method. *European Journal of Operational Research*, 2005, **160**, 803-820.

Chen, S.M. Evaluating weapon systems using fuzzy arithmetic operations. *Fuzzy Sets and Systems*, 1996, **77**, 265-276.

Cheng, C.H., Evaluating naval tactical missile systems by fuzzy AHP based on the grade value of membership function. *European Journal of Operational Research*, 1996, **96**, 343-350.

Cheng, C.H., Evaluating weapon systems using ranking fuzzy numbers. *Fuzzy Sets and Systems*, 1999, **107**, 25-35.

Cravens, K., Piercy, N. and Cravens, D., Assessing the performance of strategic alliances: matching metrics to strategies. *European Management Journal*, 2000, **18**(5), 529-541.

Dacin, M.T. and Hitt, M.A., Selecting partners for successful international alliances: examination of U. S. and Korean firms. *Journal of World Business*, 1997, **32**(1), 3-16.

Das, T.K. and Teng, B.-S., A resource-based theory of strategic alliances. *Journal of Management*, 2000, **26**(1), 31-61.

Das, T.K. and Teng, B.-S., Partner analysis and alliance performance. *Scandinavian Journal of Management*, 2003, **19**, 279-308.

Elmuti, D. and Kathawala, Y., An overview of strategic alliances. *Management Decision*, 2001, **39**(3), 2005-2017.

Harbison, J. and Pekar, P.J., *A practical guide to alliances: leapfrogging the learning curve*, 1994 (Viewpoint-Booz-Allen and Hamilton: Los Angeles).

Kalmbach, C. Jr. and Roussel, C., Dispelling the myths of alliances. *Outlook*, 1999, October, 5-32.

Kang, H.-Y. and Lee, A.H.I., Priority mix planning for semiconductor fabrication by fuzzy AHP ranking. *Expert Systems with Applications*, **32**, 2006, 560-570.

Kaufmann, A., Gupta, M.M., *Introduction to Fuzzy Arithmetic Theory and Applications*, 1991 (Van Nostrand Reinhold: New York).

Kuo, R.J., Chi, S.C. and Kao, S.S., A decision support system for selecting convenience store location through integration of fuzzy AHP and artificial neural network. *Computers in Industry*, 2002, **47**, 199-214.

Lee, A.H.I., Kang, H.Y. and Wang, W.P., Analysis of priority mix planning for semiconductor fabrication under uncertainty. *International Journal of Advanced Manufacturing Technology*, 2006, **28**, 351-361.

Malott, R.H., Managing the global enterprise. *Executive Speeches*, 1992, **7**(4), 6-10.

Michelet, R. and Remacle, R., Forming successful strategic marketing alliance in Europe. *Journal of European Business*, 1992, **4**(1), 11-15.

Mon, D.L., Cheng, C.H. and Lin, J.C., Evaluating weapon system using fuzzy analytical hierarchy process based on entropy weight, *Fuzzy Sets and Systems*, 1994, **62**, 127-134.

Murray, J.Y., Kotabe, M. and Zhou, J.N., Strategic alliance-based sourcing and market performance: evidence from foreign firms operating in China. *Journal of International Business Studies*, 2005, **36**, 187-209.

Saaty, R.W., *Decision Making in Complex Environment: The Analytic Hierarchy Process (AHP) for Decision Making and the Analytic Network Process (ANP) for Decision Making with Dependence and Feedback*, 2003 (Super Decisions: Pittsburgh).

Saaty, T.L., *Decision Making with Dependence and Feedback: The Analytic Network Process*, 1996 (RWS Publications: Pittsburgh).

Saaty, T.L., *Theory and Applications of the Analytic Network Process: Decision Making with Benefits, Opportunities, Costs, and Risks*, 2005 (RWS Publications: Pittsburgh)

Saaty, T.L. and Ozdemir, M., Negative priorities in the analytic hierarchy process. *Mathematical and Computer Modelling*, 2003, **37**, 1063-1075.

Soursac, T., When the hub spoke. *The Alliance Analyst*, 1996, 1-4. http://www.allianceanalyst.com

The Economist (1999), Flying in circles, **17**, 57-59.

Townsend, J.D., Understanding alliances: a review of international aspects in strategic marketing. *Marketing Intelligence & Planning*, 2003, **21**(3), 143-156.

Vilkamo, T. and Keil, T., Strategic technology partnering in high velocity environments-lessons from a case study. *Technovation*, 2003, **23**, 193-204.

Wheelen, T.L. and Hungar, D.J., *Strategic Management and Business Policy*, 2000 (Addison-Wesley: New York).

Whipple, J.M. and Frankel, R., Strategic alliance success factors. *Journal of Supply Chain Management*, 2000, **36**(3), 21-28.

Yasuda, H. and Iijima, J., Linkage between strategic alliances and firm's business strategy: the case of semiconductor industry. *Technovation*, 2005, **25**, 513-521.

Zineldin, M. and Bredenlöw, T., Strategic alliance: synergies and challenges: a case of strategic outsourcing relationship "SOUR". *International Journal of Physical Distribution & Logistics Management*, 2003, **33**(5), 449-464.

Zineldin, M. and Jonsson, P., An examination of the main factors affecting trust/commitment in supplier-dealer relationships: an empirical study of Swedish wood industry. *The TQM Magazine*, 2000, **12**(4), 245-65.

計畫成果自評

本計畫之相關成果已發表於國際研討會並已受 SCI 級國際期刊接受。

International conference:

A buyer-supplier relationship evaluation model with the consideration of benefits, opportunities, costs and risks, *The 13th Asia Pacific Management Conference*, Melbourne, Australia, pp. 753-759.

SCI journal:

A fuzzy AHP evaluation model for buyer-supplier relationships with the consideration of benefits, opportunities, costs and risks, *International Journal of Production Research*, accepted. (SCI)

行政院國家科學委員會補助國內專家學者出席國際學術會議報告

96 年 11 月 29 日

附件三

報告人姓名	李欣怡	服務機構及職稱	工業工程與系統管理學系副教授
會議 時間 地點	自 96 年11月18日至 96 年11 月 20 日 Melbourne, Australia	本會核定補助文號	NSC 96-2416-H-216-002
會議名稱	(中文) 第 13 屆亞太管理會議 (英文) The 13th Asia Pacific Management Conference		
發表論文題目	(中文) 考量優勢、機會、成本、風險之買賣關係評估模式 (英文) A Buyer-Supplier Relationship Evaluation Model with the Consideration of Benefits, Opportunities, Costs and Risks		

報告內容應包括下列各項：

一、參加會議經過

The 13th Asia Pacific Management Conference was a major forum for international researchers and professionals to present their latest research, results, and ideas in all areas of management. The theme of the conference is "Managing Transitions in the Asia Pacific: Globalization and Localization". The conference comprises 176 papers that were offered in 19 parallel streams. The papers are from many areas of management and have been organized into the following streams, including customer relationship management, design planning and management, design support systems, E-commerce, E-marketing, financial management, human resources and cross-cultural management, information systems/information technology management, innovation management, knowledge management, operations and technology management, operations research and quantitative methods, organization and purchasing management, performance evaluation, performance evaluation and consumer research, product development and operations management, strategic management, supply chain management, and technology adoption. The conference featured one distinguished keynote speaker, Professor Ron Weber (Dean, Faculty of Information Technology, Monash University, Australia), with topic "Some Futures of Universities in an IT-enabled, Globalized World."

二、與會心得

The scientific level of a conference is controlled by the quality of the reviews. Each paper was blind peer-reviewed. In the conference, I presented a paper entitled "A buyer-supplier relationship evaluation model with the consideration of benefits, opportunities, costs and risks," and the topic attracted the attention of attendants because the issue has not been researched in the past. I also served as a session chair of Session E1- "Performance Evaluation," and this gave me, Chung Hua University and Taiwan, a great opportunity to be known by other scholars.

三、考察參觀活動(無是項活動者省略)

None.

四、建議

Even though the NSF funds us for attending conferences overseas, the funding is limited. The total expenditures incurred were much higher than the supports from the NSC. In order to share research findings and practical experiences with scholars in other parts of the world and to enhance our research ability, I sincerely suggest the NSC to adjust airfare quotes and daily allowances overseas to meet the real market prices and to increase the funding for teachers who are willing to present in international conferences.

五、攜回資料名稱及內容

1. Conference Program: The 13th Asia Pacific Management Conference.
2. CD of the proceedings.

六、其他

Proceedings of the 13th Asia Pacific Management Conference, Melbourne, Australia, 2007, 753-759

A Buyer-Supplier Relationship Evaluation Model with the Consideration of Benefits, Opportunities, Costs and Risks

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Abstract

During the past two decades, the nature of buyer-supplier relationships has been undergoing dramatic changes. With increasingly fierce global competition, firms in various industries need to build a cooperative buyer-supplier relationship to survive and to acquire reasonable profit. Despite the popularity of developing alliances among firms, strategic alliances often fail, and the failure rate was reported to be as high as 70%. Therefore, in order to achieve the eventual success of the buyer-supplier relationship, a formal purchasing strategy development process, a supplier assessment and selection process, followed by the evaluation and selection of the type of collaborations are necessary. The main objective of this study is to propose an analytical approach to evaluate the forms of buyer-supplier relationship between a manufacturer and its supplier. A fuzzy analytic hierarchy process (AHP) model, which applies fuzzy set theory and the benefits, opportunities, costs and risks (BOCR) concept, is constructed to deal with uncertainty and to consider various aspects of alternatives. Multiple factors that affect the success of the relationship are analyzed by incorporating experts' opinions on their priority of importance, and a performance ranking of the buyer-supplier forms can be obtained. The proposed model is a general form that can be tailored and applied by firms that are making decisions on buyer-supplier relationship.

Keywords: Buyer-supplier relationship; Fuzzy analytic hierarchy process; Performance ranking; BOCR; TFT-LCD

1. Introduction

With increasingly fierce global competition, firms in various industries need to build a cooperative buyer-supplier relationship to survive and to acquire reasonable profit. One of the most important trends in industrial purchasing is the radical change in buying attitudes and behavior. Buyer and supplier ties have become closer with a myriad of collaborative strategies instead of the traditional arm's length transaction. Many firms are shrinking and consolidating their supplier base and developing longer-term, closer inter-firm relationships, such as strategic alliances and joint ventures, with some of the remaining key suppliers to achieve strategic goals that range from cost and risk reduction to new skills or knowledge acquisition. These collaborations can improve the competitiveness of companies in complex and turbulent environments by providing access to external resources, by providing synergies and by fostering rapid learning and change.

Strategic alliances are defined as inter-firm cooperative arrangements aimed at pursuing mutual strategic objectives. There are various types of alliances, including joint ventures, joint R&D, contracted R&D, joint production, product bundling, joint bidding, co-marketing, licensing, and code-sharing. Strategic alliances are becoming an increasingly popular strategy, particularly in high-tech industries, in which the pace of new technology and product development is remarkably high and the lifecycle of products is short. A dramatic increase in strategic alliances is observed. The trend is attributed to the firm's strategic responses to the rapid environmental changes, such as sharing risk and resources, gaining knowledge, accelerating technology advancements, building new sources of competitive advantage, concentrating on the firm's core competencies, increasing capital requirements, increasing importance of customer relationships, obtaining access to new markets, and the globalization of markets.

Even though many firms enter into some kind of

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inter-organizational relationship, few firms succeed eventually (Malott, 1992; Michelet and Remacle, 1992; Soursac, 1996; Elmuti and Kathawala, 2001; Zineldin and Bredenlöw, 2003). Research estimated that two-thirds of the strategic alliances formed between 1992 and 1995 were dissolved (The Economist, 1999; Cravens et al., 2000). The failure rate of strategic alliance strategies to meet partner expectations and of termination of alliances is projected to be as high as 70 percent (Kalmbach and Roussel, 1999; Whipple and Frankel, 2000). Although the basic concept of alliances is well known, there are relatively few guidelines for implementing and developing strategic alliances. Therefore, in order to achieve the eventual success of the buyer-supplier relationship, a formal purchasing strategy development process, a supplier assessment and selection process, followed by the evaluation and selection of the type of collaborations are necessary.

The literatures on various types of collaborations between firms are abundant and the works on supplier selection models are numerous, but the research that provides a mathematical model for the selection of the most appropriate form of buyer-supplier relationship is very limited. Existing buyer-supplier evaluation models usually only consider the benefits from the relationship, but not the opportunities, costs and risks that may need to confront.

The goal of this research is to propose an analytical approach to evaluate the forms of buyer-supplier relationship between a manufacturer and its supplier. The rest of this paper is organized as follows. Section 2 reviews the key concepts of analytic hierarchy process (AHP), fuzzy AHP, and benefits, opportunities, costs and risks (BOCR) methods. A fuzzy analytic hierarchy process (FAHP) model is constructed to evaluate the forms of buyer-supplier relationship in section 3. Section 4 provides a case study that applies the proposed model to evaluate the efficiency under different types of buyer-supplier relationships between TFT-LCD manufacturer and color filter manufacturer. Some concluding remarks are made in the last section.

2. AHP, fuzzy AHP, and BOCR

2.1 AHP

Introduced by Saaty in 1971, the analytic hierarchy process (AHP) has become one of the most widely used methods for multiple criteria decision-making (MCDM) (Saaty, 1980). It can solve unstructured problems in different areas of human needs and interests. The procedures of AHP to solve a complex problem involve six essential steps (Zahedi, 1986; Cheng et al., 1999; Murtaza, 2003; Lee et al., 2006):

1. Define the unstructured problem and state clearly the objectives and outcomes;
2. Decompose the problem into a hierarchical structure with decision elements (e.g., criteria and alternatives);
3. Employ pairwise comparisons among decision elements and form comparison matrices;
4. Use the eigenvalue method to estimate the relative weights of the decision elements;
5. Check the consistency property of matrices to ensure that the judgments of decision makers are consistent; and
6. Aggregate the relative weights of decision elements to obtain an overall rating for the alternatives.

2.2 Fuzzy AHP

Fuzziness and vagueness are common characteristics in many decision-making problems, and good decision-making models should be able to tolerate vagueness or ambiguity since (Yu, 2002). The transformation of qualitative preferences to point estimates in an evaluation may not be sensible since experts very naturally provide uncertain answers rather than precise values. Therefore, pairwise comparison under traditional AHP may not be appropriate due to the necessity of selecting arbitrary values in the process. Uncertainty should be considered in some or all of the pairwise comparison values, and the use of fuzzy numbers and linguistic terms may be more suitable (Yu 2002). The fuzzy theory in AHP should be more appropriate and effective than conventional AHP in an uncertain pairwise comparison environment.

Different methods have been devised to rank fuzzy numbers, and each method has its own advantages and disadvantages (Klir and Yuan, 1995). This research uses the centroid ranking method (Yagar, 1978). Let $f_c(x)$ be a membership function for triangular fuzzy number $C = (p,q,s)$, the centroid ranking method formula of triangular fuzzy number C is :

$$R(C) = \int x f_C(x)dx \Big/ \int f_C(x)dx \tag{1}$$

Define $C_i = (p_i, q_i, s_i)$, $i = 1,2,\dots,n$ be n triangular fuzzy numbers. By the formula stated above, one can obtain the centroid rank value of triangular fuzzy number:

$$R(C_i) = \left[\frac{1}{q_i - p_i}\left(\frac{1}{3}q_i^3 - \frac{1}{2}q_i^2 p_i + \frac{1}{6}p_i^3\right) + \frac{1}{s_i - q_i}\left(\frac{1}{3}q_i^3 - \frac{1}{2}q_i^2 s_i + \frac{1}{6}s_i^3\right)\right] \Big/ \left[\frac{1}{2}(s_i - p_i)\right] \tag{2}$$

Finally, the centroid rank value of triangular fuzzy numbers is:

$$R(C_i) = \tfrac{1}{3}(p_i + q_i + s_i) \tag{3}$$

2.3 AHP

Saaty (1996) proposed a general theory of the analytic network process (ANP), called the benefits, opportunities, costs, and risks (the BOCR merits). A network (hierarchy) can consist of four sub-networks (hierarchies): benefits, opportunities, costs, and risks. Under benefits (B) and opportunities (O), pairwise comparison questions ask which alternative is most beneficial or has the best opportunity under each control criterion/sub-criterion. Under risks (R) and costs (C), the pairwise comparison questions ask which alternative is riskiest or costliest under each control criterion/sub-criterion. Therefore, while the best alternative gets the highest priority for B and C subnets, the worst alternative also gets the highest priority for R and C. The weights of the alternatives under each sub-network (hierarchy) can be calculated based on the opinions of experts. These weights are further combined to get a single outcome for each alternative. Saaty (2003) proposed five ways to combine the scores of each alternative under B, O, C and R:

1. *Additive*
   Relative priority for alternatives =
   $bB+oO+c(1/C)_{\text{Normalized}} + r(1/R)_{\text{Normalized}}$
   where B, O, C and R represent the synthesized results and b, o, c and r are normalized weights of B, O, C and R subnets, respectively.
2. *Probabilistic additive*
   Relative priority for alternatives =
   $bB+oO+c(1-C)+r(1-R)$
3. *Subtractive*
   Relative priority for alternatives = $bB+oO-cC-rR$
4. *Multiplicative priority powers*
   Relative priority for alternatives =
   $B^b O^o [(1/C)_{\text{Normalized}}]^c [(1/R)_{\text{Normalized}}]^r$
5. *Multiplicative*
   Relative priority for alternatives = BO/CR

3. FAHP model with BOCR

A systematic fuzzy AHP model for evaluating the forms of buyer-supplier relationship is proposed in this section. The steps are summarized as follows:

Step 1: Form a committee of experts in the industry and define the buyer-supplier relationship problem. Different forms of collaboration have different impacts on a manufacturer, and the selection of an appropriate relationship is essential to be competitive in the market.

Step 2: Decompose the problem hierarchically. Two hierarchies, in the form as in Figure 1, are constructed based on literature review and experts' opinions. For the control hierarchy, the overall objective is to achieve the most efficient performance of a manufacturer through maintaining the best form of buyer-supplier relationship. The strategic criteria for achieving the overall objective are in the second level, and each of the strategic criteria can be considered as sub-goals that the firm is willing to realize (Erdogmus et al. 2005). The four merits, benefits (B), opportunities (O), costs (C) and risks (R), for the evaluation of the best form of buyer-supplier relationship are in the third level. The purpose of control hierarchy is to calculate the relative weights, b, o, c and r, for the four merits B, O, C and R, respectively (Saaty and Ozdemir, 2003; Saaty, 2005). The overall objective of the second hierarchy, the BOCR hierarchy, is also to select the best form of buyer-supplier relationship. BOCR are considered simultaneously to achieve the goal. Under each merit, there are control criteria and other sub-criteria. The forms of buyer-supplier relationship are alternatives in the lowest level. The relative weights of BOCR, obtained from the calculation of the first hierarchy, are input here to calculate the overall priority weight of each alternative.

Step 3: Formulate a questionnaire based on the proposed structure, and experts in the field are asked to fill out the questionnaire. There are basically two types of questions. The first type of questions is to pairwise compare the importance of strategic criteria with respect to their upper-level factor. The second type of questions is to give a rating of the importance of each merit on each strategic criterion, the importance of each control criterion on each merit, the importance of each sub-criterion on each control criterion, and the performance of each strategy on each sub-criterion.

Step 4: Phase I calculations. Calculate the relative weights, b, o, c and r, for the four merits B, O, C and R based on control hierarchy.

Step 4.1: From experts' questionnaire results, obtain pairwise comparison results of the importance of strategic criteria toward achieving the overall objective. A five-point scale is used to express preferences among options as equally (1), moderately (3), strongly (5), very strongly (7), or extremely preferred (9), and the reciprocal of the value is used to express less preference. For example, if S1 is strongly important than S2, then S1/S2=5/1. On the other hand, if S2 is strongly important than S1, then S1/S2=1/5. The consistency property of each expert's comparison results is examined. If an inconsistency is found in an expert's result, the expert is asked to revise the questionnaire until a consistency is met.

Step 4.2: Combine experts' opinions on the importance weight for each strategic criterion. For a number of **S** experts, the synthetic set representing the relative

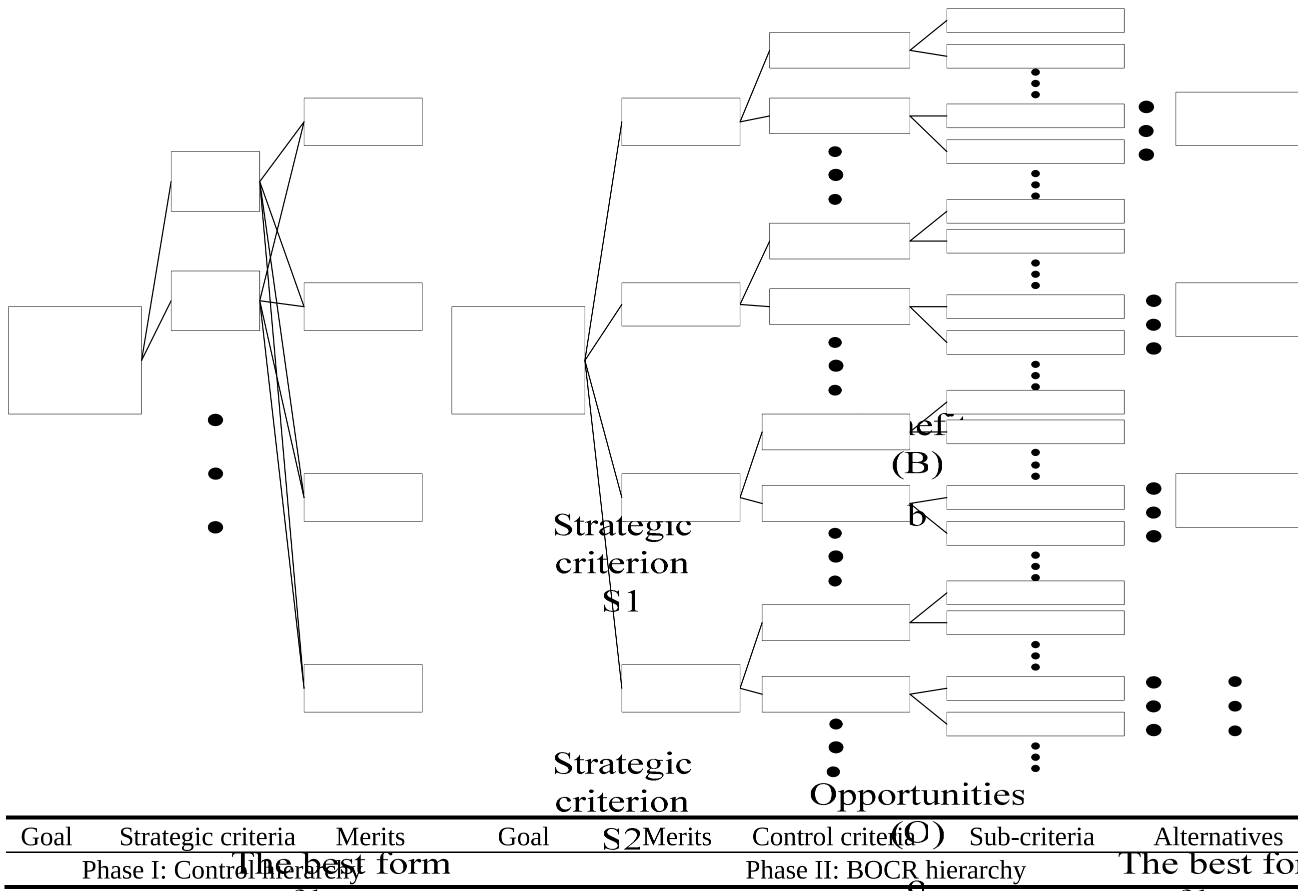

Figure 1. The Framework

importance level between strategic criteria p and q can be generated by geometric average as (Kuo et al., 2002; Lee et al., 2006):

$$\eta_{pq} = \left(\prod_{t=1}^{s} \eta_{pqt}\right)^{\frac{1}{s}}, \forall \quad t = 1,2,...,s. \tag{4}$$

$$\beta = \begin{bmatrix} \eta_{11} & \eta_{12} & \cdots & \eta_{1n} \\ \eta_{21} & \eta_{22} & \cdots & \eta_{2n} \\ \vdots & \vdots & \eta_{pq} & \vdots \\ \eta_{n1} & \eta_{n2} & \cdots & \eta_{nn} \end{bmatrix} \tag{5}$$

where $\eta_{qp} = \begin{cases} \eta_{pq}^{-1}, & if \quad p \neq q \\ 1 \quad , & if \quad p = q \end{cases}$

$$\alpha_p = \sum_{q=1}^{n} \eta_{pq}, \forall \quad p = 1,2,...,n \tag{6}$$

$$Z_p = \alpha_p \Big/ \sum_{p=1}^{n} \alpha_p, \forall \quad p = 1,2,...,n. \tag{7}$$

Step 4.3: Establish fuzzy importance weight for each strategic criterion. By synthesizing experts' opinions, the weights of strategic criteria can be represented by a weight vector, $\tilde{\mathbf{w}}$ (Mon et al., 1994; Lee et al., 2006):

$$\tilde{\mathbf{w}} = \begin{bmatrix} \tilde{w}_1 \\ \tilde{w}_2 \\ . \\ \tilde{w}_p \\ . \\ \tilde{w}_n \end{bmatrix} \tag{8}$$

where $\tilde{w}_p = \tilde{1}, \tilde{3}, \tilde{5}, \tilde{7}, \tilde{9}$, and are defined as in Table 1.

Table 1. Characteristic Function of the Fuzzy Numbers

Fuzzy number	Characteristic (Membership) function
$\tilde{1}$	(1, 1, 3)
$\tilde{\mathbf{x}}$	($\boldsymbol{x}$ –2, $\boldsymbol{x}$, $\boldsymbol{x}$+2) for $\boldsymbol{x}$ =3,5,7
$\tilde{9}$	(7, 9, 9)

Step 4.4: Calculate fuzzy importance (impact) of each merit on each strategic criterion. Obtain experts' opinions on the importance (impact) of the merit (B, O, C and R) on each strategic criterion by a five-point scale (from very unimportant (1) to very important (9)). The approach is not a pairwise comparison of two merits with respect to each strategic criterion, but

is based on the approach proposed by Satty (2005) and Saaty and Ozdemir (2003). A rating is given by each expert on the level of benefit (opportunity, cost or risk) on that strategic criterion. A triangular fuzzy number $\tilde{D}$ is obtained by combining the experts' opinions.

$$\tilde{D} = (l, m, u) \tag{9}$$

where $l = \min(k_t), \forall \quad t = 1,2,...,s$ (10)

$$u = \max(k_t), \forall \quad t = 1,2,...,s \tag{11}$$

$$m = \left(\frac{\prod_{t=1}^{s} k_t}{l \times u} \right)^{\frac{1}{(s-2)}}, \forall \quad t = 1,2,..., s. \tag{12}$$

and k_t is the importance weight from expert *t*.

Step 4.5: Prioritize the relative importance of the four merits by considering their ratings on the strategic criteria. The fuzzy importance weight for each strategic criterion from Step 4.3 and the fuzzy importance (impact) of the merit on each strategic criterion from Step 4.4 are multiplied to obtain the fuzzy priorities of merits B, O, C and R. By applying the centroid method, a defuzzified priority for each merit is obtained. The deffuzified priorities for the four merits are normalized into b, o, c and r.

Step 5: Phase II calculations. Calculate the fuzzy ranking of alternatives under each merit (B, O, C and R) based on BOCR hierarchy.

Step 5.1: Obtain the importance weight of each control criterion (and sub-criterion) by a similar step as Step 4.4.

Step **5.2:** Calculate the integrated normalized priority of each sub-criterion under each merit. A fuzzy integrated priority of each sub-criterion is calculated by multiplying the importance weight of the sub-criterion with the importance weight of its upper-level control criterion. The fuzzy integrated priority of each sub-criterion is defuzzified into an integrated defuzzified priority by the centroid method. The integrated defuzzified priorities under the same merit are normalized into normalized integrated priorities.

Step 5.3: Obtain the performances of each alternative under each quantitative sub-criterion by experts' forecasting. Normalize the value into a number between zero and one:

- For direct sub-criterion *j* :

$$\rho_{ij} = (r_{ij} - R_j^-)/(R_j^+ - R_j^-) \tag{13}$$

- For inverse sub-criterion *j* :

$$\rho_{ij} = (r_{ij} - R_j^+)/(R_j^- - R_j^+) \tag{14}$$

where $R_j^+ = \max_i \{r_{ij}\}$, $R_j^- = \min_i \{r_{ij}\}$, $0 \le \rho_{ij} \le 1$, and r_{ij} is the value of sub-criterion *j* in evaluating alternative *i*.

Step 5.4: Obtain the performances of each alternative under each qualitative sub-criterion. The performances of alternatives under each qualitative sub-criterion are generated through expert's evaluations since these data may not be quantified. Five levels of evaluation are used here and their linguistic values are as in Table 2. Experts' opinions are collected through questionnaire, and the same procedure as Step 4.4 is applied here.

Table 2. Linguistic Value

Language	Quantitative value
Very good	1
Good	0.75
Fair	0.5
Poor	0.25
Very poor	0.1

Step 5.5: Determine the relative performance of alternatives with respect to each control criterion by forming a matrix for each control criterion. Use the data generated from Step 5.3 and 5.4, the performances of alternatives in each sub-criterion under the same control criterion are entered in the matrix.

Step 5.6: Synthesize and establish the fuzzy ranking of alternatives under each merit (B, O, C and R) by combining the results from Step 5.2 and 5.5.

Step 6: Calculate overall priorities of alternatives by combining BOCR priorities of each alternative from Step 5.6 with corresponding normalized weights b, o, c and r from Step 4.5. As stated in section 2.3, there are five ways to combine the scores of each alternative under B, O, C and R.

4. Application of a TFT-LCD Manufacturer

As the TFT-LCD industry is becoming extremely competitive, various strategies and cost control efforts have been stressed by manufacturers. These include the increase in the size of the substrates, the decrease in the number of process steps, the simplification of the processes, the improvement in the utilization of processes, the decrease in cycle time and the improvement in yields (Moslehi, 2006). Among all the cost-control strategies, the reduction of the cost of materials and the increase in the utilization rate of the materials are especially important since raw materials accounts for as high as 79% of the total manufacturing cost (Hsieh, 2006).

Color filter is on of the most critical materials in TFT-LCD manufacturing. The cost of color filters can be as high as 25% of raw material cost or 16% of total manufacturing cost, exceeding that for all other materials except backlight unit (Hsieh, 2006). In order to achieve cost reduction, ensure product availability and obtain leading-technology color filters, the buyer-supplier relationship with color filter manufacturers is especially important for TFT-LCD manufacturers.

A model for selecting the most appropriate buyer-supplier relationship between TFT-LCD manufacturer and color filter manufacturer is proposed here. A committee of experts in the TFT-LCD industry is formed to define the buyer-supplier relationship problem between TFT-LCD manufacturers and color filter manufacturers. The research scope is on TFT-LCD plants with fifth generation or lower. With a comprehensive review of literature, consultation with domain experts and consideration of data accessibility, the hierarchy and the factors for determining the efficiency of a TFT-LCD manufacturer in terms of a buyer-supplier relationship form is organized. Four forms of buyer-supplier relationship, which are currently possible and are highly recommended, are considered here: contractual alliance (I), minority equity ownership (II), joint venture (III) and acquisition (IV).

The control hierarchy, as displayed in Figure 2, shows the strategic criteria for the buyer-supplier relationship form. The management should select a relationship form that will optimize the performance of the firm, and the strategic criteria are the sub-goals. The control hierarchy is used to rate the relative importance, b, o, c and r, of benefits (B), opportunities (O), costs (C) and risk (R) respectively. The BOCR hierarchy will also be constructed to evaluate the forms of buyer-supplier relationship.

By applying the proposed model, decision makers in the TFT-LCD manufacturer can base on the results to examine the expected performance of each relationship form on various criteria and sub-criteria, and can select the most appropriate form of relationship with its color filter manufacturer.

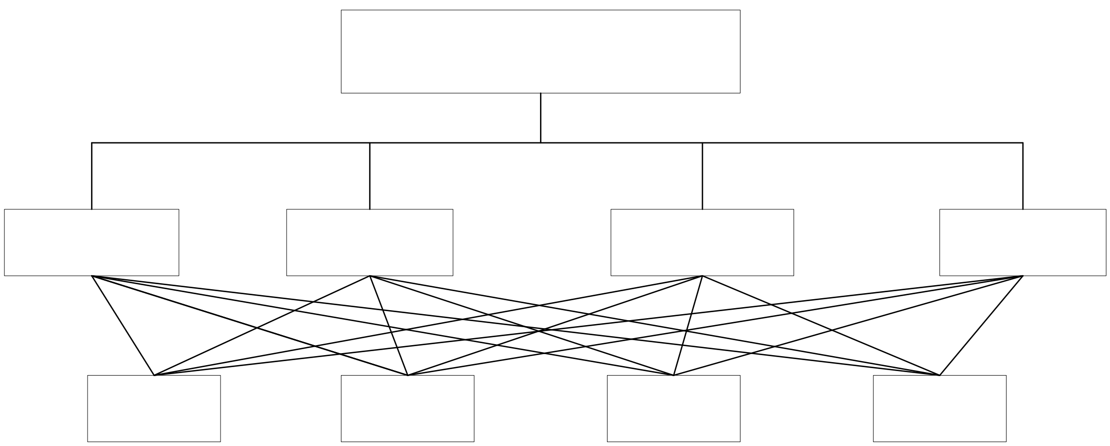

Figure 2. The Control Hierarchy

5. Conclusions

A fuzzy analytic hierarchy process (AHP) model is constructed in this research to evaluate the forms of buyer-supplier relationship. The proposed model can help decision makers in the buyer-supplier relationship selection process by considering the benefits, opportunities, costs and risks (BOCR) perspectives. Because human decision making process involves ambiguity and uncertainty, fuzzy theory is also incorporated into the model.

By applying the proposed model, decision makers in the TFT-LCD manufacturer can base on the results to examine the expected performance of each relationship form on various criteria and sub-criteria, and can select the most appropriate form of relationship with its color filter manufacturer. The BOCR hierarchy will be constructed based on literature review and interview with experts in the field. Based on the proposed model, questionnaires will be sent out to decision makers in the anonymous TFT-LCD manufacturer, and calculations will be carried out to generate the final ranking of the buyer-supplier relationships.

Acknowledgments

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References

Cheng, C.H. (1999). Evaluating weapon systems using ranking fuzzy numbers. *Fuzzy Sets and Systems*, **107**, 25-35.

Cravens, K., Piercy, N. and Cravens, D. (2000). Assessing the performance of strategic alliances: matching metrics to strategies. *European Management Journal*, **18** (5), 529-541.

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Elmuti, D. and Kathawala, Y. (2001). An overview of strategic alliances. *Management Decision*, **39** (3), 2005-2017.

Erdogmus, S., Kapanoglu, M. and Koc, E. (2005). Evaluating high-tech alternatives by using analytic network process with BOCR and multiactors. *Evaluation and Program Planning*, **28**, 391-399.

Hsieh, D. (2006). 2006 TFT LCD and component market trend. *DisplaySearch Taiwan*. http://www.displaysearch.com/free/presos.html

Kalmbach, C. Jr. and Roussel, C. (1999). Dispelling the myths of alliances. *Outlook*, October, 5-32.

Klir, G.I. and Yuan, B. (1995). *Fuzzy Sets and Fuzzy Logic Theory and Applications*, London: Prentice-Hall.

Kuo, R.J., Chi, S.C. and Kao, S.S. (2002). A decision support system for selecting convenience store location through integration of fuzzy AHP and artificial neural network. *Computers in Industry*, **47**, 199-214.

Lee, A.H.I., Kang, H.Y. and Wang, W.P. (2006). Analysis of priority mix planning for semiconductor fabrication under uncertainty. *International Journal of Advanced Manufacturing Technology*, **28**, 351-361.

Malott, R.H. (1992). Managing the global enterprise. *Executive Speeches*, **7**(4), 6-10.

Michelet, R. and Remacle, R. (1992). Forming successful strategic marketing alliance in Europe. *Journal of European Business*, **4** (1), 11-15.

Mon, D.L., Cheng, C.H. and Lin, J.C. (1994). Evaluating weapon system using fuzzy analytical hierarchy process based on entropy weight, *Fuzzy Sets and Systems*, **62**, 127-134.

Moslehi, B. (2006). Flat-panel displays achieving dominance. *MICRO Magazine*. http://www.micromagazine.com/archive/06/07/reality.html

Murtaza, M.B. (2003). Fuzzy-AHP application to country risk assessment. *American Business Review*, **21** (2), 109-116.

Saaty, R.W. (2003). *Decision Making in Complex Environment: The Analytic Hierarchy Process (AHP) for Decision Making and the Analytic Network Process (ANP) for Decision Making with Dependence and Feedback*, Pittsburgh: Super Decisions.

Saaty, T.L. (1996). *Decision Making with Dependence and Feedback: The Analytic Network Process*, Pittsburgh: RWS Publications.

Saaty, T.L. (1980). *The Analytic Hierarchy Process*, New York: McGraw–Hill.

Saaty, T.L. (2005). *Theory and Applications of the Analytic Network Process: Decision Making with Benefits, Opportunities, Costs, and Risks*, Pittsburgh: RWS Publications.

Saaty, T.L. and Ozdemir, M. (2003). Negative priorities in the analytic hierarchy process. *Mathematical and Computer Modelling*, **37**, 1063-1075.

Soursac, T. (1996). When the hub spoke. *The Alliance Analyst*, 1-4.

The Economist (1999), Flying in circles, **17**, 57-59.

Whipple, J.M. and Frankel, R. (2000). Strategic alliance success factors. *Journal of Supply Chain Management*, **36** (3), 21-28.

Yagar, R.R. (1978). On a general class of fuzzy connective. *Fuzzy Sets and Systems*, **4**, 235-242.

Yu, C.S. (2002). A GP-AHP method for solving group decision-making fuzzy AHP problems. *Computers and Operations Research*, **29**, 1969-2001.

Zahedi, F. (1986). The analytic hierarchy process- a survey of the method and its applications. *Interfaces*, **16**, 96-108.

Zineldin, M. and Bredenlöw, T. (2003). Strategic alliance: synergies and challenges: a case of strategic outsourcing relationship "SOUR". *International Journal of Physical Distribution & Logistics Management*, **33** (5), 449-464.