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*Full Length Research Paper*

# The use of a hybrid ANP-VIKOR approach for establishing the performance evaluation model of e-business project

**Shih-Ching Wang[1*] and Ming-Kuen Chen[2]**

[1]Institute of Services Technology and Management, National Taipei University of Technology, Taipei, Taiwan.
[2]Regional R&D Service Dept., MIRDC, MOEA, Taiwan; IDB, Ministry of Economic Affairs (MOEA), Taiwan.

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**These years, Taiwan enterprises face a rapidly changing environment. This transformation was brought about by both the pressure to take on an international and global outlook and the increase to apply more e-business or information communication and technology (ICT) solutions. Furthermore, the subjects of the e-business research increase day by day. In accordance with this tendency, Taiwan authority schemes out e-business policy and promotes representative e-business plan as a benchmark of achieving technological development and industrial competition. Therefore, the performance evaluation of e-business project is a key issue for policies. However, so far, there is no comprehensive mechanism to evaluate such kinds of project performance. Therefore, in this research, it is expected to reorganize the criteria for e-business project's performance evaluation, which were derived from discussion of the e-business performance evaluation, relevant literature of project evaluation and meetings with experts. Based on these criteria, the systematic evaluation model is constructed. This research is studied through Fuzzy Analytic Network Process (FANP) approach to construct achievements of appraisal pattern and VIseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR) approach to rank the performance of project cases of Taiwan e-business. We look forward to the result that this research may be regarded as reference material to the government and enterprises.**

**Key words:** E-business project, FANP, VIKOR, performance evaluation.

## INTRODUCTION

The coming and impact of the era of digitalization and globalization make the e-business become major study recently. Furthermore, the boost of e-business broadly changes the chain of the internal parts of the enterprise with the external distributorship and business partners. With several trends of industrial development in recently couple years, the issues of studying e-business increases day by day, such as the rise of the related issues of the enterprise flow, the e-market place, the e-purchase, the supply chain management, the global logistics management, the coordination commerce, the enterprise resources plan, the customer relationship and the e-

*Corresponding author. E-mail: shihching.wang@gmail.com.

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financial market (Kauffman and Walden, 2001; Ngai and Wat, 2002). To promote, influence and induce the development of industrial techniques, the government often enacts the industrial integral policy to advance the technical development, and to achieve the goal of technical development by a variety of technical policy; the most common way is the government assists the enterprise to proceed every project driven by coping with the situation and the business trends. So far, there is not a fit mechanism to evaluate such kinds of project performance. Thus, if we can set up a complete model to evaluate e-business project performance, for the enterprise (profit organization) and the government (non profit organization), it would be beneficial for them to push the execution of e-business projects, it could avoid not only improper planning of preliminary program which makes the following execution difficult, but also inappropriate resource distribution that makes unfavorable performance; and it could be used to examine and improve the program with worse performance.

Therefore, by searching for the related paper about the enterprise e-business in recent years and the current issue existing within the industrial application and government 's guidance and assistance, we try to retrieve the evaluation principle of executing enterprise e-business program in this study and further construct a systematic performance evaluation model of executing enterprise e-business program, and explain how to utilize this evaluation model with a representative case study of enterprise e-business for the reference of the government and enterprise.

This study constructs a performance evaluation model fit in generalizing the enterprise e-business program and utilizes the FANP and DEA to evaluate the model. Finally, the study will illustrate the application of this model with a representative case.

## MATERIALS

In the aspects of enterprise e-business performance evaluation, Kenneth et al. (2005) bring out the concept of dimensional valuable chain activity, the level of EDI (customer and supplier) and the enterprise process integration. Claycomb et al. (2005) address on innovation, route, content and the construct aspect of organization evaluation. Sherry et al. (2006) suggest the industry, government, organization and culture should be considered. Performance is an index to evaluate the level of goal achievements of organization (or individuals) with two meanings: efficiency and effect (including satisfaction); however, the project performance management means "a management process of the level of goal achievements in organizations , including measurements, checks and improvements on project performance"; the performance is a part of performance management. In the preliminary development of project performance management. The focus is on the performance measurement which means the evaluation of the level of organization (or individuals) goal achievements. With the increasing related research, the performance measurement has gradually transformed into the performance management.

Manzoor (2004) points our enterprises need to know their project performance and broach a model structure to evaluate the relative project performance. It will assist the enterprises to compare their project performance and give formal reference for the decision maker to judge a factor that should be considered for a successful project and suggest a proper way, Project Deadline Factor (PDF), to quantify every evaluation factor for a more specific evaluation. Belmiro and Duarte (2006) broach a set of project combination evaluation system for assistance with the central public administration of Portugal to choose a operating program measured by a finance method. The research utilized the overall multiple attribute value function (OMVF) and structuralized the problem in advance with consideration of national revenue (including the support of economical activities, efficient policies and regional development ) and so on.

Eddie et al. (2005) retrieve the factor for consideration of project choosing decision making such as the operation, management, finance, technology and circumstance and so on, from the related reference of projecting, project life cycle, project evaluation, investment decision making and the development of decision making model. They also take the Analytic Network Process (ANP) to construct the evaluation choosing model. In summary, the authors collect relevant issues for e-business projects as listed in Table 1.

On the other hand, the project evaluation is dominated by the linear algebra, linear programming and statistics, such as AHP (Saaty, 1980, 1996), ANP (Jaganathan et al., 2007) etc.

The structure of this study for the performance evaluation model is shown in Figure 1. Firstly, the important constructional aspects and their indices influencing the enterprise e-business project performance evaluation from the related researches were collected so as to extract the appropriate indices and classify them into five constructional aspects: scale, time, IT connection, financial index and the degree of achieving goals with 10 indices. Following this model to clarify the influence between principles, professionals in related areas were interviewed and they answered the questions about the influence correlation and level of importance between principles. Moreover, their fuzzy weightings were calculated by Csutora and Buckley's Lambda-Max FANP; fuzzy weighting was solved by Chen (2000)'s fuzziation-solving method, and then ANP completely imitating software, Super Decisions 1.6.0 was used to proceed the calculation of extreme relationship weighting. Finally, the referential weighting and sorting condition with experts' consensus of every evaluation principle was acquired and the criteria for a complete performance model were set up.

Furthermore, the ANP results of each criterion weight were used as a base for VIKOR approach to rank the performance of e-business projects (the 13 reprehensive cases of "Taiwan IT industry B-Plan") (Figure 1).

### FANP Approach

In the evaluation principle, Buckley and Csutora（2001）thought it could not reflect the judgment of subject, and they combine the theory of fuzzy and the analysis of layer coming out as FANP. They unite the advantage of subjective judgment problems solved by the theory of fuzzy, and the benefit of easy analysis essence of problem in layer analysis. It was able to reflect the problem encountered within decision making analysis under certain circumstance.

This study will utilize Lambda-Max FANP and consult the application of steps of FANP broached by Mikhailov and Madan (2003) to proceed the project evaluation of enterprise e- business, whose step is: 1. Establishing the ANP network structure of groups, 2. Extracting the opinion of experts, 3. Checking the consistency of trend, 4. Defuzzy and ranking, and 5. Listing supermatrix.

Firstly, it was based on literature (Table 1) and related reference about the enterprise e-business performance and project evaluation. The layer structural model of enterprise e-business

**Table 1.** Summary of the performance evaluation criteria of e-business project.

| Criteria | Principle | Definition | Related research |
|---|---|---|---|
| Time | Evaluation time | The time length from project start to end | Manzoor, 2004 |
| | Commitment time | The estimated time from project start to end | Manzoor, 2004 |
| | Real time | Project length ( or cycle time) | Manzoor, 2004; Belmiro and Duarte 2006; Eddie, et al.2005 |
| Scale | Range | Company scale | Claycomb et al. 2005; Sherry et al. 2006 |
| | Team scale | Project cost | Claycomb et al. 2005; Manzoor, 2004 |
| | Project scale | Input total human resource for project | Claycomb et al. 2005; Manzoor, 2004 |
| IT Connectivity | Connectivity members | The total members joining B2B e-business system | Kenneth et al. 2005; Sherry et al. 2006 |
| | Connectivity functions | The degree of function for e-business | Kenneth et al. 2005; Belmiro and Duarte, 2006 |
| | Connectivity fathomable | The degree of connection for e-business | Kenneth et al. 2005; Sherry et al. 2006 |
| Finance – Index | Profit | Net profit by project | Belmiro and Duarte, 2006; Eddie, et al.2005 |
| | ROI | Return on Investment | Belmiro and Duarte, 2006; Eddie, et al.2005 |
| Finance – Efficiency | Cost-income ratio | Cost-income ratio of project | Belmiro and Duarte, 2006; Eddie, et al.2005 |
| | Investment Value | Investment value of project | Belmiro and Duarte, 2006; Eddie, et al.2005 |
| Object Achievement | KPI achievement | KPI achievement of project | Manzoor, 2004; Claycomb et al. 2005; Chen and Wang, 2010 |

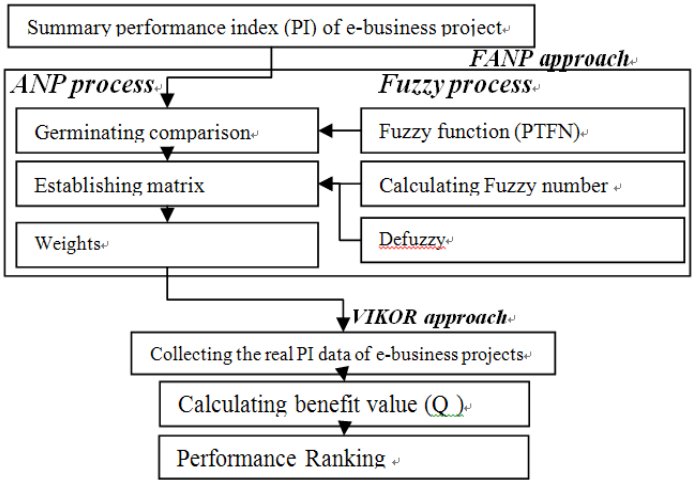


**Figure 1.** Research pattern.

evaluation constructed by this study is shown in Figure 2. By interviewing with experts with plenty of experiences in correlated areas and asking them to answer the questions of correlation and the level of importance for the principles, the authors figure out the relationship of groups as shown in Figure 3.

According to the evaluation of model for the structure (step 1: establish the structure of network for groups and principles), the authors have interviewed the experts for their opinions about the relationship of principles and the influence of intensifying to ensure the relationship of interdependence among principles. At least 3~7 of them are the senior experts of industry or government agency with abundant experience, including: pushing the related enterprise e-business project in unit A of government.

B works for in the consultative institution (Unit B). This institution executes the plans which are assigned by the government. C is the professional consulter for the information technology industry. They work as the seniority of expert of each area for more than 10 years. We sent 9 questionnaires to these experts (9 experts). These questionnaires are valid, and the rate of receiving is 100%.

After combining two principles for the correlatives evaluation of importance value we assumed every expert is expressed by semantic variables; we integrated the opinion of 9 experts with the average geometry (Csutora and Buckley, 2001). These semantic variables can be expressed by positive triangular fuzzy number (PTFN) as shown in Figure 3, and referred to Jaganathan et al. （2007）semantic fuzziation method; we set the permitable fuzzy residue of two extreme semantic scales as 0. And the fuzzy residue of other semantic scale is 1. (Step 2 and 3: the integration of group opinions and establishing positive fuzzy reciprocal matrix T).

The five groups of scale, time, IT connections, level of goal achievement and financial indices are represented individually in G1~G5. Besides the characteristic value computation and test of consistency, other calculating steps are represented by computing process examples of paired comparisons based on scale group, and the others are computed in the same way. Table 2 shows the positive reciprocal value of preliminary scale on questionnaires answered by experts; after the triangular fuzziation, the scale value has transformed into a 5x15 matrix. In the principle of scale group, the group needs to proceed paired comparison as “scale”, “time”, ”IT connection”, ”level of goal achievement” and ”financial indices”. Based on the last step, we integrate the opinion of every expert with

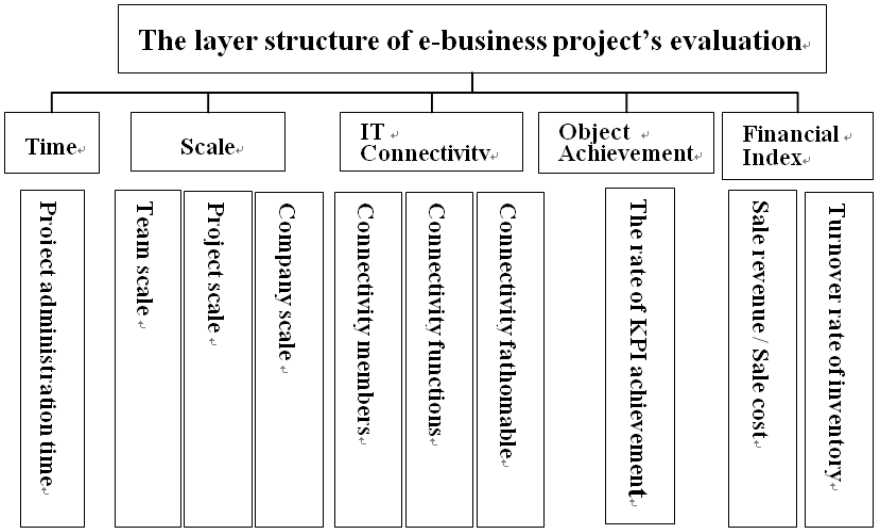


**Figure 2.** The layer structural model.

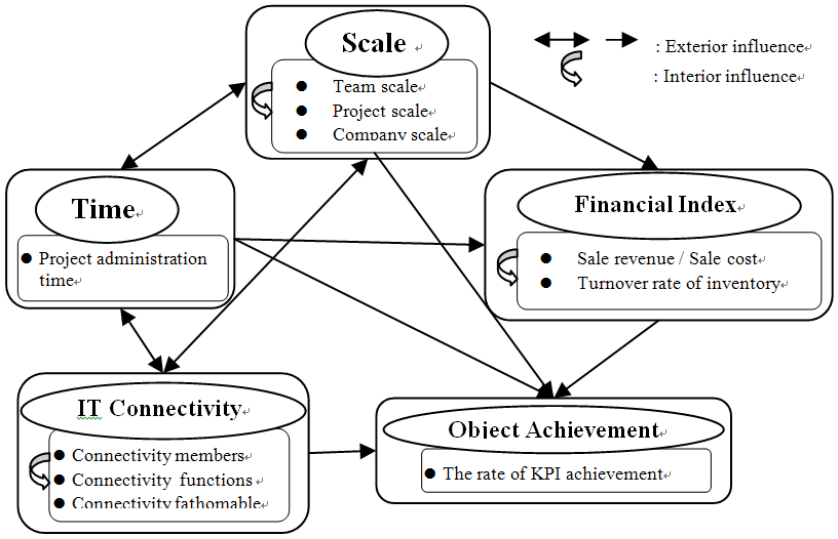


**Figure 3.** FANP- Network evaluation model-group interrelatedness.

**Table 2.** The ratings by valuator under scale (G1).

| | G1 | | | G2 | | | G3 | | | G4 | | | G5 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **G1** | 1 | 1 | 1 | 1/6 | 1/5 | 1/4 | 3 | 4 | 5 | 1 | 2 | 3 | 1 | 2 | 3 |
| **G2** | 4 | 5 | 6 | 1 | 1 | 1 | 1 | 2 | 3 | 1 | 2 | 3 | 2 | 3 | 4 |
| **G3** | 1/5 | 1/4 | 1/3 | 1/3 | 1/2 | 1 | 1 | 1 | 1 | 1/5 | 1/4 | 1/3 | 1/6 | 1/5 | 1/4 |
| **G4** | 1/3 | 1/2 | 1 | 1/3 | 1/2 | 1 | 3 | 4 | 5 | 1 | 1 | 1 | 1/5 | 1/4 | 1/3 |
| **G5** | 1/3 | 1/2 | 1 | 1/4 | 1/3 | 1/2 | 4 | 5 | 6 | 3 | 4 | 5 | 1 | 1 | 1 |

Note: G1 - Scale, G2 - Time, G3 - IT connectivity, G4 - Object Achievement, and G5 - Financial Index.

the average geometry method, and then set up the fuzzy positive reciprocal matrix T as shown in Table 3.

In the test of characteristic values and consistency between groups and principles, to make sure if the item of questionnaires in this study achieves the standard of consistency, we can utilize the characteristic value and characteristic vector got from paired comparison matrix, take the Consistency index (C.I.) and Consistence Ratio (C.R.) to evaluate the level of consistency in

**Table 3.** Aggregation of the weight of scale to get fuzzy weight.

| *T* | G1 | | | G2 | | | G3 | | | G4 | | | G5 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **G1** | 1.0000 | 1.0000 | 1.0000 | 0.4947 | 0.4229 | 0.8137 | 2.0377 | 3.1395 | 4.1860 | 1.2857 | 2.3478 | 3.3750 | 1.4211 | 2.5116 | 3.5526 |
| **G2** | 1.2290 | 2.3648 | 2.0216 | 1.0000 | 1.0000 | 1.0000 | 1.7419 | 2.8421 | 3.8849 | 1.8305 | 2.9670 | 4.0299 | 1.3171 | 2.4000 | 3.4395 |
| **G3** | 0.2389 | 0.3185 | 0.4907 | 0.2574 | 0.3519 | 0.5741 | 1.0000 | 1.0000 | 1.0000 | 0.4675 | 0.6490 | 0.9643 | 0.3462 | 0.4463 | 0.5806 |
| **G4** | 0.2963 | 0.4259 | 0.7778 | 0.2481 | 0.3370 | 0.5463 | 1.0370 | 1.5407 | 2.1389 | 1.0000 | 1.0000 | 1.0000 | 0.4500 | 0.5934 | 0.8308 |
| **G5** | 0.2815 | 0.3981 | 0.7037 | 0.2907 | 0.4167 | 0.7593 | 1.7222 | 2.2407 | 2.8889 | 1.2037 | 1.6852 | 2.2222 | 1.0000 | 1.0000 | 1.0000 |

**Table 4.** RCI values of sets of different order.

| *n* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *R.I* | N/A | N/A | 0.58 | 0.9 | 1.12 | 1.24 | 1.32 | 1.41 | 1.45 | 1.49 | 1.51 | 1.48 | 1.56 | 1.57 | 1.58 |

**Table 5.** Consistency ratio of the paired comparison matrix.

| Criteria | *n* | *C.I.* | *R.I.* | *C.R.* | Under Criteria | *n* | *C.I.* | *R.I.* | *C.R.* |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 0.0496 | Team scale (C1) | 3 | 0.0187 | 0.58 | 0.0324 |
| Scale (G1) | 5 | 0.055 | 1.12 | | Project scale(C2) | 4 | 0.0682 | 0.9 | 0.076 |
| | | | | | Company scale (C3) | 4 | 0.0763 | 0.9 | 0.085 |
| Time (G2) | 4 | 0.895 | 0.9 | 0.099 | Project administration time(C4) | 3 | 0.0107 | 0.58 | 0.0185 |
| | | | | 0.0795 | Connectivity members (C5) | 2 | 0 | 0 | 0 |
| IT connectivity(G3) | 5 | 0.089 | 1.12 | | Connectivity functions (6) | 2 | 0 | 0 | 0 |
| | | | | | Connectivity fathomable (7) | 2 | 0 | 0 | 0 |
| Financial Index | 2 | 0 | 0 | 0 | N/A | | | - | |

**Table 6.** Fuzzy weighted matrix.

| | G1 | | | G2 | | | G3 | | | G4 | | | G5 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **G1** | 0.3283 | 0.2219 | 0.2002 | 0.2159 | 0.1672 | 0.2203 | 0.2703 | 0.2917 | 0.2969 | 0.2222 | 0.2715 | 0.2912 | 0.3134 | 0.3613 | 0.3778 |
| **G2** | 0.4035 | 0.5247 | 0.4048 | 0.4365 | 0.3955 | 0.2708 | 0.2311 | 0.2641 | 0.2755 | 0.3163 | 0.3430 | 0.3477 | 0.2905 | 0.3453 | 0.3658 |
| **G3** | 0.0784 | 0.0707 | 0.0983 | 0.1124 | 0.1392 | 0.1554 | 0.1326 | 0.0929 | 0.0709 | 0.0808 | 0.0750 | 0.0832 | 0.0763 | 0.0642 | 0.0617 |
| **G4** | 0.0973 | 0.0945 | 0.1557 | 0.1083 | 0.1333 | 0.1479 | 0.1376 | 0.1431 | 0.1517 | 0.1728 | 0.1156 | 0.0863 | 0.0992 | 0.0854 | 0.0883 |
| **G5** | 0.0924 | 0.0883 | 0.1409 | 0.1269 | 0.1648 | 0.2056 | 0.2284 | 0.2082 | 0.2049 | 0.2080 | 0.1948 | 0.1917 | 0.2205 | 0.1439 | 0.1063 |

questionnaire.

According to the so-called randomized index R.I. broached by Saaty's study, it can be used to adjust the variation of different C.I. values from different layer numbers; the number of layers n and its corresponding randomized index values are shown in Table 4.

From Table 5, it can be understood the level of consistency of every construct aspect in this study is considerably ideal (C.R.< 0.1, C.I.≦0) and fits the demand of general research; it means there is no paradox or inconsistency in the questionnaire design and subject answering process in this study and conforms to the demand of consistency test.

Based on the former fuzzy positive reciprocal matrix T, we compute the fuzzy weighting value in Lambda-Max's type of positive fuzzy number ( $\tilde{T}$ ) as shown in Table 6. Then we integrate $W_m$ and $W_{l,u}$ to get a positive triangular fuzzy weighting matrix $W^T = \left[\tilde{w}_i^t\right]$, $\tilde{w}_i^t = \left(w_l^t, w_m^t, w_u^t\right)$, and proceed the normalization to get the normalized fuzzy weighting shown as Table 7.

Furthermore, we utilize the fuzziation-solving method broached by Chen (2000), $R_t = \frac{d^-\left(\tilde{r}_t^{l,u}, 0\right)}{d^-\left(\tilde{r}_t^{l,u}, 0\right) + d^-\left(\tilde{r}_t^m, 1\right)}$, to get the fuzziation-solving value of every fuzzy weighting matrix. The greater t $R_t$ is, the more prior the sequence of this evaluation principle is. It is shown in Table 8.

In Table 8, the ranking of the weights of the criteria is: scale (0.271), time (0.166), financial index (0.12134), object achievement (0.350), and IT connectivity (0.092). These results manifest the most influential construct for the e-business projects to enterprise as scale, and the least influential is IT connectivity.

**Table 7.** Aggregate of the fuzzy weighted and normalized.

| | $\widetilde{w}_i^{\,t}$ | | | $\widetilde{w}_i^{\,t_N}$ | | |
|---|---|---|---|---|---|---|
| | ***l*** | ***m*** | ***u*** | ***l*** | ***m*** | ***u*** |
| **G1** | 0.266097 | 0.254207 | 0.270224 | 0.2737898 | 0.2621185 | 0.2773733 |
| **G2** | 0.3270038 | 0.3651269 | 0.3287617 | 0.3364573 | 0.3764904 | 0.3374597 |
| **G3** | 0.0936652 | 0.0848642 | 0.08894 | 0.096373 | 0.0875053 | 0.091293 |
| **G4** | 0.1199741 | 0.1122195 | 0.1216466 | 0.1234425 | 0.115712 | 0.124865 |
| **G5** | 0.1651626 | 0.1533996 | 0.1646528 | 0.1699374 | 0.1581737 | 0.169009 |
| **Total** | 0.9719 | 0.9698 | 0.9742 | 1 | 1 | 1 |

**Table 8.** Defuzzy weighted.

| | **α = 0** | **α = 1** | $R_t$ | $R_{t_N}$ | **Rank** |
|---|---|---|---|---|---|
| df1=G1 | 0.271172 | 0.728935 | 0.271143 | 0.271016 | 1 |
| df2=G2 | 0.165793 | 0.83431 | 0.1657756 | 0.165698 | 2 |
| df3=G3 | 0.091796 | 0.908283 | 0.0917884 | 0.091745 | 5 |
| df4=G4 | 0.350632 | 0.650131 | 0.3503643 | 0.3502 | 4 |
| df5=G5 | 0.121406 | 0.878669 | 0.1213973 | 0.12134 | 3 |
| Total. | 1.000799 | 4.00033 | 1.0004686 | **1** | |

Note: G1 - Scale, G2 - Time, G3 - IT connectivity, G4 - Object Achievement, and G5 - Financial Index.

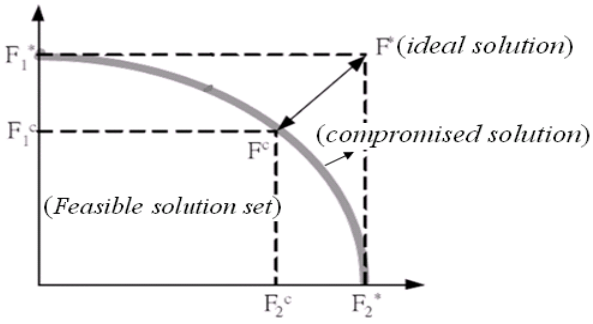


**Figure 4.** Ideal solution and compromised solution.

**VIKOR approach**

Based on the weights of criteria as shown in Figure 2, the following procedure is to evaluate the level of B Plan projects through VIKOR approach. Even though SFA & DEA (Golany and Roll, 1989) have been widely used in MCDM implementations meant to study operational performance in past research, the explanatory power of the rankings is relatively weak due to the difficulty of identifying significant differences or identical performances when the rankings are all nearly identical. Hwang and Yoon (1981) used compromised solutions to develop TOPSIS, a multi-attribute decision method with aggregations; however, when there are conflicts or offsets among measurement items, the results may be biased, and therefore cannot reflect the closeness between each solution and the ideal solution(s).To mend the shortcomings of TOPSIS, Opricovic (1998) proposed the VIseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR) method, which is a compromise to multi-criteria sequencing method. (Opricovic and Tzeng, 2007; Tzeng et al., 2005). In other words, the decision makers may make a compromise and choose a plan that is closest to the ideal solution, while they cannot obtain an optimal goal at the same time. In Figure 4, $F_1^*$ (the ideal value of the first assessment criterion) and $F_2^*$ (the ideal value of the second criterion) cannot reach F*(ideal solution) at the same time. The compromised solution is a point on the curve. $F^c$ is closest to the ideal solution ($F^*$) among all non-inferior solutions. Therefore, $F^c$ is closest to the ideal solution ($F^*$) among all non-inferior solutions. Therefore, $F^c$ is a viable solution ($F^c = (F_1^c, F_2^c)$ ).

The compromised ranking algorithm of VIKOR consists of the following steps:

Step 1: Determine the ideal solution ($f^*$) and the negative ideal solution ($f^-$) for all measured criteria. $I_1$ in equations (1) and (2) is the benefit criteria set. The larger it value is, the better. $I_2$ is the cost criteria set. The smaller it value is, the better.

$$f_i^* = [(\max_j f_{ij} | i \in I_1), (\min_j f_{ij} \mid i \in I_2)], \forall_i \quad (1)$$

$$f_i^- = [(\min_j f_{ij} | i \in I_1), (\max_j f_{ij} | i \in I_2)], \forall_i \quad (2)$$

Step 2: Calculation of $S_j$ and $R_j$

$(f_i^* - f_{ij})/(f_i^* - f_i^-)$ in Equations (3) and (4) is the distance ratio of the i criterion of j to the ideal solution. $w_i$ is the weight obtained by using the i criterion. By adding all criteria in j together, we can get the maximum "collective" benefit ($S_j$). $R_j$ is the ratio criterion selected from j and is farthest from the ideal solution. The smaller $S_j$ and $R_j$

**Table 9.** Performance index list.

| Criteria | Formula |
|---|---|
| Team efficiency | Projects scale / Team scale |
| Project efficiency | Total connected B2B number / project length (months) |
| IT connectivity | (Total connected B2B number) +(ERP to ERP firms / connecting B2B number ) / 2 |
| Financial index | Turnover rate of inventory |
| KPI achievement | Total Project outcome (i.e. KPI) |

are, the better j will be.

$$S_j = \sum_{i=1}^{n} w_i (f_i^* - f_{ij}) / (f_i^* - f_i^-) \quad (3)$$

$$R_j = \max_i \left[ w_i (f_i^* - f_{ij}) / (f_i^* - f_i^-) \right], \ j = 1,2,\ldots.J \quad (4)$$

Step 3: Calculation of Q value

$Q_j$ is the benefit value of j combining collective ($S_j$) and individual ($R_j$). Its calculation is shown in Equation (5). The parameter v is the coefficient for decision-making mechanism. When it is larger than 0.5, v will represent the decision of the majority of the people. When it is equal to 0.5, v represents the decision that is passed reluctantly. When it is smaller than 0.5, v means that the decision is not approved.

$$Q_j = v(S_j - S^*) / (S^- - S^*) + (1 - v)(R_j - R^*) / (R^- - R^*) \quad (5)$$

Where $S^* = \min_j S_j$, $S^- = \max_j S_j$, $R^* = \min_j R_j$, $R^- \max_j R_j$

Step 4: Rank and improve the alternatives, sort by the values S, R, and Q, in decreasing order and reduce the gaps in the criteria. The results are three ranking lists, with the best alternatives

Step 5: Propose a compromised solution. For a given criteria weight, the alternatives (a≧), are the best ranked by measure Q (minimum) if the following two conditions are satisfied:

C1: "Acceptable advantage": Q(a″) - Q(a′) ≧DQ, where a″ is the alternative with second position in the ranking list by Q; DQ = 1/(J-1); J is the number of alternatives.
C2. ''Acceptable stability in decision making": Alternative a′ must also be the best ranked by S or/and R. This compromised solution is stable within a decision making process.

If either one of the above two requirements fails to be satisfied, a compromised solution can be worked out by the following means: (1) If the first requirement fails to be satisfied, a′ and a″ shall be taken as the compromised solution. (2) If the second requirement fails to be satisfied, a′, a″, … , a(M) shall be taken as the compromised solution.

## Case study

The "A, B, C, D, and E plan" is the first one which the Taiwan government promotes the domestic enterprise to develop the electronic technology in large-scale with policy plans. The government hopes to advance the ability of industry e-business by the improvement of electronic task ability between enterprises, advance the enterprise operating model, increase the industrial competition power, and connect the upstream, midstream and downstream to form the chain reaction and extend the successful experience to different industries and service industry (including information service sector). After pushing of more than four years, the plan has finished in 2004 and brought out more than NT $ four billions of the involvement of resource comes from the government and people. Because the B plan is bigger B2B e-business projects, this research adopts the B plan as the application case. There are 13 PC/notebook manufacturers joining the B plan; besides the announced public issues, the type of enterprise has divided into three categories: system of manufacture, NB and boards, and peripheral products; and the system manufacturers are A~E company, the NB and motherboard manufacturers are F~J company, and other peripheral manufacturers are K~M company.

This study is based on the value chain structure broached by Chen and Chang (2004)'s analysis of the real situation of information industry e-business as the principle of sorting the value chain activity of every manufacturer. The primary activities of system of manufacture are research and development, component purchase, materials logistics, production, product logistics, midstream trader's purchase and service after selling, and the component purchase and midstream trader's purchase are the primary core activity, and the main consideration is based on their purpose of joining the plan. The primary activities of NB and motherboard manufacturer are research and development, component purchase, farming out, product logistics, the midstream trader purchase, and retailer/ agent marketing, and the component purchase and midstream trader's purchase are the primary core activity; the main consideration is based on their purpose of joining the plan. The primary activities of peripheral manufacturers are component purchase, materials logistics, production, product logistics, the midstream trader purchase, retailer/agent marketing, and service after selling, and the component purchase, midstream trader's purchase and retailer/ agent marketing are the primary core activity; the main consideration is based on their purpose of joining the plan. Overall, this three have similar activities of value chain.

## VIKOR ranking

According to the compromised ranking algorithm of VIKOR approach, the "S" value of equation (3) and "R" of equation (4) need to use the FANP weights (Table 8) as a base for each criteria of VIKOR. On the other hand, through these five criteria of performance evaluation for e-business projects as listed Table 1, this study by in-depth interview experts of Taiwan B-plan firms presents a conversion formula of each criterion as a performance index for e-business projects (Table 9).

Listed in Table 10 is the performance index (PI) information, which is real data of five e-Business projects of Taiwan's B- Plan. These PI values, such as IT Connectivity, Financial Index, and KPI achievement are average value of five consecutive years, while TE represents project team executed efficiency, or, the ratio of project

**Table 10.** Summary of case performance index (PI) information.

| PI / Project | Team Efficiency | Project Efficiency | IT Connectivity | Financial Index | KPI Achievement |
|---|---|---|---|---|---|
| A | 1.2307 | 11.1297 | 115.0308 | 0.4159 | 20.1580 |
| B | 0.4887 | 4.2344 | 48.0317 | 0.4828 | 15.2423 |
| C | 0.5055 | 1.7225 | 14.5785 | 0.4898 | 24.9730 |
| D | 0.2747 | 9.5622 | 129.0831 | 0.9996 | 84.8936 |
| E | 1.3530 | 1.6868 | 22.7756 | 15.2040 | 127.3053 |
| F | 0.8066 | 2.5936 | 24.3145 | 5.2879 | 54.4471 |
| G | 1.2233 | 2.7589 | 28.5186 | 44.8723 | 45.6187 |
| H | 0.4103 | 0.7458 | 8.4633 | 1.2095 | 34.7540 |
| I | 0.2310 | 1.0795 | 11.1837 | 0.3599 | 37.5708 |
| J | 0.7990 | 3.4118 | 25.9253 | 0.4898 | 69.1528 |
| K | 0.3858 | 5.4926 | 46.4694 | 10.2360 | 54.4471 |
| L | 1.4964 | 0.1666 | 1.5829 | 19.3524 | 37.5708 |
| M | 0.8089 | 0.8058 | 8.3335 | 0.6397 | 49.9353 |

**Table 11.** The normalized value of PI; the value of fi* and fi$^-$

| PI / Project | Team Efficiency | Project Efficiency | IT Connectivity | Financial Index | Kpi Achievement |
|---|---|---|---|---|---|
| A | 0.3899 | 0.6452 | 0.5945 | 0.0079 | 0.0961 |
| B | 0.1548 | 0.2455 | 0.2482 | 0.0092 | 0.0727 |
| C | 0.1602 | 0.0998 | 0.0753 | 0.0093 | 0.1191 |
| D | 0.0870 | 0.5543 | 0.6671 | 0.0190 | 0.4047 |
| E | 0.4286 | 0.0978 | 0.1177 | 0.2896 | 0.6070 |
| F | 0.2555 | 0.1503 | 0.1257 | 0.1007 | 0.2596 |
| G | 0.3875 | 0.1599 | 0.1474 | 0.8548 | 0.2175 |
| H | 0.1300 | 0.0432 | 0.0437 | 0.0230 | 0.1657 |
| I | 0.0732 | 0.0626 | 0.0578 | 0.0069 | 0.1791 |
| J | 0.2531 | 0.1978 | 0.1340 | 0.0093 | 0.3297 |
| K | 0.1222 | 0.3184 | 0.2402 | 0.1950 | 0.2596 |
| L | 0.4740 | 0.0097 | 0.0082 | 0.3686 | 0.1791 |
| M | 0.2563 | 0.0467 | 0.0431 | 0.0122 | 0.2381 |
| Total | 3.1723 | 2.6312 | 2.5030 | 1.9057 | 3.1280 |
| F* | 0.4740 | 0.6452 | 0.6671 | 0.8548 | 0.6070 |
| F- | 0.0732 | 0.0097 | 0.0082 | 0.0069 | 0.0727 |

Note: The meaning of PI is described in Table 2.

finding and staff costs, and PE stands for project efficiency (that is, the project length).

Listed in Table 11 is the ideal solution ($f^*$) and the negative ideal solution ($f^-$), which is calculated by equation (1) and (2). In addition, this study also applies the equation (3) and (4) to calculate $S_j$ and $R_j$ (Tables 12~13; Figure 5.

Finally, this study obtains the ranking of performance using equation (5) as listed in Table 13. In Table 12, the rankings of the benefit value $Q_j$ of the e-business project A~M are: project G, project L, project E, project K, project A, project F, project D, project J, project M, project B, project C, project H, and project I.

In Table 13 and Figure 5, the acceptable conditions and the threshold "DQ" value, that is, 1/ (13-1) = 0.0833, where j=13 are seen. Hence, we could calculate the performance values of top 1 case (Table 14). We identify case G as the benchmark. This finding is consistent with previous studies (Opricovic and Tzeng, 2007).

Furthermore, a closer look at case G indicates that this case has a better strategy and allocation for each criterion. Overall, while they are establishing their e-business project, they catch the follow key points: 1. having a clear project target and project cost balance for e-business, 2. realizing business model is part of e-business projects, 3. having a better KPI monitor scheme, 4. closely connective with B2B partners through e-business project, 5. CEO is project leader, 6. having a clear connection classification, and more

**Table 12.** The value $S_j$, $S^*$ and $S^-$

| PI / Project | Team Efficiency | Project Efficiency | IT Connectivity | Financial Index | KPI Achievement | Sj |
|---|---|---|---|---|---|---|
| A | 0.210 | - | 0.110 | 0.999 | 0.956 | 0.5328 |
| B | 0.796 | 0.629 | 0.636 | 0.997 | 1.000 | 0.8489 |
| C | 0.783 | 0.858 | 0.898 | 0.997 | 0.913 | 0.8968 |
| D | 0.965 | 0.143 | - | 0.986 | 0.378 | 0.6764 |
| E | 0.113 | 0.861 | 0.834 | 0.667 | - | 0.4833 |
| F | 0.545 | 0.779 | 0.822 | 0.889 | 0.650 | 0.7424 |
| G | 0.216 | 0.764 | 0.789 | - | 0.729 | 0.3458 |
| H | 0.858 | 0.947 | 0.946 | 0.981 | 0.826 | 0.9201 |
| I | 1.000 | 0.917 | 0.925 | 1.000 | 0.801 | 0.9551 |
| J | 0.551 | 0.704 | 0.809 | 0.997 | 0.519 | 0.7524 |
| K | 0.878 | 0.514 | 0.648 | 0.778 | 0.650 | 0.7339 |
| L | - | 1.000 | 1.000 | 0.573 | 0.801 | 0.5554 |
| M | 0.543 | 0.942 | 0.947 | 0.994 | 0.690 | 0.8219 |

**Table 13.** The value of $R_j$ , $Q_j$

| PI / Project | Team Efficiency | Project Efficiency | IT Connectivity | Financial Index | KPI Achievement | Rj | Qj | Rank |
|---|---|---|---|---|---|---|---|---|
| A | 0.057 | - | 0.010 | 0.350 | 0.116 | .3498 | 0.652 | 5 |
| B | 0.216 | 0.104 | 0.058 | 0.349 | 0.121 | .3492 | 0.911 | 10 |
| C | 0.212 | 0.142 | 0.082 | 0.349 | 0.111 | .3492 | 0.950 | 11 |
| D | 0.262 | 0.024 | - | 0.345 | 0.046 | .3452 | 0.760 | 7 |
| E | 0.031 | 0.143 | 0.076 | 0.233 | - | .2334 | 0.352 | 3 |
| F | 0.148 | 0.129 | 0.075 | 0.311 | 0.079 | .3114 | 0.739 | 6 |
| G | 0.058 | 0.127 | 0.072 | - | 0.088 | .1265 | 0.000 | 1 |
| H | 0.233 | 0.157 | 0.087 | 0.344 | 0.100 | .3435 | 0.956 | 12 |
| I | 0.271 | 0.152 | 0.085 | 0.350 | 0.097 | .3502 | 1.000 | 13 |
| J | 0.149 | 0.117 | 0.074 | 0.349 | 0.063 | .3492 | 0.831 | 8 |
| K | 0.238 | 0.085 | 0.059 | 0.273 | 0.079 | .2725 | 0.645 | 4 |
| L | - | 0.166 | 0.092 | 0.201 | 0.097 | .2008 | 0.338 | 2 |
| M | 0.147 | 0.156 | 0.087 | 0.348 | 0.084 | .3480 | 0.886 | 9 |

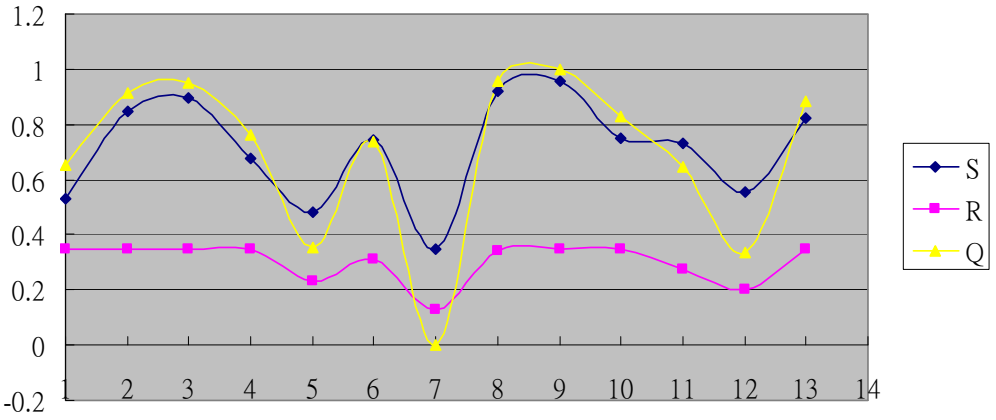


**Figure 5.** The S, R, and Q value line.

**Table 14.** The performance values of 2 top cases.

| Rank 1 | Q(a′) | Rank 2 | Q(a″) | Q(a″)- (a′) | DQ | Q(a″)-Q(a′)≧DQ |
|---|---|---|---|---|---|---|
| Project G | 0.000 | Project L | 0.338 | 0.338 | 0.0833 | Yes |

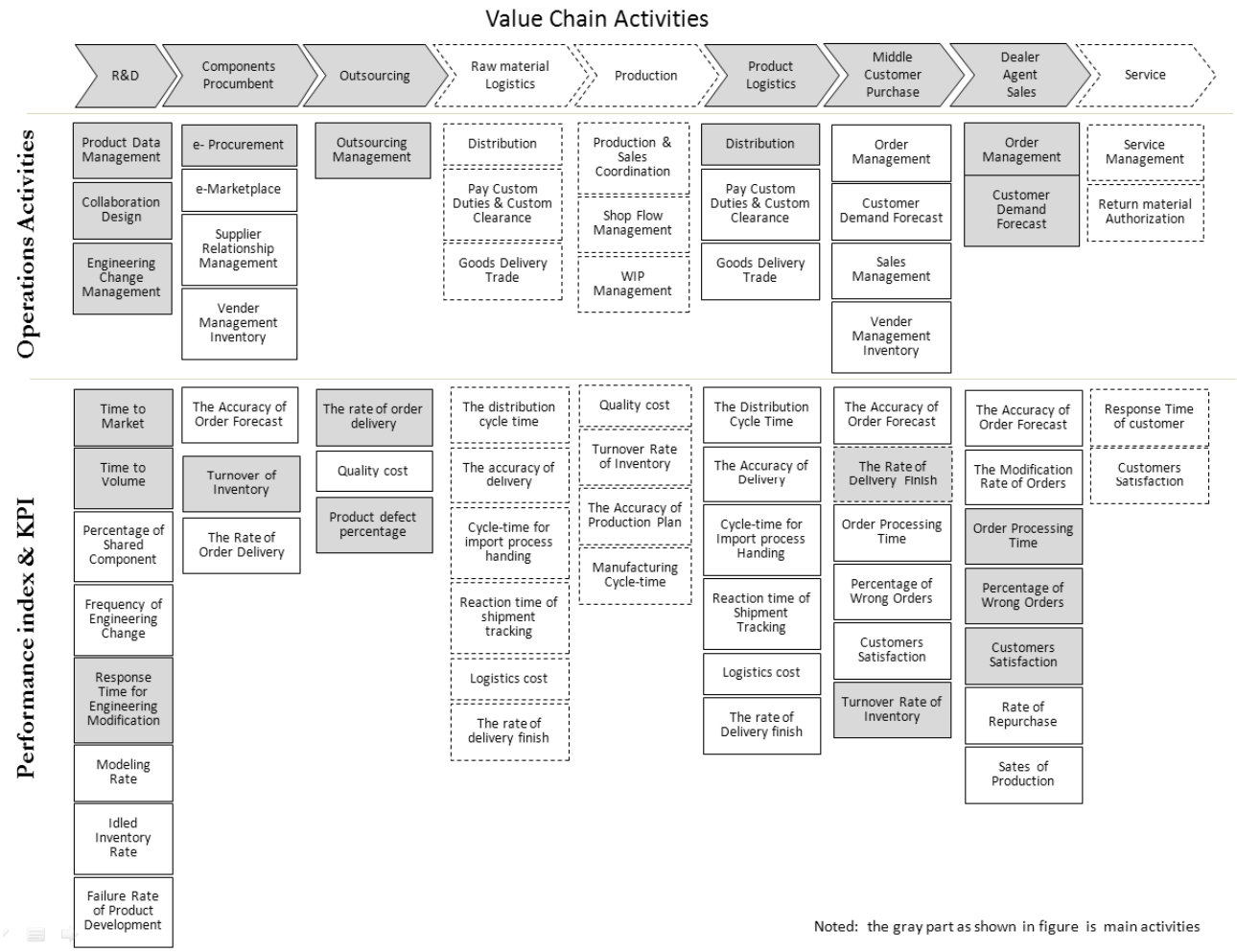


**Figure 6.** Case G e-business activities, sub-activities and the KPI for each activity of value chain in sub-industry of NB&PC manufacture.

deeply combine each activity of value chain (Figure 6).

## RESULTS

This research analyzed e-business project performance for Taiwan B-plan cases through a VIKOR approach, which is based on the five criteria of FAHP approach. Thus the authors calculate the performance ranking order as listed in Table 6 from VIKOR approach.

Firstly, This study used the FANP real examination result in this study so it can be learned the most influential is scale group (G1), the second is level of goal achievement group (G4), the third is IT connection group (G3), then the following is time group (G2), and financial index group is the last with relative inefficiency (g5).

Secondly, this research is based on the results by FANP approach to calculate the performance information for 13 B-plan projects by five formula of performance indexes as listed in Table 2.

Finally, this study employs VIKOR approach to rank 13 projects' performance. The study shows the Q(a″)-Q(a′) value of project G (Q rank 1) is over DQ value (0.0833). Hence, the project G maps out several critical successful strategies of e-business projects: a clear plan by each criterion, a strong teamwork and project targets, projects

which match firms' vision, and projects which is more supported by firm's CEO.

## DISCUSSION AND CONCLUSION

Based on the result of this research derived from the academic and industrial viewpoints, it is proposed to have an e-business project performance evaluation model which may be comprehensive, representative, integral and worthy of reference material not only for enterprises (or software service firm) to build an effective and efficient e-business projects but for the government to propel industrial policies as well. In the future, other studies could refer to our study as the basis for extending related research (such as comparison to the results by DEA approach, etc.) to enrich evaluation model.

### Conflict of Interests

The author(s) have not declared any conflict of interests.

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