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多準則決策整合 BOCR 於地區活化再生之方案評選
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多準則決策整合 BOCR 於地區活化再生之方案評選

An integrated approach with MCDM and BOCR for the project selection of regional revitalization and regeneration

中文摘要

地區的永續發展不單止於外部實體的拆除重建，而應著重於彰顯出內在的地方價值與自明性（此即活化），進而創造出地區發展的新生力與競爭力（此即再生）。為了有效落實活化再生抽象概念於地區實際發展之上，必須將偏屬主觀、質性的感知與期待，轉換成客觀、可量化之發展方案的評選以資實際應用。然而，在評估決選過程中，往往卻存在有諸多正、反雙向同時影響的複雜因素；例如，利益之於成本、機會之於風險，這些複雜因素明顯地對於計畫方案之評選與決策形成困擾。因此，本研究首先透過既有相關研究文獻回顧與整理，先行釐清地區活化再生的意涵；爾後，再藉由整合利益/機會/成本/風險（BOCR）之概念，將相關可能影響因子歸納並分派於利益、機會、成本、與風險等四個不同群集之下。接著，利用模糊德爾菲法（Fuzzy Delphi Method; FDM）從中篩選出確切的依循準則以做為後續評價時之基礎。然而，由於考慮評價時於相關群集/準則彼此間、以及與發展方案之間存在有複雜的相互影響與相依關係，特援引結合 BOCR 概念之分析網路程序法（Analytic Network Process with BOCR; ANP with BOCR）以資因應解決；並進一步地建構出客觀、且具實用性的方案評選模式。研究結果顯示，該評選模式能將複雜之正、反衝擊與相依關係轉換成客觀而有效之單純數值的評量。實證的結果不僅能為地區的復甦提供創新的思維，更可成為未來實際發展方案評選的重要參考與導引。

關鍵詞：方案評選、地區活化再生、模糊德爾菲法、結合 BOCR 之分析網路程序法

Abstract

A district’s sustainable development should not focus on the external demolition and construction, but should stress on manifesting internal local values and identities (revitalization) and creating renaissance and competitiveness of regional development (regeneration). In order to fulfill the abstract concepts of revitalization and regeneration to actual district development effectively, the transformation of subjective and qualitative perception and expectation into objective and quantitative project evaluation is necessary. Nevertheless, there exist many complex influence factors, which have simultaneous interaction of positive or negative impacts, such as benefits versus costs and opportunities versus risks. It would simply make perplexity for project selection and decision. Hence, in this study, the meaning of the district revitalization and regeneration is clarified by literature reviews first. Then, the related possible impact factors under benefits, opportunities, costs and risks clusters are generalized by integrating the concept of BOCR. Thereafter, fuzzy Delphi method (FDM) is applied to extract the criteria for the foundation of evaluation. Since there is complex interaction and interdependence among clusters (criteria) and alternatives, the method of analytic network process (ANP) with BOCR is employed. An objective and practicable project selection model can then be established. The results show that the model can transform complex positive or negative impacts and interrelationship into simple quantitative values for objective and effective evaluation. The empirical results not only can provide innovative thinking for district reviving, but also can be guidance for practical project development selection in the future.

Keywords: Project selection, District revitalization and regeneration (DRAR), Fuzzy Delphi method (FDM), Analytic network process (ANP) with BOCR

1. Introduction

When the trend of development and management of district becomes focusing on the concept of sustainable development over the world, globalize homogenization for district development is resulted. Thus, the principle of "thinking globally and action locally" needs to be incorporated into specific and practicable implementations.

A number of studies (Couch & Dennemann, 2000; Doratli, Hoskara, & Fasli, 2004; Ghose, 2003; Orueta, 2007; Raco, 2003) show that manifesting local values and identities and creating renaissance are the direction of development for regional action principle, especially for developed district. In Taiwan, due to dense population with small land area, the district development has been saturated and possessed of the self-local characteristics and historical cultures. In traditional urban renewal for district reviving, developing arts and cultures, injecting commercial activities, and advancing tourism and recreation have been the major development types (Wang, Lee, & Wu, 2009). However, the local characteristics were usually neglected, and unfortunately, the resulted developments had a very high similarity.

A district's sustainable development should not focus on the external demolition and construction, but should stress on manifesting internal local values and identities (revitalization) and creating renaissance and competitiveness of regional development (regeneration). Consequently, the core of district revitalization and regeneration (DRAR) should reveal provincialism and continuity, and furthermore, to stimulate the new life and competitiveness (Çevik, Vural, Tavşan, & Aşık, 2008; Couch & Dennemann, 2000; Razzu, 2005). In order to fulfill the abstract concepts of revitalization and regeneration to actual district development effectively, the transformation of subjective and qualitative perception and expectation into objective and quantitative project evaluation is necessary. Such a characteristic belongs to multi-attribute decision analysis (MADA).

Nevertheless, like any MADA decision problem in real life, there are usually several favorable and unfavorable concerns that must be considered at the same time (Saaty & Vargas, 2006). There exist many complex influence factors in the evaluation process, which have simultaneous interaction of positive or negative impacts, such as criteria in benefits versus those in costs, and criteria in opportunities versus those in risks. It would simply make perplexity for project selection and decision. The analytic network process (ANP) with the benefits, opportunities, costs, and risks (the BOCR merits) can solve this arduous problem effectively. The ANP, proposed by Satty (1996), is a simple, mathematically based multi-criteria decision-making tool to deal with complex, interdependent and multi-attribute problems. Saaty (2005) further proposed the BOCR to solve the positive and negative impacts of a problem simultaneously. The ANP with BOCR has been applied in some recent works (Erdoğmuş, Kapanoglu, & Koç, 2005; Feglar, Levy, Feglar, & Feglar, 2006; Saaty & Shang, 2007)

In this paper, an evaluation framework for project selection of DRAR is proposed. The related issues of district's revitalization and regeneration are reviewed through literature first. Fuzzy Delphi method (FDM) by generalizing experts' opinions is applied next to extract the most critical factors. Then, interpretive structural modeling (ISM) is employed to determine the interrelationship among the critical factors. An analytic network process (ANP) with BOCR model is constructed to evaluate the project selection for district's revitalization and regeneration, and the relative importance weights of the critical factors and alternatives are calculated. The results show that the model can transform complex positive or negative impacts and interrelationship into simple quantitative values for objective and effective evaluation. The empirical results also can be the consultation and guidance for practical project development selection in the future.

2. Methodologies

2.1 Fuzzy Delphi method (FDM)

Since its conception and development by Dalkey and Helmer in 1963, Delphi method has been used in a wide range of research applications. Despite its merits, the method has ambiguity and uncertainty problems in survey questions and responses (Chang, Huang, & Lin, 2000; Wey & Wu, 2007). The incorporation of fuzzy set theory with Delphi method is one of the approaches to tackle the problems (Lee, Wang, & Lin, 2010). Murray, Pipino, & Van Gigch (1985) first applied the fuzzy theory to the traditional Delphi method. Ishikawa, Amagasa, Shiga, Tomizawa, Tatsuta, & Mieno (1993) employed the cumulative frequency distribution function and the fuzzy integration to integrate experts' estimation into fuzzy numbers, and utilized the "gray zone", the intersection of the fuzzy numbers, to develop the Max-Min FDM and the FDM via Fuzzy Integration (FDMFI).

This paper bases on the FDM developed by Ishikawa et al. (1993) to find the critical factors, and the procedures for executing the method are as follows (Ishikawa et al., 1993, Wang et al., 2009):

Step 1: Construct a table of cumulative frequency distribution, with $F_i^1(x)$ being a function that denotes the period of realization with an extremely high degree of possibility, and $F_i^2(x)$ being a function that denotes the period of non-realization with an extremely high degree of possibility.

Step 2: Obtain respectively the upper and lower quartiles of $F_i^1(x)$ and $F_i^2(x)$, i.e. (C_i^1, D_i^1) and (C_i^2, D_i^2), as shown in Figure 1. Medians corresponding to $F_i^1(x)$ and $F_i^2(x)$ are calculated and designated as M_i^1 and M_i^2, respectively.

Step 3: Link C_i^1, M_i^1, D_i^1 and C_i^2, M_i^2, D_i^2 respectively, and obtain the Max-Min forecast value X_i^* is to be obtained. The overlap section of the two functions is called the gray zone (see Figure 1).

Step 4: Extract critical factors by comparing X_i^* with the threshold value (***S***). If $X_i^* \geqq S$, select factor ***i***; and if $X_i^* < S$, eliminate factor ***i***. In general, the threshold value is determined by decision makers subjectively (Dzeng & Wen, 2005; Kuo & Chen, 2008).

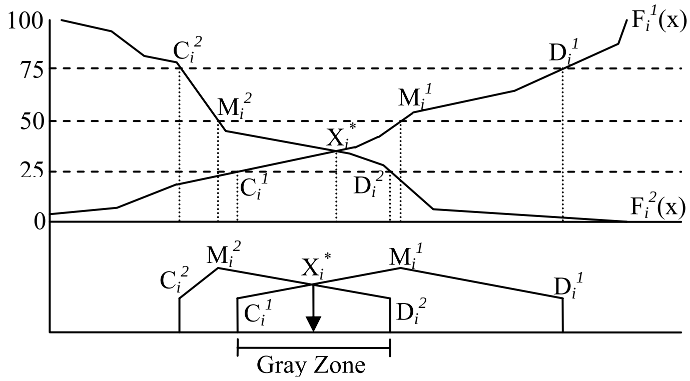

FIGURE 1. Construct membership function and Max-Min forecast value

2.2 Interpretive structural modeling (ISM)

Interpretive structural modeling (ISM), proposed by Warfield (1974, 1976), is often used to provide fundamental understanding of complex situations and to put together a course of action for solving a problem (Lee et al., 2010). The method helps impose order and direction on the complexity of relationships among elements of a system. It is a suitable modeling technique for analyzing the influence of one variable on other variables (Agarwal, Shankar, & Tiwari, 2007). In this paper, ISM is applied to understand the interaction among criteria.

The procedures of the binary matrix manipulation of ISM are as follows (Huang, Tzeng, & Ong, 2005; Lee et al., 2010; Warfield, 1973):

Step 1: Establish relation matrix which shows the relationship among the criteria. The general form of the relation matrix ***D*** can be presented as follows:

$$\boldsymbol{D} = \begin{array}{c} \\ e_1 \\ e_2 \\ \vdots \\ e_n \end{array} \begin{array}{c} \begin{array}{cccc} e_1 & e_2 & \cdots & e_n \end{array} \\ \begin{bmatrix} 0 & \pi_{12} & \cdots & \pi_{1n} \\ \pi_{21} & 0 & \cdots & \pi_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \pi_{m1} & \pi_{m2} & \cdots & 0 \end{bmatrix} \end{array}$$

where π_{ij} denotes the relation between the *i*th row and *j*th column criteria, if criterion e_i affects criterion e_j, then $\pi_{ij} = 1$, otherwise $\pi_{ij} = 0$.

Step 2: Calculate the reachability matrix as follows:

$$\boldsymbol{M} = \boldsymbol{D} + \boldsymbol{I} \quad (1)$$

$$\boldsymbol{M}^* = \boldsymbol{M}^k = \boldsymbol{M}^{k+1} \quad k > 1 \quad (2)$$

where ***I*** is the identity matrix, k denotes the powers, and $\boldsymbol{M}^*$ is the reachability matrix. The reachability matrix is under the operators of the Boolean multiplication and addition (i.e., 1×0=0×1=0, 1+0=0+1=1).

Step 3: Calculate the reachability set and the priority set, respectively.

$$R(t_i) = \{ e_i | m^*_{ji} = 1 \} \quad (3)$$

$$A(t_i) = \{ e_i | m^*_{ij} = 1 \} \quad (4)$$

Step 4: Determine the levels and relationships between the criteria by Equation (5). The relationships of all the criteria and plot the network structure can be constructed.

$$R(t_i) \cap A(t_i) = R(t_i) \quad (5)$$

2.3 Analytic network process (ANP) with BOCR

The benefits, opportunities, costs, and risks (the BOCR merits) is a concept of the analytic network process (ANP), proposed by Saaty (1996). It is a simple, mathematically based multi-criteria decision-making tool to deal with complex and multi-attribute problems. The ANP with BOCR has been applied in some works (Chang, Wey, & Tseng, 2009; Erdoğmuş et al., 2005; Liang & Li, 2008; Ustun & Demirtas, 2008). Under the BOCR, a network can consist of four sub-networks: benefits, opportunities, costs, and risks. Under benefits and opportunities (risks and costs), pairwise comparison questions ask which alternative is most profitable or has the best chance (riskiest or costliest) under each control criterion. Therefore, while the best alternative gets the highest priority for benefits and opportunities subnet, and the worst alternative also gets the highest priority for costs and risks. Then, the weights of the alternatives under each sub-network can be calculated, and these weights are further combined to get a single outcome for each alternative (Lee, Kang, Liu, & Wang, 2007).

The steps of ANP with BOCR are summarized as follows (Erdoğmuş et al., 2005; Lee et al., 2007; Lee, 2009; Lee, Chen, & Kang, 2009; Saaty, 2005):

Step 1: Decompose the problem hierarchically, an integrated control hierarchy and BOCR network evaluation framework is constructed. The control hierarchy contains the objective of the problem, strategic criteria, and the four merits, benefits (B), opportunities (O), costs (C), and risks (R). The BOCR network aims to achieve the goal with simultaneous consideration of the four merits. Under each merit, there are control criteria and alternatives. The framework is shown in Figure 2.

Step 2: Determine the priorities of the strategic criteria in the control hierarchy. The nine-point scale is applied to obtain pairwise comparison results of the importance of strategic criteria toward achieving the overall objective (Saaty, 1980). Arithmetic mean method is applied to aggregate experts' opinions.

Step 3: Based on the BOCR network, pairwise compare the criteria with respect to the same upper level merit, the interdependence among the criteria, and the performance of alternatives under each criterion by the nine-point scale.

Step 4: Calculate the relative priorities of the criteria with respect to the same upper level merit, the relative priorities of the interdependence among the criteria, and the relative priorities of the performance of alternatives under each criterion. Form a supermatrix for each sub-network by ANP, which is proposed by Saaty (1996). Calculate the priority (B_i, O_i, C_i, R_i) of alternative i under each merit.

Step 5: Determine the importance of benefits, opportunities, costs, and risks with respect to each strategic criterion. A five-step scale is used, and the values of each scale is assigned to be very high, 0.42; high, 0.26; medium, 0.16; low, 0.10; and very low, 0.06 (Erdoğmuş et al., 2005; Saaty, 2005). Geometric mean method is applied to aggregate experts' opinions.

Step 6: Determine the priorities (b, o, c, r) of the merits. Calculate the priority of a merit by multiplying the priority of the respective strategic criterion from Step 2 with the score of a merit on each strategic criterion from Step 5, and summing up the calculated values for the merit.

Step 7: Calculate overall priorities of the alternatives by synthesizing the priority (B_i, O_i, C_i, R_i) of each alternative under each merit from Step 4 with corresponding priorities of the merits (b, o, c, r) from Step 6. There are some ways to combine the scores of each alternative under B, O, C and R (Saaty & Ozdemir, 2003).

1. *Multiplicative*: $P_i = B_i O_i / C_i R_i$ (6)
2. *Additive*: $P_i = bB_i + oO_i + c(1/C_i)_{Normalized} + r(1/R_i)_{Normalized}$ (7)
3. *Probabilistic additive*: $P_i = bB_i + oO_i + c(1 - C_i) + r(1 - R_i)$ (8)
4. *Subtractive*: $P_i = bB_i + oO_i - cC_i - rR_i$ (9)

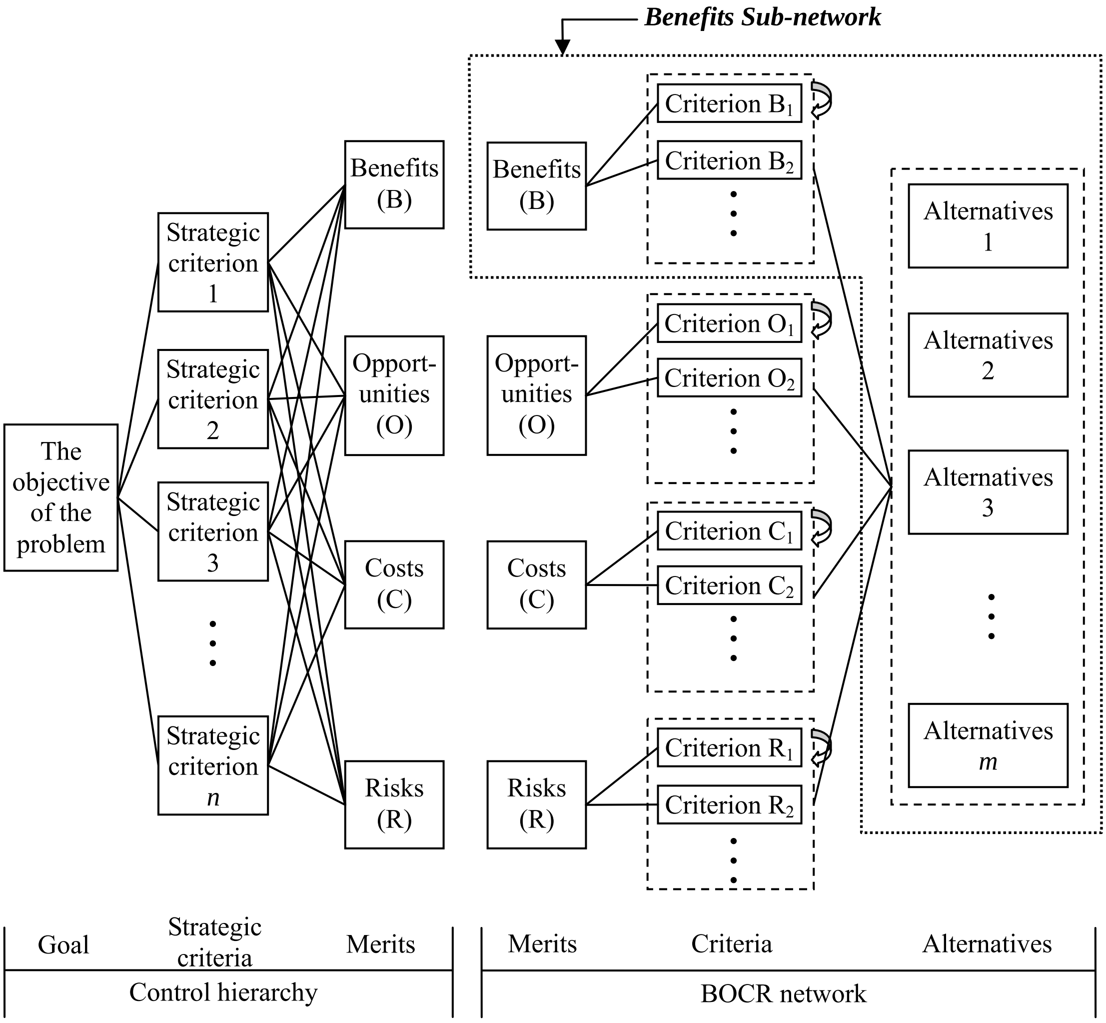

FIGURE 2. The framework

3. Construction of evaluation model

The major goal of this research is to select the best revitalization and regeneration project in a district, and therefore the research design contains two significant parts: determining critical evaluation criteria and establishing an evaluation model.

3.1 Determining critical evaluation criteria

Based on extensive literature reviews (Aravot, 1996; Çevik, et al., 2008; Helleman & Wassenberg, 2004; Raco, 2003; Wang & Wu, 2008; Wedding & Crawford-Brown, 2007), regional environmental nature and developmental demands, and the study of Wang et al. (2009), we generalized and categorized 30 possible impact factors for the DRAR project under benefits (B), opportunities (O), costs (C), and risks (R). FDM was applied next to extract the most critical factors.

An anonymous questionnaire was prepared, and 15 experts in the fields of DRAR were asked to evaluate the importance of each possible impact factor. A convergence of their opinions was obtained, and 13 critical factors were extracted (Wu, 2010). In this research, we subjectively set 6.6, 7.1, 6.7, and 6.8 as the threshold values for the four merits B, O, C, and R, respectively. The results are shown in Table 1, and the factors shaded in gray are selected.

The 13 extracted factors for the DRAR project under benefits (B), opportunities (O), costs (C), and risks (R) are represented as C_1, C_2, …, C_{13}, and described here. Under benefits (B), the criteria are: external utilities of district regeneration (EUD; C_1), revitalization of district industry (RDI; C_2), and improvement of living environment (ILE; C_3). The criteria under opportunities (O) are linkage of open space network system (LOS; C_4), guidance of government planning (GGP; C_5), and place marketing and strategy management (PMS; C_6). The criteria under costs (C) are: ecology and landscape resource (ELR; C_7), conservation of cultural and historical prospect (CCH; C_8), expenditure of physical construction (EPC; C_9), and integration and management of local resource (IML; C_{10}). The criteria under risks (R) are: negative impact of government policy (NIG; C_{11}), ignorance of local residents' equity (IRE; C_{12}), and loss of existing district value and identity (LEV; C_{13}). In order to evaluate the performance of DRAR projects, this research constructed a BOCR network framework using the above-mentioned 13 critical success criteria.

TABLE 1. Extraction results of the possible impact factors

Merits	Possible impact factors	$F_i^1(x)$			$F_i^2(x)$			X_i^*	Threshold values
		C_i^1	M_i^1	D_i^1	C_i^2	M_i^2	D_i^2		
B	1 Conservation and continuum of space-time value (CCS)	6.25	7.38	8.42	4.38	5.42	6.08	6.17	6.6
	2 External utilities of district regeneration (EUD)	7.25	7.63	8.56	5.15	5.90	6.81	7.03	
	3 Revitalization of district industry (RDI)	7.44	8.30	9.06	3.92	6.07	6.61	7.02	
	4 Appearance of vitality (AOV)	5.94	8.50	9.25	3.69	5.10	5.85	5.89	
	5 Exchange of local value (ELV)	6.55	7.38	8.31	4.38	5.83	6.46	6.51	
	6 Acknowledgement of local ideology (ALI)	6.75	7.70	8.56	4.19	5.17	6.31	6.53	
	7 Preservation of historical space and architecture (PHS)	6.58	8.25	8.87	4.19	5.25	6.45	6.52	
	8 Communication of sensation (COS)	6.35	7.13	8.25	3.75	4.70	5.45	5.90	
	9 Improvement of living environment (ILE)	7.44	8.25	8.87	4.58	5.50	6.62	7.03	
O	10 Expression of district identity (EDI)	7.38	8.36	8.89	4.88	6.19	6.66	7.02	7.1
	11 Activation of capital asset and potential (ACP)	7.44	8.21	8.75	4.38	5.50	6.63	7.03	
	12 Linkage of open space network system (LOS)	7.75	8.44	8.91	4.38	5.50	7.25	7.50	
	13 Connection of circulation and quality improvement (CCQ)	6.55	7.25	7.88	3.58	5.63	6.37	6.46	
	14 Guidance of government planning (GGP)	7.69	8.63	9.38	4.25	5.50	6.75	7.22	
	15 Place marketing and strategy management (PMS)	7.92	8.39	8.81	4.19	5.25	6.45	7.18	
	16 Promotion of cultural interpretation (PCI)	6.75	7.70	8.56	4.15	4.90	6.42	6.58	
C	17 Ecology and landscape resource (ELR)	7.44	8.21	8.75	4.38	5.42	6.08	6.76	6.7
	18 Conservation of cultural and historical prospect (CCH)	7.58	8.42	9.06	5.25	6.25	6.88	7.23	
	19 Expenditure of physical construction (EPC)	7.35	8.13	9.06	4.38	5.50	6.63	6.99	
	20 Integration and management of local resource (IML)	8.09	8.56	9.06	5.13	5.75	7.08	7.59	
	21 Cost of time (CTI)	6.55	7.25	7.87	2.92	4.50	5.45	6.00	
	22 Cost of Space (CSP)	6.55	7.30	8.12	3.25	4.30	5.12	5.84	
	23 Cost of advertisement and marketing (CAM)	6.58	8.07	8.61	3.75	4.58	5.42	6.00	
R	24 Consumption of ecology resource (CER)	6.75	7.70	8.56	3.75	5.25	6.56	6.66	6.8
	25 Negative impact of government policy (NIG)	7.44	8.21	8.75	3.92	6.07	6.61	7.02	
	26 Existing restriction of district development (ERD)	6.46	7.17	8.31	3.25	4.75	6.38	6.42	
	27 Conflict of participation process (CPP)	7.25	8.19	8.66	2.87	4.87	6.08	6.67	
	28 Ignorance of local resident's equity (IRE)	7.38	8.36	8.89	4.25	5.50	6.75	7.06	
	29 Downfall of local industry (DLI)	6.75	7.70	8.56	3.58	4.83	6.13	6.44	
	30 Lose of existing district value and identity (LEV)	7.19	8.10	8.85	3.75	6.13	7.08	7.14	

Number of extracted factors: 13, and shown in gray.

3.2 Establishing an evaluation model

In order to determine the priorities of the four merits, three strategic criteria have been incorporated into the framework (Wang et al., 2009). These strategic criteria are (1) to animate district assets effectively (represented as SC_1), (2) to manifest and sustain local activities (SC_2), and (3) to stimulate district sustainable development (SC_3). Each of these strategic criteria can be thought of as sub-goals.

In addition, since there are possible interdependent relationships among extracted factors (criteria) under each merit, ISM is employed next to clarify the interrelationship among the criteria. A questionnaire was prepared to ask the relationship of one criterion to another. The mode of experts' opinions on the relationship between a pair of criteria was calculated (Yang, Chiu, Tzeng, & Yeh, 2008), and then used to determine whether the criteria were dependent or not. Under benefits (B), the integrated relation matrix ($\boldsymbol{D_B}$) among criteria C_1-C_3 was obtained:

$$\boldsymbol{D_B} = \begin{array}{c} \\ C_1 \\ C_2 \\ C_3 \end{array} \begin{array}{c} \begin{array}{ccc} C_1 & C_2 & C_3 \end{array} \\ \begin{bmatrix} 0 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 0 & 0 \end{bmatrix} \end{array}$$

The final reachability matrix for criteria was calculated:

$$\boldsymbol{M}_B^* = \boldsymbol{M}_B^2 = \boldsymbol{M}_B^3 = \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$$

Next, the levels and relationships among the criteria can be clarified by Equation (3)-(5) (shown in Table 2) (Wu, 2010). And then, based on $\boldsymbol{M}_B^*$ and Table 2, the interrelationship among the criteria (C_1, C_2, and C_3) under benefits (B) can be depicted as in Figure 3. Similarly, the interrelationship among the criteria C_4-C_6, C_7-C_{10}, and C_{11}-C_{13} are clarified under opportunities (O), costs (C) and risks (R) merits, respectively (see Figure 3) (Wu, 2010).

TABLE 2. The reachability set and the priority of benefits (B)

	Criteria	$R(t_i)$	$A(t_i)$	$R(t_i) \cap A(t_i)$
Level 1	C_1	C_1, C_2, C_3	C_1, C_2, C_3	C_1, C_2, C_3
	C_2	C_1, C_2, C_3	C_1, C_2, C_3	C_1, C_2, C_3
	C_3	C_1, C_2, C_3	C_1, C_2, C_3	C_1, C_2, C_3

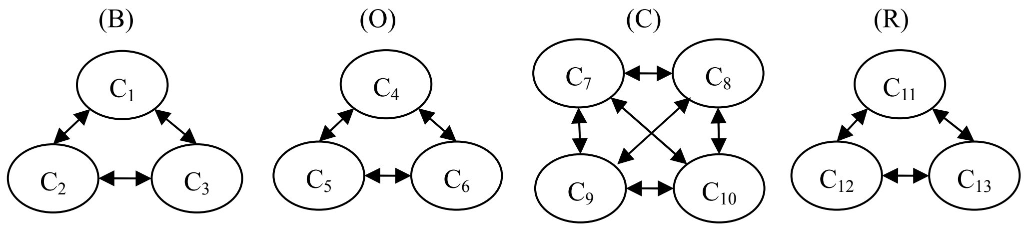

FIGURE 3. The interrelationship among the criteria under B, O, C, and R

With the results from FDM and ISM, projects to be evaluated (different district development alternatives) were added to establish a complete evaluation model for the revitalization and regeneration project selection of a district is constructed, as shown in Figure 4 (Wang et al., 2009).

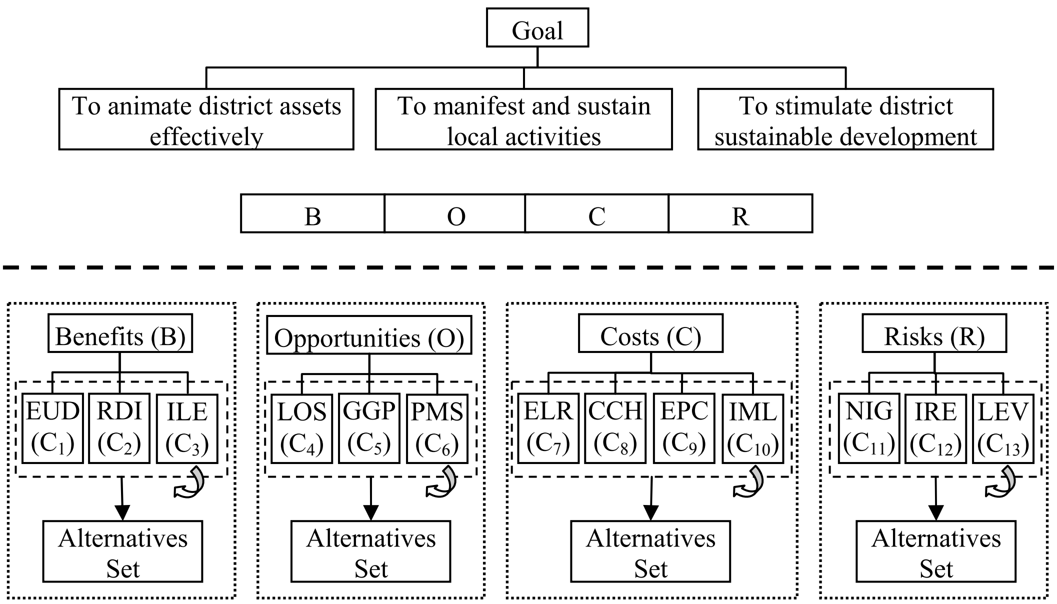

FIGURE 4. The evaluation model

4. Empirical study

The subject of the empirical study was Jioufen, which is located in the northeast of Taiwan. A mountain town in the Rueifang Township of Taipei County, Jioufen was formerly renowned for its mining industry. Today, the town is a famous tourist attraction with affluence commercial activities, traditional settlement space formation and distinct local identity. Four projects (denote A_1-A_4) were evaluated for district revitalization and regeneration development: (1) mixed-use of residence and commerce (A_1), museum of local culture and tradition (A_2), local industrial and commercial circles (A_3), and development of tourist and recreational activities (A_4).

Based on the proposed model and experts' opinions, the performance of the four district projects (alternative A_1-A_4) could be generated. In the first part of the model, seven experts were asked to evaluate the priorities of benefits, opportunities, costs, and risks. A pairwise comparison matrix of expert 1 was formed (Table 3) to evaluate the three strategic criteria (Wu, 2010). The arithmetic mean method was applied to synthesize experts' opinions. The integrated priorities of experts (Wu, 2010) for the strategic criteria were calculated (see Table 4).

TABLE 3. Pairwise comparison of strategic criteria with respect to G by expert 1

G	SG^1_1	SG^1_2	SG^1_3	EV_{EP1}
SG^1_1	1	2	5	***0.6098***
SG^1_2	1/2	1	1	***0.2247***
SG^1_3	1/5	1	1	***0.1655***

TABLE 4. Integrated priorities (7 experts) of strategic criteria with respect to G

G	EV_{EP1}	EV_{EP2}	EV_{EP3}	EV_{EP4}	EV_{EP5}	EV_{EP6}	EV_{EP7}	***EV***
SG^j_1	0.6098	0.4395	0.6833	0.6337	0.5499	0.1021	0.0880	***0.4438***
SG^j_2	0.2247	0.1210	0.1998	0.1919	0.2098	0.1721	0.6694	***0.2555***
SG^j_3	0.1655	0.4395	0.1169	0.1744	0.2403	0.7258	0.2426	***0.3007***

In the second part of the model, the priorities of the alternatives under each merit are calculated. There are four sub-networks, namely benefits, opportunities, costs, and risks. Under each merit, the relative importance weights of criteria (alternatives) with respect to the same upper level merit (criterion), and the interdependence priorities among the criteria that have the same upper-level merit are calculated using the arithmetic mean of the experts' pairwise comparison results. The above importance weights of criteria and alternatives, and the interdependence priorities among criteria are entered into appropriate places in the unweighted super-matrix for each merit sub-network. As an example, the unweighted super-matrix for the ***benefits*** sub-network is as shown in Table 5 (Wu, 2010), and then, the limit super-matrix is obtained. Similarly, the limit super-matrices for other sub-networks are calculated, and then the priorities (***B***, ***O***, ***C***, ***R***) of the alternatives under each merit (Wu, 2010) are obtained (see Table 6).

TABLE 5. The unweighted super-matrix for the ***benefits*** sub-network

Benefits	**B** (merit)	C_1	C_2	C_3	A_1	A_2	A_3	A_4
B (merit)	0	0	0	0	0	0	0	0
C_1	0.3626	0.3810	0.3804	0.3608	0	0	0	0
C_2	0.2532	0.3921	0.2847	0.2782	0	0	0	0
C_3	0.3842	0.2269	0.3349	0.3610	0	0	0	0
A_1	0	0.3769	0.2040	0.2463	1	0	0	0
A_2	0	0.1405	0.1675	0.3070	0	1	0	0
A_3	0	0.2107	0.2622	0.1821	0	0	1	0
A_4	0	0.2719	0.3663	0.2646	0	0	0	1

TABLE 6. The priorities (***B***, ***O***, ***C***, ***R***) of the alternatives under each merit

	B	***O***	***C***	***R***
A_1	0.2822	0.3250	0.2748	0.2855
A_2	0.2056	0.1517	0.2697	0.2829
A_3	0.2157	0.2011	0.1355	0.1665
A_4	0.2965	0.3222	0.3200	0.2651

The seven experts were asked next to estimate the priorities of the four merits according to strategic criteria by the five-step scale. The ratings of the four merits on strategic criteria are calculated by the geometric mean method and are shown in Table 7 and Table 8 (Wu, 2010). The priorities (b, o, c, r) of the merits were obtained by integrating the data in Table 4 and Table 8, and the results are shown in Table 9 (Wu, 2010). The normalized priorities (b, o, c, r) are shown in the last column of Table 9.

TABLE 7. The ratings of the four merits on strategic criteria 1 (SG_1)

SG_1	m_{EP1}	m_{EP2}	m_{EP3}	m_{EP4}	m_{EP5}	m_{EP6}	m_{EP7}	***merits***
B	0.1600	0.1600	0.4200	0.1600	0.4200	0.2600	0.2600	***0.2422***
O	0.2600	0.1600	0.2600	0.1000	0.1600	0.4200	0.2600	***0.2114***
C	0.1000	0.2600	0.1600	0.2600	0.2600	0.2600	0.1600	***0.1974***
R	0.2600	0.2600	0.1000	0.1000	0.1000	0.1600	0.1600	***0.1503***

TABLE 8. The ratings of the four merits on strategic criteria (SG_1- SG_3)

	SG_1	SG_2	SG_3
B	0.2422	0.1715	0.2264
O	0.2114	0.2261	0.2596
C	0.1974	0.2269	0.2112
R	0.1503	0.1059	0.1299

TABLE 9. The priorities (b, o, c, r) of the merits

	SG_1	SG_2	SG_3	SUM	Normalized
B	0.1075	0.0438	0.0681	0.2194	0.2774 (***b***)
O	0.0938	0.0578	0.0781	0.2297	0.2904 (***o***)
C	0.0876	0.0580	0.0635	0.2091	0.2644 (***c***)
R	0.0667	0.0271	0.0391	0.1328	0.1678 (***r***)
SUM				0.7910	1.0000

The final ranking of DRAR projects is calculated by Equation (7)-(9) to combine the scores of each alternative under B, O, C and R. Because *BO/CR* is a marginal formula (Saaty & Vargas, 2006) this research did not adopt the multiplicative method to calculate the priorities. The results are as shown in Table 10 (Wu, 2010).

TABLE 10. Final synthesis of priorities of alternatives

	Synthesizing methods					
	Additive		Probabilistic additive		Subtractive	
Alternatives	Priority	Rank	Priority	Rank	Priority	Rank
A_1	0.2615	2	0.4843	2	0.0520	2
A_2	0.1913	4	0.4145	4	-0.0177	4
A_3	***0.2875***	**1**	***0.4867***	**1**	***0.0545***	**1**
A_4	0.2597	3	0.4790	3	0.0467	3

Under the different methods of synthesizing the scores of alternatives, we get an identical ranking outcome, that is, $\mathbf{A_3}$ (local industrial and commercial circles) $\succ$ $\mathbf{A_1}$ (mixed-use of residence and commerce) $\succ$ $\mathbf{A_4}$ (development of tourist and recreational activities) $\succ$ $\mathbf{A_2}$ (museum of local culture and tradition). In consequence, developing the project of local industrial and commercial circles ($\mathbf{A_3}$) is the best for the revitalization and regeneration of Jioufen.

5. Conclusions

An integrated FDM, ISM and ANP evaluation model is constructed in this research for project selection of district revitalization and regeneration. Because human decision making process involves many complex influence factors, which have simultaneous interaction of positive or negative impacts, the proposed model can help decision makers in the developmental project selection process by considering the benefits, opportunities, costs and risks (BOCR) perspectives.

By applying the proposed model, decision makers in the district development can base on the results to examine the expected performance of the projects on various criteria, and can select the most appropriate project of district with its revitalization and regeneration in the future. The network of ANP with BOCR is constructed based on literature review and interview with experts in the field, and there are 13 extracted critical criteria under benefits, opportunities, costs and risks. In addition, the interdependent relationship among criteria also can be clarified. Based on the proposed model, the priorities for the four possible projects are calculated to generate the final ranking. The result of the empirical study shows that the ranking is identical under different synthesizing methods, and the project of local industrial and commercial circles (alternative $\mathbf{A_3}$) is the best project for Jioufen.

To sum up, this paper sets up an objective and practicable project selection model for district revitalization and regeneration. The results show that the model can transform complex positive or negative impacts and interrelationship into simple quantitative values for objective and effective evaluation. The empirical results not only can provide innovative thinking for district reviving, but also can be guidance for practical project development selection in the future.

Acknowledgements

1. Part of this research was carried out as supervision of Wu, Zih-Ling's Master thesis.
2. The result of this research has been presented at the 2010 International Conference on Business and Information, Kitakyushu, Japan.

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附件四

國科會補助專題研究計畫項下出席國際學術會議心得報告

日期：99 年 07 月 13 日

<table>
<tr><td>計畫編號</td><td colspan="3">NSC　98　－　2410　－　H　－　216　－　021　－</td></tr>
<tr><td>計畫名稱</td><td colspan="3">多準則決策整合 BOCR 於地區活化再生之方案評選</td></tr>
<tr><td>出國人員
姓名</td><td>王　維　民</td><td>服務機構
及職稱</td><td>中華大學　建築與都市計畫學系
助理教授</td></tr>
<tr><td>會議時間</td><td>99 年 7 月 5 日至
99 年 7 月 7 日</td><td>會議地點</td><td>Kitakyushu, Japan</td></tr>
<tr><td>會議名稱</td><td colspan="3">（中文）
（英文）2010 International Conference on Business And Information</td></tr>
<tr><td>發表論文
題目</td><td colspan="3">（中文）
（英文）ANP with BOCR Applied to Project Selection of District Revitalization and Regeneration</td></tr>
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一、參加會議經過

本人於 7 月 4 日搭乘國泰航空 CX510 班機抵達 Fukuoka, Japan，參加 7 月 5 日至 7 月 7 日由 Academy of Taiwan Information Systems Research 於 Kitakyushu city ” Rihga Royal Hotel Kokura” 所舉行的 ”the 2010 International Conference on Business and Information” (The BAI 2010 Conference)國際研討會。該研討會本年度共區分 ”Social Issues in Management” 等 24 項主題徵文，合計有來自 28 個不同地區、國家之 630 篇學術論文投稿；經審查後，有 471 篇得於本次議程中分派於 A1～L6 等 67 個不同場次進行發表。本人所發表之 ”ANP with BOCR Applied to Project Selection of District Revitalization and Regeneration“ 論文，投稿於 ”Social Issues in Management” 主題，並被安排於 6 日上午 8:20~10:00 之〔C7〕場次、第 6 順位發表。該場次主持人由泰國 Chiang Mai 大學 Chaiwat Nimanussornkul 學者擔任，共計安排有 7 篇學術論文發表。

本人所發表之論文係針對既已開發之地區，以能彰顯出地方價值、自明性與創造地區新生命力之地區活化再生為研究課題。其間，考量促成地區活化再生之相關影響因素複雜、且同時存在有像利益與成本、風險與機會之正、反雙向的衝擊，將造成發展決策評選時之困難；遂透過結合 BOCR 概念，歸納出可能影響因子、並藉由整合相關客觀且可量化的數學方法（FDM、ISM、ANP），建立起一整體、具可操作性的方案評選模式。過程中，將相關量化研究方法整合為質性問題之整體評價操作，頗受與會學者之注意而引起提問與討論。此外，個人尚依大會議程選擇參與其他部分發表場次，除瞭解現下相關研究領域之趨勢與重點外、並汲取新穎之研究觀念與研究方法。研討會會議於 7 月 7 日傍晚圓滿閉幕，本人於隔天 7 月 8 日搭機返國。

二、與會心得

本次國際研討會的發表，多數由第一作者親自解說，有機會參與並聆聽相關國際學者之精湛內容，實為難得之經驗與收穫。此外，自身之研究不論在研究主題的設定、或是研究方法的引用與整合，尚能引起其他學者專家之興趣與討論，給予自我信心與正面的鼓勵。

而，藉由此次國際會議之參與交流，深刻地體會到跨領域研究之未來趨勢性與重要性；並且，透過相關不同專業領域研究、與新穎思維觀念之接觸，除可增長見聞拓展視野外，對於未來研究議題的開發與設定、以及研究方法的引用與整合，有著莫大的啟發與正向的幫助。

此外，由於本研討會舉辦之所在城市（Kitakyushu），在日本為一深具自我城市意象與風格特色之已發展都市。與會期間強烈地感受到該城市地區無論在人文特質的展現、環境資源的整合利用、以及商業與觀光產業的結合…等，都能快速地感染予每一位外來的旅客。而且，該城市在新與舊之地區建設、與環境設施上結合的和諧與一致，為本研究主題「地區活化再生」提供了鮮活的實境感受與體驗印證。

三、考察參觀活動(無是項活動者略)

四、建議

國際研討會的舉辦，若能展開心胸、廣徵研究議題，不但能有效增加國際間的參與交流，更能快速地提升學術研究之國際能見度；此外，尚能鼓勵跨領域研究之整合、促進異業間的合作，此一直接的效益與成果，在本次研討會之各會場處處可見。是以，強烈地建議國家學術研究領導單位能更積極地制訂相關具體的作業辦法，以鼓勵各學校單位舉辦具自我特色之常設性年度國際研討會，將可快速且有效地宣傳學術研究成果、並可有效刺激相關研究能量與促進國際合作。

五、攜回資料名稱及內容

(一) Proceedings of Business And Information 2010 (ISSN:1729-9322)（乙本）。

(二) 論文光碟（乙片）。

(三) Contemporary Management Research Vol.6, No.1 March 2010 (ISSN:1813-5498) (乙本）。

六、其他

ANP WITH BOCR APPLIED TO PROJECT SELECTION OF DISTRICT REVITALIZATION AND REGENERATION

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ABSTRACT

A district's sustainable development should not focus on the external demolition and construction, but should stress on manifesting internal local values and identities (revitalization) and creating renaissance and competitiveness of regional development (regeneration). In order to fulfill the abstract concepts of revitalization and regeneration to actual district development effectively, the transformation of subjective and qualitative perception and expectation into objective and quantitative project evaluation is necessary. Nevertheless, there exist many complex influence factors, which have simultaneous interaction of positive or negative impacts, such as benefits versus costs and opportunities versus risks. It would simply make perplexity for project selection and decision. Hence, in this study, the meaning of the district revitalization and regeneration is clarified by literature reviews first. Then, the related possible impact factors under benefits, opportunities, costs and risks clusters are generalized by integrating the concept of BOCR. Thereafter, fuzzy Delphi method (FDM) is applied to extract the criteria for the foundation of evaluation. Since there is complex interaction and interdependence among clusters (criteria) and alternatives, the method of analytic network process (ANP) with BOCR is employed. An objective and practicable project selection model can then be established. The results show that the model can transform complex positive or negative impacts and interrelationship into simple quantitative values for objective and effective evaluation. The empirical results not only can provide innovative thinking for district reviving, but also can be guidance for practical project development selection in the future.

Keyword: Project selection, District revitalization and regeneration (DRAR), Fuzzy Delphi method (FDM), Analytic network process (ANP) with BOCR

INTRODUCTION

When the trend of development and management of district becomes focusing on the concept of sustainable development over the world, globalize homogenization for district development is resulted. Thus, the principle of "thinking globally and action locally" needs to be incorporated into specific and practicable implementations.

A number of studies (Couch & Dennemann, 2000; Doratli, Hoskara, & Fasli, 2004; Ghose, 2003; Orueta, 2007; Raco, 2003) show that manifesting local values and identities and creating renaissance are the direction of development for regional action principle, especially for developed district. In Taiwan, due to dense population with small land area, the district development has been saturated and possessed of the self-local characteristics and historical cultures. In traditional urban renewal for district reviving, developing arts and cultures, injecting commercial activities, and advancing tourism and recreation have been the major development types (Wang, Lee, & Wu, 2009). However, the local characteristics were usually neglected, and unfortunately, the resulted developments had a very high similarity.

A district's sustainable development should not focus on the external demolition and construction, but should stress on manifesting internal local values and identities (revitalization) and creating renaissance and competitiveness of regional development (regeneration). Consequently, the core of district revitalization and regeneration (DRAR) should reveal provincialism and continuity, and furthermore, to stimulate the new life and competitiveness (Çevik, Vural, Tavşan, & Aşık, 2008; Couch & Dennemann, 2000; Razzu, 2005). In order to fulfill the abstract concepts of revitalization and regeneration to actual district development effectively, the transformation of subjective and qualitative perception and expectation into objective and quantitative project evaluation is necessary. Such a characteristic belongs to multi-attribute decision analysis (MADA).

Nevertheless, like any MADA decision problem in real life, there are usually several favorable and unfavorable concerns that must be considered at the same time (Saaty & Vargas, 2006). There exist many complex influence factors in the evaluation process, which have simultaneous interaction of positive or negative impacts, such as criteria in benefits versus those in costs, and criteria in opportunities versus those in risks. It would simply make perplexity for project selection and decision. The analytic network process (ANP) with the benefits, opportunities, costs, and risks (the BOCR merits) can solve this arduous problem effectively. The ANP, proposed by Satty (1996), is a simple, mathematically based multi-criteria decision-making tool to deal with complex, interdependent and multi-attribute problems. Saaty (2005) further proposed the BOCR to solve the positive and negative impacts of a problem simultaneously. The ANP with BOCR has been applied in some recent works (Erdoğmuş, Kapanoglu, & Koç, 2005; Feglar, Levy, Feglar, & Feglar, 2006; Saaty & Shang, 2007)

In this paper, an evaluation framework for project selection of DRAR is proposed. The related issues of district's revitalization and regeneration are reviewed through literature first. Fuzzy Delphi method (FDM) by generalizing experts' opinions is applied next to extract the most critical factors. Then, interpretive structural modeling (ISM) is employed to determine the interrelationship among the critical factors. An analytic network process (ANP) with BOCR model is constructed to evaluate the project selection for district's revitalization and regeneration, and the relative importance weights of the critical factors and alternatives are calculated. The results show that the model can transform complex positive or negative impacts and interrelationship into simple quantitative values for objective and effective evaluation. The empirical results also can be the consultation and guidance for practical project development selection in the future.

METHODOLOGIES

Fuzzy Delphi method (FDM)

Since its conception and development by Dalkey and Helmer in 1963, Delphi method has been used in a wide range of research applications. Despite its merits, the method has ambiguity and uncertainty problems in survey questions and responses (Chang, Huang, & Lin, 2000; Wey & Wu, 2007). The incorporation of fuzzy set theory with Delphi method is one of the approaches to tackle the problems (Lee, Wang, & Lin, 2010). Murray, Pipino, & Van Gigch (1985) first applied the fuzzy theory to the traditional Delphi method. Ishikawa, Amagasa, Shiga, Tomizawa, Tatsuta, & Mieno (1993) employed the cumulative frequency distribution function and the fuzzy integration to integrate experts' estimation into fuzzy numbers, and utilized the "gray zone", the intersection of the fuzzy numbers, to develop the Max-Min FDM and the FDM via Fuzzy Integration (FDMFI).

This paper bases on the FDM developed by Ishikawa et al. (1993) to find the critical factors, and the procedures for executing the method are as follows (Ishikawa et al., 1993, Wang et al., 2009):

Step 1: Construct a table of cumulative frequency distribution, with $F_i^1(x)$ being a function that denotes the period of realization with an extremely high degree of possibility, and $F_i^2(x)$ being a function that denotes the period of non-realization with an extremely high degree of possibility.

Step 2: Obtain respectively the upper and lower quartiles of $F_i^1(x)$ and $F_i^2(x)$, i.e. (C_i^1, D_i^1) and (C_i^2, D_i^2), as shown in Figure 1. Medians corresponding to $F_i^1(x)$ and $F_i^2(x)$ are calculated and designated as M_i^1 and M_i^2, respectively.

Step 3: Link C_i^1, M_i^1, D_i^1 and C_i^2, M_i^2, D_i^2 respectively, and obtain the Max-Min forecast value X_i^* is to be obtained. The overlap section of the two functions is called the gray zone (see Figure 1).

Step 4: Extract critical factors by comparing X_i^* with the threshold value (***S***). If $X_i^* \geqq \boldsymbol{S}$, select factor ***i***; and if $X_i^* < \boldsymbol{S}$, eliminate factor ***i***. In general, the threshold value is determined by decision makers subjectively (Dzeng & Wen, 2005; Kuo & Chen, 2008).

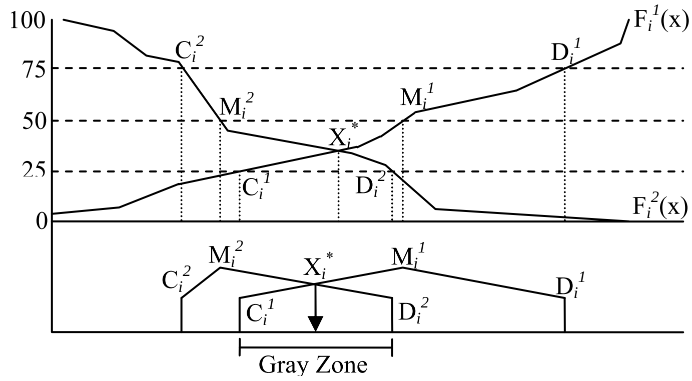

FIGURE 1. Construct membership function and Max-Min forecast value

Interpretive structural modeling (ISM)

Interpretive structural modeling (ISM), proposed by Warfield (1974, 1976), is often used to provide fundamental understanding of complex situations and to put together a course of action for solving a problem (Lee et al., 2010). The method helps impose order and direction on the complexity of relationships among elements of a system. It is a suitable modeling technique for analyzing the influence of one variable on other variables (Agarwal, Shankar, & Tiwari, 2007). In this paper, ISM is applied to understand the interaction among criteria.

The procedures of the binary matrix manipulation of ISM are as follows (Huang, Tzeng, & Ong, 2005; Lee et al., 2010; Warfield, 1973):

Step 1: Establish relation matrix which shows the relationship among the criteria. The general form of the relation matrix ***D*** can be presented as follows:

$$\boldsymbol{D} = \begin{matrix} & e_1 & e_2 & \cdots & e_n \\ e_1 & 0 & \pi_{12} & \cdots & \pi_{1n} \\ e_2 & \pi_{21} & 0 & \cdots & \pi_{2n} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ e_n & \pi_{m1} & \pi_{m2} & \cdots & 0 \end{matrix}$$

where π_{ij} denotes the relation between the *i*th row and *j*th column criteria, if criterion e_i affects criterion e_j, then $\pi_{ij} = 1$, otherwise $\pi_{ij} = 0$.

Step 2: Calculate the reachability matrix as follows:

$$\boldsymbol{M} = \boldsymbol{D} + \boldsymbol{I} \quad (1)$$

$$\boldsymbol{M}^* = \boldsymbol{M}^k = \boldsymbol{M}^{k+1} \quad k > 1 \quad (2)$$

where $\boldsymbol{I}$ is the identity matrix, k denotes the powers, and $\boldsymbol{M}^*$ is the reachability matrix. The reachability matrix is under the operators of the Boolean multiplication and addition (i.e., 1×0=0×1=0, 1+0=0+1=1).

Step 3: Calculate the reachability set and the priority set, respectively.

$$R(t_i) = \left\{ e_i \middle| m_{ji}^* = 1 \right\} \quad (3)$$

$$A(t_i) = \left\{ e_i \middle| m_{ij}^* = 1 \right\} \quad (4)$$

Step 4: Determine the levels and relationships between the criteria by Equation (5). The relationships of all the criteria and plot the network structure can be constructed.

$$R(t_i) \cap A(t_i) = R(t_i) \quad (5)$$

Analytic network process (ANP) with BOCR

The benefits, opportunities, costs, and risks (the BOCR merits) is a concept of the analytic network process (ANP), proposed by Saaty (1996). It is a simple, mathematically based multi-criteria decision-making tool to deal with complex and multi-attribute problems. The ANP with BOCR has been applied in some works (Chang, Wey, & Tseng, 2009; Erdoğmuş et al., 2005; Liang & Li, 2008; Ustun & Demirtas, 2008). Under the BOCR, a network can consist of four sub-networks: benefits, opportunities, costs, and risks. Under benefits and opportunities (risks and costs), pairwise comparison questions ask which alternative is most profitable or has the best chance (riskiest or costliest) under each control criterion. Therefore, while the best alternative gets the highest priority for benefits and opportunities subnet, and the worst alternative also gets the highest priority for costs and risks. Then, the weights of the alternatives under each sub-network can be calculated, and these weights are further combined to get a single outcome for each alternative (Lee, Kang, Liu, & Wang, 2007).

The steps of ANP with BOCR are summarized as follows (Erdoğmuş et al., 2005; Lee et al., 2007; Lee, 2009; Lee, Chen, & Kang, 2009; Saaty, 2005):

Step 1: Decompose the problem hierarchically, an integrated control hierarchy and BOCR network evaluation framework is constructed. The control hierarchy contains the objective of the problem, strategic criteria, and the four merits, benefits (B), opportunities (O), costs (C), and risks (R). The BOCR network aims to achieve the goal with simultaneous consideration of the four merits. Under each merit, there are control criteria and alternatives. The framework is shown in Figure 2.

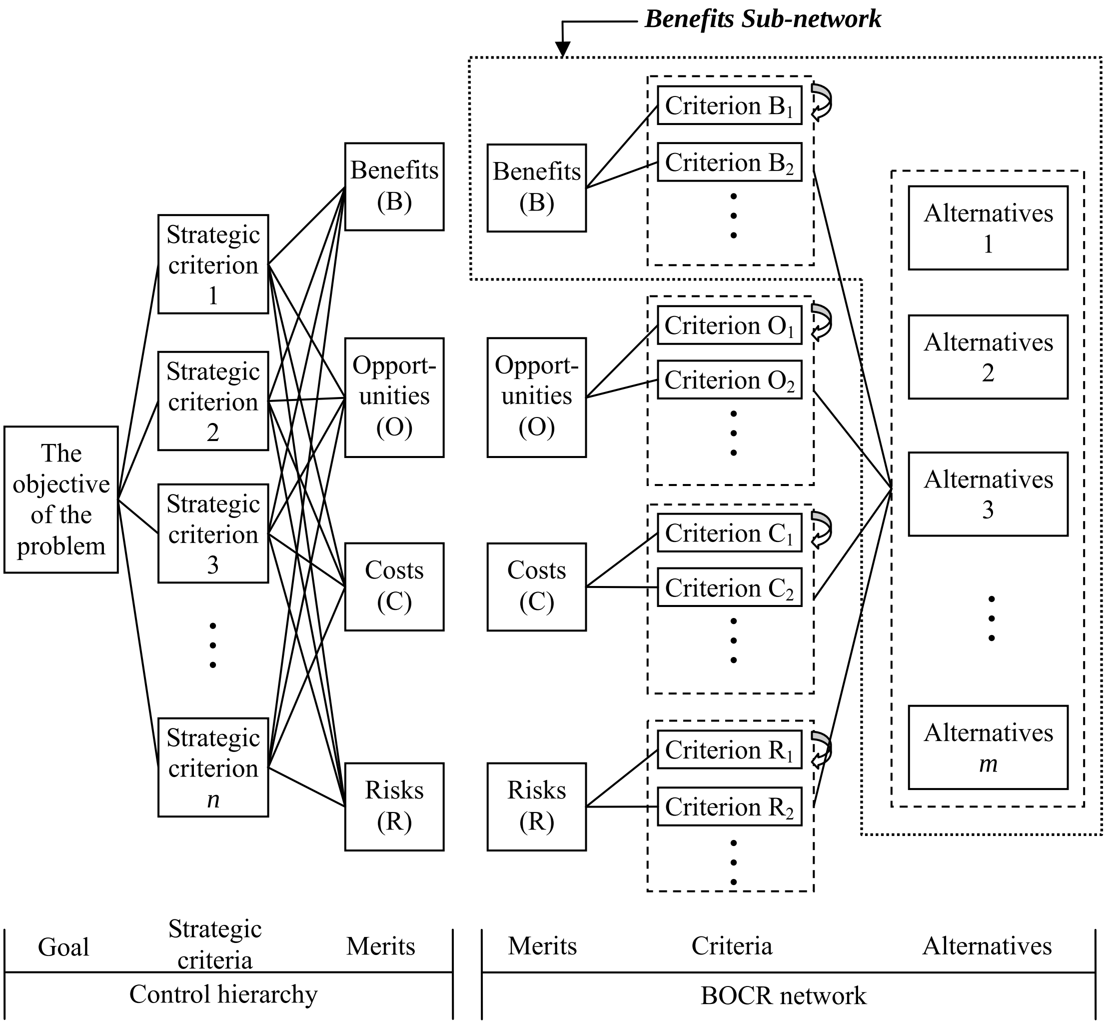

FIGURE 2. The framework

Step 2: Determine the priorities of the strategic criteria in the control hierarchy. The nine-point scale is applied to obtain pairwise comparison results of the importance of strategic criteria toward achieving the overall objective (Saaty, 1980). Arithmetic mean method is applied to aggregate experts' opinions.

Step 3: Based on the BOCR network, pairwise compare the criteria with respect to the same upper level merit, the interdependence among the criteria, and the performance of alternatives under each criterion by the nine-point scale.

Step 4: Calculate the relative priorities of the criteria with respect to the same upper level merit, the relative priorities of the interdependence among the criteria, and the relative priorities of the performance of alternatives under each criterion. Form a supermatrix for each sub-network by ANP, which is proposed by Saaty (1996). Calculate the priority (B_i, O_i, C_i, R_i) of alternative *i* under each merit.

Step 5: Determine the importance of benefits, opportunities, costs, and risks with respect to each strategic criterion. A five-step scale is used, and the values of each scale is assigned to be very high, 0.42; high, 0.26; medium, 0.16; low, 0.10; and very low, 0.06 (Erdoğmuş et al., 2005; Saaty, 2005). Geometric mean method is applied to aggregate experts' opinions.

Step 6: Determine the priorities (*b*, *o*, *c*, *r*) of the merits. Calculate the priority of a merit by multiplying the priority of the respective strategic criterion from Step 2 with the score of a merit on each strategic criterion from Step 5, and summing up the calculated values for the merit.

Step 7: Calculate overall priorities of the alternatives by synthesizing the priority (B_i, O_i, C_i, R_i) of each alternative under each merit from Step 4 with corresponding priorities of the merits (*b*, *o*, *c*, *r*) from Step 6. There are some ways to combine the scores of each alternative under B, O, C and R (Saaty & Ozdemir, 2003).

1. *Multiplicative*: $P_i = B_i \; O_i \; / \; C_i \; R_i$ (6)
2. *Additive*: $P_i = bB_i + oO_i + c(1/C_i)_{Normalized} + r\,(1/R_i)_{Normalized}$ (7)
3. *Probabilistic additive*: $P_i = bB_i + oO_i + c(1 - C_i) + r\,(1 - R_i)$ (8)
4. *Subtractive*: $P_i = bB_i + oO_i - cC_i - r\,R_i$ (9)

CONSTRUCTION OF EVALUATION MODEL

The major goal of this research is to select the best revitalization and regeneration project in a district, and therefore the research design contains two significant parts: determining critical evaluation criteria and establishing an evaluation model.

Determining critical evaluation criteria

Based on extensive literature reviews (Aravot, 1996; Çevik, et al., 2008; Helleman & Wassenberg, 2004; Raco, 2003; Wang & Wu, 2008; Wedding & Crawford-Brown, 2007), regional environmental nature and developmental demands, and the study of Wang et al. (2009), we generalized and categorized 30 possible impact factors for the DRAR project under benefits (B), opportunities (O), costs (C), and risks (R). FDM was applied next to extract the most critical factors.

An anonymous questionnaire was prepared, and 15 experts in the fields of DRAR were asked to evaluate the importance of each possible impact factor. A convergence of their opinions was obtained, and 13 critical factors were extracted. In this research, we subjectively set 6.6, 7.1, 6.7, and 6.8 as the threshold values for the four merits B, O, C, and R, respectively. The results are shown in Table 1, and the factors shaded in gray are selected.

The 13 extracted factors for the DRAR project under benefits (B), opportunities (O), costs (C), and risks (R) are represented as C_1, C_2, …, C_{13}, and described here. Under benefits (B), the criteria are: external utilities of district regeneration (EUD; C_1), revitalization of district industry (RDI; C_2), and improvement of living environment (ILE; C_3). The criteria under opportunities (O) are linkage of open space network system (LOS; C_4), guidance of government planning (GGP; C_5), and place marketing and strategy management (PMS; C_6). The criteria under costs (C) are: ecology and landscape resource (ELR; C_7), conservation of cultural and historical prospect (CCH; C_8), expenditure of physical construction (EPC; C_9), and integration and management of local resource (IML; C_{10}). The criteria under risks (R) are: negative impact of government policy (NIG; C_{11}), ignorance of local residents' equity (IRE; C_{12}), and loss of existing district value and identity (LEV; C_{13}). In order to evaluate the performance of DRAR projects, this research constructed a BOCR network framework using the above-mentioned 13 critical success criteria.

TABLE 1. Extraction results of the possible impact factors

Merits	Possible impact factors	$F_i^1(x)$			$F_i^2(x)$			X_i^*	Threshold values
		C_i^1	M_i^1	D_i^1	C_i^2	M_i^2	D_i^2		
B	1 Conservation and continuum of space-time value (CCS)	6.25	7.38	8.42	4.38	5.42	6.08	6.17	6.6
	2 External utilities of district regeneration (EUD)	7.25	7.63	8.56	5.15	5.90	6.81	7.03	
	3 Revitalization of district industry (RDI)	7.44	8.30	9.06	3.92	6.07	6.61	7.02	
	4 Appearance of vitality (AOV)	5.94	8.50	9.25	3.69	5.10	5.85	5.89	
	5 Exchange of local value (ELV)	6.55	7.38	8.31	4.38	5.83	6.46	6.51	
	6 Acknowledgement of local ideology (ALI)	6.75	7.70	8.56	4.19	5.17	6.31	6.53	
	7 Preservation of historical space and architecture (PHS)	6.58	8.25	8.87	4.19	5.25	6.45	6.52	
	8 Communication of sensation (COS)	6.35	7.13	8.25	3.75	4.70	5.45	5.90	
	9 Improvement of living environment (ILE)	7.44	8.25	8.87	4.58	5.50	6.62	7.03	
O	10 Expression of district identity (EDI)	7.38	8.36	8.89	4.88	6.19	6.66	7.02	7.1
	11 Activation of capital asset and potential (ACP)	7.44	8.21	8.75	4.38	5.50	6.63	7.03	
	12 Linkage of open space network system (LOS)	7.75	8.44	8.91	4.38	5.50	7.25	7.50	
	13 Connection of circulation and quality improvement (CCQ)	6.55	7.25	7.88	3.58	5.63	6.37	6.46	
	14 Guidance of government planning (GGP)	7.69	8.63	9.38	4.25	5.50	6.75	7.22	
	15 Place marketing and strategy management (PMS)	7.92	8.39	8.81	4.19	5.25	6.45	7.18	
	16 Promotion of cultural interpretation (PCI)	6.75	7.70	8.56	4.15	4.90	6.42	6.58	
C	17 Ecology and landscape resource (ELR)	7.44	8.21	8.75	4.38	5.42	6.08	6.76	6.7
	18 Conservation of cultural and historical prospect (CCH)	7.58	8.42	9.06	5.25	6.25	6.88	7.23	
	19 Expenditure of physical construction (EPC)	7.35	8.13	9.06	4.38	5.50	6.63	6.99	
	20 Integration and management of local resource (IML)	8.09	8.56	9.06	5.13	5.75	7.08	7.59	
	21 Cost of time (CTI)	6.55	7.25	7.87	2.92	4.50	5.45	6.00	
	22 Cost of Space (CSP)	6.55	7.30	8.12	3.25	4.30	5.12	5.84	
	23 Cost of advertisement and marketing (CAM)	6.58	8.07	8.61	3.75	4.58	5.42	6.00	
R	24 Consumption of ecology resource (CER)	6.75	7.70	8.56	3.75	5.25	6.56	6.66	6.8
	25 Negative impact of government policy (NIG)	7.44	8.21	8.75	3.92	6.07	6.61	7.02	
	26 Existing restriction of district development (ERD)	6.46	7.17	8.31	3.25	4.75	6.38	6.42	
	27 Conflict of participation process (CPP)	7.25	8.19	8.66	2.87	4.87	6.08	6.67	
	28 Ignorance of local resident's equity (IRE)	7.38	8.36	8.89	4.25	5.50	6.75	7.06	
	29 Downfall of local industry (DLI)	6.75	7.70	8.56	3.58	4.83	6.13	6.44	
	30 Lose of existing district value and identity (LEV)	7.19	8.10	8.85	3.75	6.13	7.08	7.14	

Number of extracted factors: 13, and shown in gray.

Establishing an evaluation model

In order to determine the priorities of the four merits, three strategic criteria have been incorporated into the framework. These strategic criteria are (1) to animate district assets effectively (represented as SC_1), (2) to manifest and sustain local activities (SC_2), and (3) to stimulate district sustainable development (SC_3). Each of these strategic criteria can be thought of as sub-goals.

In addition, since there are possible interdependent relationships among extracted factors (criteria) under each merit, ISM is employed next to clarify the interrelationship among the criteria. A questionnaire was prepared to ask the relationship of one criterion to another. The mode of experts' opinions on the relationship between a pair of criteria was calculated (Yang, Chiu, Tzeng, & Yeh, 2008), and then used to determine whether the criteria were dependent or not. Under benefits (B), the integrated relation matrix ($\boldsymbol{D_B}$) among criteria C_1-C_3 was obtained:

$$
\boldsymbol{D_B} = \begin{array}{c} \\ C_1 \\ C_2 \\ C_3 \end{array} \begin{array}{c} \begin{array}{ccc} C_1 & C_2 & C_3 \end{array} \\ \begin{bmatrix} 0 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 0 & 0 \end{bmatrix} \end{array}
$$

The final reachability matrix for criteria was calculated:

$$
\boldsymbol{M}_{\boldsymbol{B}}^{*} = \boldsymbol{M}_{\boldsymbol{B}}^{2} = \boldsymbol{M}_{\boldsymbol{B}}^{3} = \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}
$$

Next, the levels and relationships among the criteria can be clarified by Equation (3)-(5) (shown in Table 2). And then, based on $\boldsymbol{M}_{\boldsymbol{B}}^{*}$ and Table 2, the interrelationship among the criteria (C_1, C_2, and C_3) under benefits (B) can be depicted as in Figure 3. Similarly, the interrelationship among the criteria C_4-C_6, C_7-C_{10}, and C_{11}-C_{13} are clarified under opportunities (O), costs (C) and risks (R) merits, respectively (shown in Figure 3).

TABLE 2. The reachability set and the priority of benefits (B)

	Criteria	$R(t_i)$	$A(t_i)$	$R(t_i) \cap A(t_i)$
	C_1	C_1, C_2, C_3	C_1, C_2, C_3	C_1, C_2, C_3
Level 1	C_2	C_1, C_2, C_3	C_1, C_2, C_3	C_1, C_2, C_3
	C_3	C_1, C_2, C_3	C_1, C_2, C_3	C_1, C_2, C_3

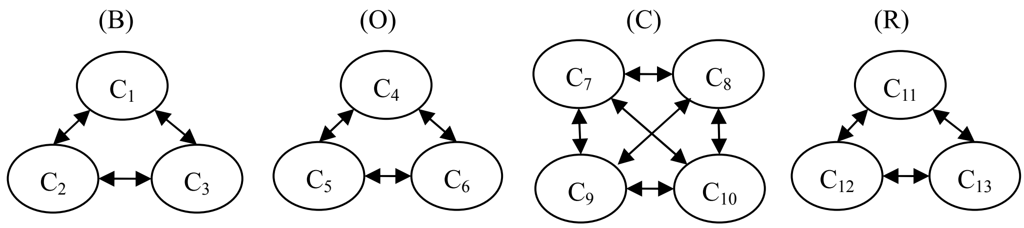

FIGURE 3. The interrelationship among the criteria under B, O, C, and R

With the results from FDM and ISM, projects to be evaluated (different district development alternatives) were added to establish a complete evaluation model for the revitalization and regeneration project selection of a district is constructed, as shown in Figure 4.

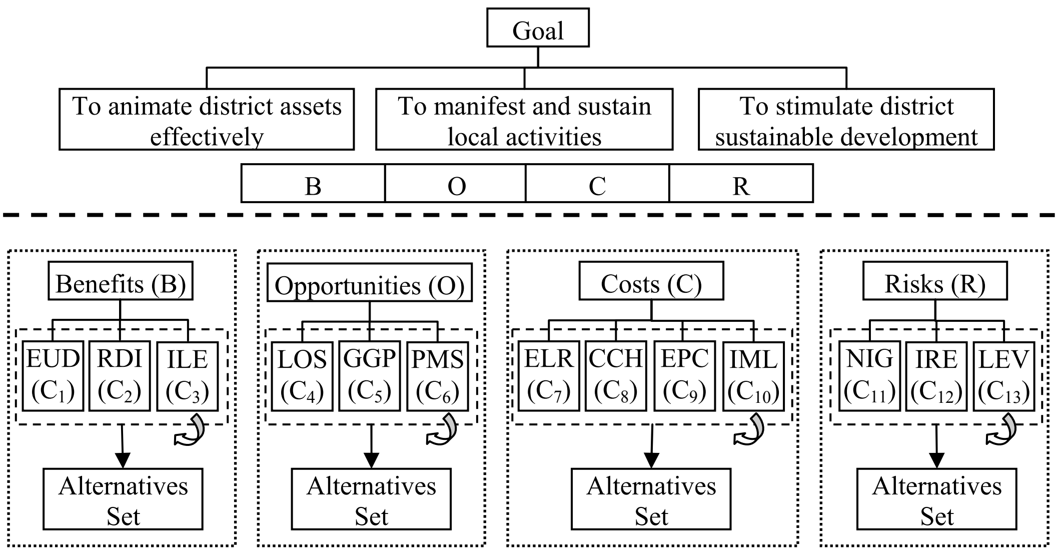

FIGURE 4. The evaluation model

EMPIRICAL STUDY

The subject of the empirical study was Jioufen, which is located in the northeast of Taiwan. A mountain town in the Rueifang Township of Taipei County, Jioufen was formerly renowned for its mining industry. Today, the town is a famous tourist attraction with affluence commercial activities, traditional settlement space formation and distinct local identity. Four projects (denote A_1-A_4) were evaluated for district revitalization and regeneration development: (1) mixed-use of residence and commerce (A_1), museum of local culture and tradition (A_2), local industrial and commercial circles (A_3), and development of tourist and recreational activities (A_4).

Based on the proposed model and experts' opinions, the performance of the four district projects (alternative A_1-A_4) could be generated. In the first part of the model, seven experts were asked to evaluate the priorities of benefits, opportunities, costs, and risks. A pairwise comparison matrix of expert 1 was formed (Table 3) to evaluate the three strategic criteria. The arithmetic mean method was applied to synthesize experts' opinions. The integrated priorities of experts for the strategic criteria were calculated (shown in Table 4).

TABLE 3. Pairwise comparison of strategic criteria with respect to G by expert 1

G	SG^1_1	SG^1_2	SG^1_3	EV_{EP1}
SG^1_1	1	2	5	***0.6098***
SG^1_2	1/2	1	1	***0.2247***
SG^1_3	1/5	1	1	***0.1655***

TABLE 4. Integrated priorities (7 experts) of strategic criteria with respect to G

G	EV_{EP1}	EV_{EP2}	EV_{EP3}	EV_{EP4}	EV_{EP5}	EV_{EP6}	EV_{EP7}	***EV***
SG^j_1	0.6098	0.4395	0.6833	0.6337	0.5499	0.1021	0.0880	***0.4438***
SG^j_2	0.2247	0.1210	0.1998	0.1919	0.2098	0.1721	0.6694	***0.2555***
SG^j_3	0.1655	0.4395	0.1169	0.1744	0.2403	0.7258	0.2426	***0.3007***

In the second part of the model, the priorities of the alternatives under each merit are calculated. There are four sub-networks, namely benefits, opportunities, costs, and risks. Under each merit, the relative importance weights of criteria (alternatives) with respect to the same upper level merit (criterion), and the interdependence priorities among the criteria that have the same upper-level merit are calculated using the arithmetic mean of the experts' pairwise comparison results. The above importance weights of criteria and alternatives, and the interdependence priorities among criteria are entered into appropriate places in the unweighted super-matrix for each merit sub-network. As an example, the unweighted super-matrix for the ***benefits*** sub-network is as shown in Table 5, and then, the limit super-matrix is obtained. Similarly, the limit super-matrices for other sub-networks are calculated, and then the priorities (***B***, ***O***, ***C***, ***R***) of the alternatives under each merit are obtained (see Table 6).

TABLE 5. The unweighted super-matrix for the ***benefits*** sub-network

Benefits	**B** (merit)	C_1	C_2	C_3	A_1	A_2	A_3	A_4
B (merit)	0	0	0	0	0	0	0	0
C_1	0.3626	0.3810	0.3804	0.3608	0	0	0	0
C_2	0.2532	0.3921	0.2847	0.2782	0	0	0	0
C_3	0.3842	0.2269	0.3349	0.3610	0	0	0	0
A_1	0	0.3769	0.2040	0.2463	1	0	0	0
A_2	0	0.1405	0.1675	0.3070	0	1	0	0
A_3	0	0.2107	0.2622	0.1821	0	0	1	0
A_4	0	0.2719	0.3663	0.2646	0	0	0	1

TABLE 6. The priorities (***B***, ***O***, ***C***, ***R***) of the alternatives under each merit

	B	***O***	***C***	***R***
A_1	0.2822	0.3250	0.2748	0.2855
A_2	0.2056	0.1517	0.2697	0.2829
A_3	0.2157	0.2011	0.1355	0.1665
A_4	0.2965	0.3222	0.3200	0.2651

The seven experts were asked next to estimate the priorities of the four merits according to strategic criteria by the five-step scale. The ratings of the four merits on strategic criteria are calculated by the geometric mean method and are shown in Table 7 and Table 8. The priorities (b, o, c, r) of the merits were obtained by integrating the data in Table 4 and Table 8, and the results are shown in Table 9. The normalized priorities (b, o, c, r) are shown in the last column of Table 9.

TABLE 7. The ratings of the four merits on strategic criteria 1 (SG_1)

SG_1	m_{EP1}	m_{EP2}	m_{EP3}	m_{EP4}	m_{EP5}	m_{EP6}	m_{EP7}	***merits***
B	0.1600	0.1600	0.4200	0.1600	0.4200	0.2600	0.2600	***0.2422***
O	0.2600	0.1600	0.2600	0.1000	0.1600	0.4200	0.2600	***0.2114***
C	0.1000	0.2600	0.1600	0.2600	0.2600	0.2600	0.1600	***0.1974***
R	0.2600	0.2600	0.1000	0.1000	0.1000	0.1600	0.1600	***0.1503***

TABLE 8. The ratings of the four merits on strategic criteria (SG_1- SG_3)

	SG_1	SG_2	SG_3
B	0.2422	0.1715	0.2264
O	0.2114	0.2261	0.2596
C	0.1974	0.2269	0.2112
R	0.1503	0.1059	0.1299

TABLE 9. The priorities (b, o, c, r) of the merits

	SG_1	SG_2	SG_3	SUM	Normalized
B	0.1075	0.0438	0.0681	0.2194	0.2774 (***b***)
O	0.0938	0.0578	0.0781	0.2297	0.2904 (***o***)
C	0.0876	0.0580	0.0635	0.2091	0.2644 (***c***)
R	0.0667	0.0271	0.0391	0.1328	0.1678 (***r***)
SUM				0.7910	1.0000

The final ranking of DRAR projects is calculated by Equation (7)-(9) to combine the scores of each alternative under B, O, C and R. Because *BO/CR* is a marginal formula (Saaty & Vargas, 2006) this research did not adopt the multiplicative method to calculate the priorities. The results are as shown in Table 10.

TABLE 10. Final synthesis of priorities of alternatives

	Synthesizing methods					
	Additive		Probabilistic additive		Subtractive	
Alternatives	Priority	Rank	Priority	Rank	Priority	Rank
A_1	0.2615	2	0.4843	2	0.0520	2
A_2	0.1913	4	0.4145	4	-0.0177	4
A_3	***0.2875***	**1**	***0.4867***	**1**	***0.0545***	**1**
A_4	0.2597	3	0.4790	3	0.0467	3

Under the different methods of synthesizing the scores of alternatives, we get an identical ranking outcome, that is, $\mathbf{A_3}$ (local industrial and commercial circles) $\succ$ $\mathbf{A_1}$ (mixed-use of residence and commerce) $\succ$ $\mathbf{A_4}$ (development of tourist and recreational activities) $\succ$ $\mathbf{A_2}$ (museum of local culture and tradition). In consequence, developing the project of local industrial and commercial circles ($\mathbf{A_3}$) is the best for the revitalization and regeneration of Jioufen.

CONCLUSIONS

An integrated FDM, ISM and ANP evaluation model is constructed in this research for project selection of district revitalization and regeneration. Because human decision making process involves many complex influence factors, which have simultaneous interaction of positive or negative impacts, the proposed model can help decision makers in the developmental project selection process by considering the benefits, opportunities, costs and risks (BOCR) perspectives.

By applying the proposed model, decision makers in the district development can base on the results to examine the expected performance of the projects on various criteria, and can select the most appropriate project of district with its revitalization and regeneration in the future. The network of ANP with BOCR is constructed based on literature review and interview with experts in the field, and there are 13 extracted critical criteria under benefits, opportunities, costs and risks. In addition, the interdependent relationship among criteria also can be clarified. Based on the proposed model, the priorities for the four possible projects are calculated to generate the final ranking. The result of the empirical study shows that the ranking is identical under different synthesizing methods, and the project of local industrial and commercial circles (alternative $\mathbf{A_3}$) is the best project for Jioufen.

To sum up, this paper sets up an objective and practicable project selection model for district revitalization and regeneration. The results show that the model can transform complex positive or negative impacts and interrelationship into simple quantitative values for objective and effective evaluation. The empirical results not only can provide innovative thinking for district reviving, but also can be guidance for practical project development selection in the future.

ACKNOWLEDGEMENTS

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無研發成果推廣資料

98 年度專題研究計畫研究成果彙整表

<table>
<tr><td colspan="3">計畫主持人：王維民</td><td colspan="5">計畫編號：98-2410-H-216-021-</td></tr>
<tr><td colspan="8">計畫名稱：多準則決策整合 BOCR 於地區活化再生之方案評選</td></tr>
<tr><td colspan="3" rowspan="2">成果項目</td><td colspan="3">量化</td><td rowspan="2">單位</td><td rowspan="2">備註（質化說明：如數個計畫共同成果、成果列為該期刊之封面故事...等）</td></tr>
<tr><td>實際已達成數（被接受或已發表）</td><td>預期總達成數(含實際已達成數)</td><td>本計畫實際貢獻百分比</td></tr>
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<tr><td>研究報告/技術報告</td><td>0</td><td>0</td><td>100%</td><td></td></tr>
<tr><td>研討會論文</td><td>1</td><td>1</td><td>100%</td><td>王維民、李欣怡、吳子鈴，2009.12.，「多屬性決策分析應用於地區活化再生評價模式建構之初探」，2009 年中華民國都市計劃學會·區域科學學會·地區發展學會聯合年會暨學術論文研討會，台灣：台北，光碟版論文集第 1-15 頁。</td></tr>
<tr><td>專書</td><td>0</td><td>0</td><td>100%</td><td></td><td></td></tr>
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		研討會論文	1	1	100%		Wei-Ming Wang, Amy H. I. Lee, and Zih-Ling Wu, Jul. 5-7, 2010, 'ANP with BOCR applied to project selection of district revitalization and regeneration', 2010 International Conference on Business and Information, Kitakyushu, Japan, Disc pp. 1-14.
		專書	0	0	100%	章/本	
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	成果項目	量化	名稱或內容性質簡述
科教處	測驗工具(含質性與量性)	0	
	課程/模組	0	
	電腦及網路系統或工具	0	

計畫加填項目	教材	0	
	舉辦之活動/競賽	0	
	研討會/工作坊	0	
	電子報、網站	0	
	計畫成果推廣之參與（閱聽）人數	0	

國科會補助專題研究計畫成果報告自評表

請就研究內容與原計畫相符程度、達成預期目標情況、研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性）、是否適合在學術期刊發表或申請專利、主要發現或其他有關價值等，作一綜合評估。

1. 請就研究內容與原計畫相符程度、達成預期目標情況作一綜合評估 ■達成目標 □未達成目標（請說明，以 100 字為限） □實驗失敗 □因故實驗中斷 □其他原因 說明：
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3. 請依學術成就、技術創新、社會影響等方面，評估研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性）（以 500 字為限） 成果呈現在(1)篩選出四群集、13 項確切評選準則，(2)建立具可操作性整體評選模式，(3)評選模式驗證應用。學術成就：將傳統多準則決策分析所面臨正、反雙向發展複雜影響，結合於簡明易懂之 BOCR 分類，可使決策過程於評價準則之考量與遴選單純化；另外，藉詮釋結構模式（ISM）之釐清評價組成元素間的相依關係，為整體評選模式奠定客觀、可信的基礎；可為相關決策評估研究領域提供參考。在技術創新上，以 BOCR 概念＋模糊德爾菲(FDM)＋詮釋結構模式(ISM)＋分析網路程序(ANP)所串連之系列操作，係有系統、且前後呼應、合邏輯地處理準則的篩選、關係釐清、與模式建構、以及結果量化之數值呈現；此系列化的操作，可為相關質性感知問題提供客觀可行之技術參考。針對整體學術與應用價值而言，研究成果所建立的方案評選模式與其內含之簡易量化操作，提供一學術研究直接應用於現實問題解決之可行型態；不但可直接為實際地區提供未來發展明確方向，更可透過偏屬學術研究之量化操作，將各方案於相關評價組成之績效表現，以客觀數值權重反映之，以供決策者作更深層應對之參考。整體而言，研究成果對地區環境活化再生之發展甚具實質應用之價值與可發展性。