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NEW PRODUCT COMMERCIALIZATION STRATEGY ASSESSMENT WITH MCDM-BASED IN LCD DISPLAY COMPANY

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Abstract

This work presents results from a research developed in a TFT LCD display company. The main objective of this research was to assess new product commercialization strategy. Commercialization performance assessment is a Multiple Criteria Decision Making (MCDM) problem. A framework is proposed and uses a novel hybrid MCDM model to address the dependence relationships of criteria with the aid of the Decision-Making Trial and Evaluation Laboratory (DEMATEL), analytical network process (ANP) and VIKOR (VlseKriterijumska Optimizacija I Kompromisno Resenje). In order to show the practicality and usefulness of this framework, an empirical study of the Taiwan TFT LCD display company is demonstrated. The results of this study should provide a base for firms in evaluating the commercialization strategy which criteria provide the most effective direction towards improvement.

Introduction

New products commercialization to market quickly is a prerequisite for acquiring a competitive advantage. Many factors contribute to this competitive pressure, including acceleration in the rate of technological development, more intense competition due to the maturing of markets and globalization, fragmentation of the marketplace due to changing demographics, shorter product life cycles, and the increasing cost of R&D. To be successful, perhaps even to survive, a company must master product commercialization strategy and skillfully navigate through proper development, and application and management of a product development strategy. In the light of the new product commercialization strategy management capabilities, we need an effective multiple criteria decision-making (MCDM) analysis tools to assess the impact of organizational innovation and performance factors so that we can promote new products commercialization performance require(Coombs & Bierly,2006; Wang et.al.,2008). Therefore, it is worth more attention. This study used the DEMATEL (Decision Making Trial and Evaluation Laboratory) technique to acquire the structure of the MCDM problems. The weights of each criterion from the structure are obtained by utilizing the ANP (Analytical Network Process). The VIKOR technique will be leveraged for calculating compromise ranking and gap of the alternatives. In short, the framework of evaluation contains three main phases: (1) constructing the network relation map (NRM) among criteria by the DEMATEL technique, (2) calculating the weights of each criterion by the ANP based on the NRM, and (3) ranking or improving the priorities of alternatives of portfolios through the VIKOR(VlseKriterijumska Optimizacija I Kompromisno Resenje). The rest of this paper is organized as follows: In section 2, the research motivation and related theoretical background is illustrated. Section 3 presents the structure of the framework of this study. Section 4 subsequently applies a proposed method in evaluating a case TFT LCD display company. Finally, conclusions are drawn in Section 5

Related works

New products commercialization has been treated as an important competitive advantage, including but not limited to financial, technological and other benefits, and to survive in a competitive and diverse market. Mechanisms for products commercialization assessment include training (on the job, on-site or elsewhere), consulting, documentation (reports, assessments, programs or drawings), demonstration, meeting, and collaborative technical work. While formal mechanisms are appropriate for capturing and transferring explicit part of technology, other approaches are necessary to share the tacit component, which is non-codifiable in nature (Chen et. al, 2011). This is particularly true for the operation of complex TFT LCD panel products. New panel products are resulted from commercialization performed by a firm aiming competitive advantage. The main requirement to assure this advantage is the development of a product which features satisfy customers' needs and expectations. Products commercialization strategies have been applied in a number of ways. Ali et al. (1995) defined four entry strategy variables. They are market pioneering, product advantage, relative promotional effort, and relative price. Appropriate products commercialization strategies are important to ensure that the alignment of the organizational process, culture, and the related information technology deployment produce effective knowledge creation, sharing, and utilization (Menguc & Auh, 2010). Among the major commercialization strategies evaluation techniques, MCDM-based decision analysis approaches have been widely adopted. MCDM-based evaluation framework for selecting the most suitable emerging technology and explore opportunities. The framework can be used in selecting technology for enhancing market competencies at enterprises. Then, the Decision Making Trial and Evaluation Laboratory (DEMATEL) will be used for configuring the structure of the decision framework. DEMATEL was first developed by American scientists in a Science and Human Affairs Program in the early 1970s (Gabus & Fontela, 1973). DEMATEL is based on graph theory, enabling us to analyze and solve problems visually. Through the analysis of visual relationship, all elements can be divided into a cause–effect group, which helps researchers understand the structural relationship between elements and plot a network relationship map. Therefore, DEMATEL is a mathematical computational method that can convert the relations between the cause and effect of criteria into a visual structural model. In addition, it can be used as an effective method to handle the inner dependences within a set of criteria. The main advantage of DEMATEL is that it involves indirect relations within a cause and effect model. The DEMATEL method is an effective procedure for analyzing structure and relationships between components; it can prioritize the criteria based on the type of relationships and severity of influences they have on one another. The criteria having a greater effect on one another are assumed to have a higher priority and are called cause criteria. In contrast, those that receive more influence from another are assumed to have lower priority and are called effect criteria. As any criterion may impact each other, this study used the DEMATEL technique to acquire the structure of the MCDM problems. The weights of each criterion from the structure are obtained by utilizing the ANP. It demonstrates that the quantitative technique of interdependences among various aspects and criteria can be effectively captured using the ANP technique and combined with DEMATEL, which is rarely applied in the literature. This study attempts to develop a hierarchical framework that is sufficiently general that it can be applied under various research settings.

The advantage of using a combination of ANP and DEMATEL is that it considers the hierarchical structure, including interdependence relationships in the condition of flexibly manages the uncertanty situation. With these advantages, the DEMATEL method is used to determine the cause and effect of criteria and to understand the hierarchical structure with interdependence relations; ANP is proposed for application in a hierarchical structure. Hence, using ANP and DEMATEL, subjectivity, uncertainty and interactivity can be supported expert subjective judgment problems involving complex hierarchical relationships among technological innovation capabilities evaluation aspects and criteria. This study provides an analytical approach for managerial decision making. It demonstrates that the quantitative technique of interdependences among various aspects and criteria can be effectively captured using the ANP technique and combined with DEMATEL. Opricovic (1998) proposed the compromise ranking method (VIKOR) as one applicable technique to implement within MCDM. This method focuses on the multiple criteria optimization and compromise solution. Thus, selecting from a set of alternatives and ranking can be possible via the VIKOR method. The compromise solution is the closest one to the ideal solution and it shows that an agreement reached by mutual concessions (Kuan et. al, 2012). The compromise-ranking method (VIKOR) is applied to determine the compromise solution and the solution is adoptable for decision-makers in that it offers a maximum group utility of the majority, and a maximal regret of minimum individuals of the opponent. This model utilizes the DEMATEL and ANP processes in Sections 3.1 and 3.2 to get the weights of criteria with dependence and feedback and employs the VIKOR method to acquire the compromise solution.

Research method

Traditional MCDM approaches based on unrealistic assumptions on independencies between criteria cannot be feasible in the real business case. Moreover, the MCDM framework based solely on the ANP can lack an appropriate method of structuring a decision, so the authors propose a hybrid, MCDM new products commercialization strategy assessment framework for selecting the most suitable emerging technology and explore opportunities. The evaluation measures are multiple and are frequently structured into the framework of this study (see figure 1), using both qualitative and quantitative assessment. The measures consist of 5 aspects and 15 criteria and were determined from an extensive literature search.

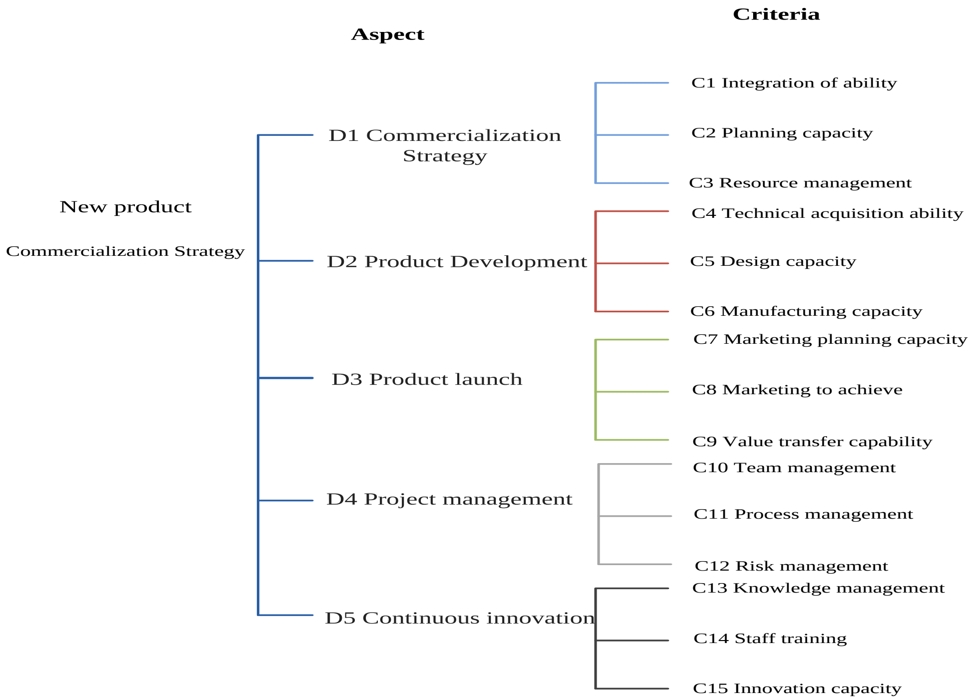


Figure1: New products commercialization strategy evaluation criteria

Using DEMATEL to construct new products commercialization strategy assessment framework

According to existing literature, DEMATEL is very useful for visually structuring the cause–effect relationship of complex assessment. The calculation of DEMATEL could be divided into five steps:

Step 1: To calculate the direct-influence matrix using scores. The experts are asked to indicate the direct effect that they believe factor i will have on factor j. In the DEMATEL formulation, respondents indicate the degree of direct influence on a scale of 0, 1, 2, 3 and 4, which represent "Complete no influence (0)", "Low influence (1)", "Medium influence (2)", "High influence (3)" and "Very high influence (4)" by experts, respectively.

Step 2: To normalize the direct-influence matrix. Based on the direct-influence of matrix, the normalized direct-relation matrix is acquired using Eqs. (1) and (2).

$$\tilde{\boldsymbol{D}} = \tilde{\boldsymbol{A}} / k \tag{1}$$

$$k = \max\left\{ \max_i \sum_{j=1}^{n} h_{ij}, \max_j \sum_{i=1}^{n} h_{ij} \right\}, \quad i, j \in \{1, 2, \ldots, n\} \tag{2}$$

Step 3: To obtain the total-influence matrix. Once the normalized direct-influence matrix D is obtained, the total-influence matrix of NRM can be obtained by using Eq. (3), which denotes the identity matrix.

$$\begin{gathered} \tilde{\boldsymbol{T}} = \tilde{\boldsymbol{D}} + \tilde{\boldsymbol{D}}^2 + \tilde{\boldsymbol{D}}^3 + \ldots + \tilde{\boldsymbol{D}}^k = \tilde{\boldsymbol{D}}(\boldsymbol{I} + \tilde{\boldsymbol{D}} + \tilde{\boldsymbol{D}}^2 + \ldots + \tilde{\boldsymbol{D}}^{k-1})[(\boldsymbol{I} - \tilde{\boldsymbol{D}})(\boldsymbol{I} - \tilde{\boldsymbol{D}})^{-1}] = \tilde{\boldsymbol{D}}(\boldsymbol{I} - \tilde{\boldsymbol{D}}^h)(\boldsymbol{I} - \tilde{\boldsymbol{D}})^{-1} \\ \tilde{\boldsymbol{T}} = \tilde{\boldsymbol{D}}(\boldsymbol{I} - \tilde{\boldsymbol{D}})^{-1}, \text{ when } k \to \infty, \ \tilde{\boldsymbol{D}}^k = [0]_{n \times n} \end{gathered} \tag{3}$$

where $\tilde{\boldsymbol{D}} = [\tilde{d}_{ij}]_{n\times n} = [(d_{ij}^l, d_{ij}^m, d_{ij}^h)]_{n\times n}$, $0 \le \tilde{d}_{ij} < 1$, $0 < \sum_{j=1}^{n} d_{ij}^h \le 1, 0 < \sum_{i=1}^{n} d_{ij}^h \le 1$. If at least one row or column of summation is equal to 1(but not all) in $\sum_{j=1}^{n} d_{ij}^h$ and $\sum_{i=1}^{n} d_{ij}^h$, then it can be guaranteed that $\lim_{k\to\infty} \boldsymbol{D}^k = [0]_{n\times n}$. And $\tilde{\boldsymbol{T}} = [\tilde{t}_{ij}]$ can be attained.

Step 4: To analyze the results. In this stage, the sum of rows $\sum_{j=1}^{n} \tilde{t}_{ij} = \tilde{t}_i$ and the sum of columns $\sum_{i=1}^{n} \tilde{t}_{ij} = \tilde{t}_j$ are separately expressed as vector $\tilde{\boldsymbol{r}} = (\tilde{r}_1, \ldots, \tilde{r}_i, \ldots, \tilde{r}_n)'$ and vector $\tilde{\boldsymbol{c}} = (\tilde{c}_1, \ldots, \tilde{c}_j, \ldots, \tilde{c}_n)'$ by using Eqs. (4), (5), and (6).

Let $i=j$ and $i, j \in \{1, 2, \ldots, n\}$; the horizontal axis vector $(\tilde{\boldsymbol{r}}+\tilde{\boldsymbol{c}})$ is then created by adding $\tilde{\boldsymbol{r}}$ to $\tilde{\boldsymbol{c}}$, which illustrates the importance of the criterion. Similarly, the vertical axis vector ($\tilde{\boldsymbol{r}}$ - $\tilde{\boldsymbol{c}}$) is constructed by deducting $\tilde{\boldsymbol{r}}$ from $\tilde{\boldsymbol{c}}$, which may separate criteria and group them into a cause group and an effect group. In general, when ($\tilde{\boldsymbol{r}}$ - $\tilde{\boldsymbol{c}}$) is positive, the criterion is part of the cause group. In contrast, if vector ($\tilde{\boldsymbol{r}}$ - $\tilde{\boldsymbol{c}}$) is negative, the criterion is part of the effect group. Therefore, the causal graph can be achieved by mapping the dataset of vectors ($\tilde{\boldsymbol{r}}+\tilde{\boldsymbol{c}}$, $\tilde{\boldsymbol{r}}$ - $\tilde{\boldsymbol{c}}$), providing a valuable approach to decision making

$$\tilde{\boldsymbol{T}} = [\tilde{t}_{ij}]_{n \times n}, \; i, j = 1, 2, \ldots, n \tag{4}$$

$$\tilde{\boldsymbol{r}} = \left[\sum_{j=1}^{n} \tilde{t}_{ij} \right]_{n \times 1} = \left[\tilde{t}_{i\cdot} \right]_{n \times 1} = (\tilde{r}_1, \ldots, \tilde{r}_i, \ldots, \tilde{r}_n)' \tag{5}$$

$$\tilde{\boldsymbol{c}} = \left[\sum_{i=1}^{n} \tilde{t}_{ij} \right]_{1 \times n}' = [\tilde{t}_{\cdot j}]_{n \times 1} = (\tilde{c}_1, \ldots, \tilde{c}_j, \ldots, \tilde{c}_n)' \tag{6}$$

where vector and vector express the sum of the rows and the sum of the columns from total-influence matrix , respectively, and the use of superscript denotes transpose.

Using DANP method to calculate the influential weights of criteria

Saaty (2004) proposed ANP by extending the Analytic Hierarchy Process (AHP). The difference of ANP from AHP is that it sees the criteria independent, while AHP considers the dependence and feedback relation in each criterion. In other words, ANP is a general form of Analytic Hierarchy Process. It also means that AHP is a special case of ANP. In fact, the dimensions formed by the criteria have not only the influence in the same level, but also the influences in different levels. In reality, it is not a linear bottom up and breakdown hierarchy, but is more like a network. The purpose of ANP is to predict the internal relationship between criteria, goals, and alternatives. Through an evaluation scale doing the pair-wise comparison, we can obtain the weight of cluster and every element after influencing each other. In this study, we use the method that combines DEMATEL technique and basic concept of ANP which is called DANP (DEMATEL-based ANP). DANP uses DEMATEL technique to confirm the degree of influence between each cluster. Furthermore, it uses the total relationship matrix *T* obtained from DEMATEL that contains "dynamic influential relationship weights". It then makes use of the total relationship matrix *T* unto the super-matrix in ANP to recognize the relation and importance which influence the management and development of a project team; thus meeting the requirement of our research topic in the TFT LCD panel industry . The following are the DANP operation steps

Step 1: Use DEMATEL method to establish evaluation index system of influential relationship, which is the system structure model.

Step 2: Establish unweighted super-matrix. Based on the influence matrix $\boldsymbol{T}$, each criterion t_{ij} of influence matrix $\boldsymbol{T}$ can show network information on how the degree of criterion i affects criterion j; and thus the network relation map (NRM) can be obtained. The influence matrix $\boldsymbol{T}$ can be divided into $\boldsymbol{T}_D$ based on dimensions, and $\boldsymbol{T}_C$ based on criteria.

$$\boldsymbol{T}_{\mathrm{C}} = \begin{array}{cc|ccccc|}
 & & D_1 & \cdots & D_{\mathrm{i}} & \cdots & D_n \\
 & & c_{11}\ldots c_{1m_1} & \cdots & c_{\mathrm{i}1}\ldots c_{\mathrm{i}m_{\mathrm{i}}} & \cdots & c_{n1}\ldots c_{nm_n} \\
\hline
D_1 & \begin{smallmatrix} c_{11} \\ c_{12} \\ \vdots \\ c_{1m_1} \end{smallmatrix} & \boldsymbol{T}_C^{11} & \cdots & \boldsymbol{T}_C^{1\mathrm{j}} & \cdots & \boldsymbol{T}_C^{1n} \\
\vdots & & \vdots & & \vdots & & \vdots \\
D_{\mathrm{i}} & \begin{smallmatrix} c_{\mathrm{i}1} \\ c_{\mathrm{i}2} \\ \vdots \\ c_{\mathrm{i}mi} \end{smallmatrix} & \boldsymbol{T}_C^{\mathrm{i}1} & \cdots & \boldsymbol{T}_C^{\mathrm{ij}} & \cdots & \boldsymbol{T}_C^{in} \\
\vdots & \vdots & \vdots & & \vdots & \ddots & \vdots \\
D_n & \begin{smallmatrix} c_{n1} \\ c_{n2} \\ \vdots \\ c_{nm_n} \end{smallmatrix} & \boldsymbol{T}_C^{n1} & \cdots & \boldsymbol{T}_C^{nj} & \cdots & \boldsymbol{T}_C^{nn} \\
\hline
\end{array} \qquad (7)$$

Then, to normalize $\boldsymbol{T}_C$ with the total degree of effect and to obtain $\boldsymbol{T}_C^{\alpha}$ as shown in Eq. (8):

$$\boldsymbol{T}_{\boldsymbol{C}}^{\alpha} = \begin{array}{cc|ccccc|}
 & & D_1 & \cdots & D_{\mathrm{i}} & \cdots & D_n \\
 & & c_{11}\ldots c_{1m_1} & \cdots & c_{\mathrm{i}1}\ldots c_{\mathrm{i}m_{\mathrm{i}}} & \cdots & c_{n1}\ldots c_{nm_n} \\
\hline
D_1 & \begin{smallmatrix} c_{11} \\ c_{12} \\ \vdots \\ c_{1m_1} \end{smallmatrix} & \boldsymbol{T}_C^{\alpha 11} & \cdots & \boldsymbol{T}_C^{\alpha 1\mathrm{j}} & \cdots & \boldsymbol{T}_C^{\alpha 1n} \\
\vdots & & \vdots & & \vdots & & \vdots \\
D_{\mathrm{i}} & \begin{smallmatrix} c_{\mathrm{i}1} \\ c_{\mathrm{i}2} \\ \vdots \\ c_{\mathrm{i}mi} \end{smallmatrix} & \boldsymbol{T}_C^{\alpha \mathrm{i}1} & \cdots & \boldsymbol{T}_C^{\alpha \mathrm{ij}} & \cdots & \boldsymbol{T}_C^{\alpha in} \\
\vdots & \vdots & \vdots & & \vdots & \ddots & \vdots \\
D_n & \begin{smallmatrix} c_{n1} \\ c_{n2} \\ \vdots \\ c_{nm_n} \end{smallmatrix} & \boldsymbol{T}_C^{\alpha n1} & \cdots & \boldsymbol{T}_C^{\alpha nj} & \cdots & \boldsymbol{T}_C^{\alpha nn} \\
\hline
\end{array} \qquad (8)$$

The method of normalization that can be obtained $\boldsymbol{T}_c^{\alpha 11}$ is shown in Eqs (9) and (10), this can be repeated to be obtain $\boldsymbol{T}_c^{\alpha nn}$

$$d_i^{11} = \sum_{j=1}^{m_1} t_{C\,ij}^{\;11}\,, i = 1, 2, \ldots, m_1 \qquad (9)$$

$$\boldsymbol{T}_{c}^{\alpha 11}=\begin{bmatrix} t_{c11}^{11}/d_{1}^{11} & \cdots & t_{c1j}^{11}/d_{1}^{11} & \cdots & t_{c1m_1}^{11}/d_{1}^{11} \\ \vdots & & \vdots & & \vdots \\ t_{ci1}^{11}/d_{i}^{11} & \cdots & t_{cij}^{11}/d_{i}^{11} & \cdots & t_{cim_1}^{11}/d_{i}^{11} \\ \vdots & & \vdots & & \vdots \\ t_{cm_1 1}^{11}/d_{m_1}^{11} & \cdots & t_{cm_1 j}^{11}/d_{m_1}^{11} & \cdots & t_{cm_1 m_1}^{11}/d_{m_1}^{11} \end{bmatrix} = \begin{bmatrix} t_{c11}^{\alpha 11} & \cdots & t_{c1j}^{\alpha 11} & \cdots & t_{c1m_1}^{\alpha 11} \\ \vdots & & \vdots & & \vdots \\ t_{ci1}^{\alpha 11} & \cdots & t_{cij}^{\alpha 11} & \cdots & t_{cim_1}^{\alpha 11} \\ \vdots & & \vdots & & \vdots \\ t_{cm_1 1}^{\alpha 11} & \cdots & t_{cm_1 1}^{\alpha 11} & \cdots & t_{cm_1 m_1}^{\alpha 11} \end{bmatrix} \qquad (10)$$

After this, the total effect matrix is normalized into a supermatrix by dimensions according to the dependent relationship within the group; this results to obtaining the unweighted supermatrix as shown in Eq. (11).

$$\boldsymbol{W}=(\boldsymbol{T}_{c}^{\alpha})'=\begin{array}{cc} & \begin{array}{ccccc} D_1 & & D_i & & D_n \\ c_{11}\ldots c_{1m_1} & \cdots & c_{i1}\ldots c_{im_i} & \cdots & c_{n1}\ldots c_{nm_n} \end{array} \\ \begin{array}{cc} D_1 & \begin{array}{c} c_{11} \\ c_{12} \\ \vdots \\ c_{1m_1} \end{array} \\ \vdots & \vdots \\ D_j & \begin{array}{c} c_{j1} \\ c_{j2} \\ \vdots \\ c_{jm_j} \end{array} \\ \vdots & \vdots \\ D_n & \begin{array}{c} c_{n1} \\ c_{n2} \\ \vdots \\ c_{nm_n} \end{array} \end{array} & \begin{bmatrix} \boldsymbol{W}^{11} & \cdots & \boldsymbol{W}^{i1} & \cdots & \boldsymbol{W}^{n1} \\ \vdots & & \vdots & & \vdots \\ \boldsymbol{W}^{1j} & \cdots & \boldsymbol{W}^{ij} & \cdots & \boldsymbol{W}^{nj} \\ \vdots & & \vdots & & \vdots \\ \boldsymbol{W}^{1n} & \cdots & \boldsymbol{W}^{in} & \cdots & \boldsymbol{W}^{nn} \end{bmatrix} \end{array} \qquad (11)$$

Furthermore, matrices $\boldsymbol{W}^{11}$ can be obtained by Eq. (12). If a blank space or 0 appears in the matrix, then the group or criterion is independent. In the same way, the matrix $\boldsymbol{W}^{nn}$ can be obtained.

$$\boldsymbol{W}^{11}=(\boldsymbol{T}^{11})'=\begin{array}{cc} & \begin{array}{ccccc} \boldsymbol{c}_{11} & \cdots & \boldsymbol{c}_{1i} & \cdots & \boldsymbol{c}_{1m_1} \end{array} \\ \begin{array}{c} \boldsymbol{c}_{11} \\ \vdots \\ \boldsymbol{c}_{1j} \\ \vdots \\ \boldsymbol{c}_{1m_1} \end{array} & \begin{bmatrix} t_{c11}^{\alpha 11} & \cdots & t_{ci1}^{\alpha 11} & \cdots & t_{cm_1 1}^{\alpha 11} \\ \vdots & & \vdots & & \vdots \\ t_{c1j}^{\alpha 11} & \cdots & t_{cij}^{\alpha 11} & \cdots & t_{cm_1 j}^{\alpha 11} \\ \vdots & & \vdots & & \vdots \\ t_{c1m_1}^{\alpha 11} & \cdots & t_{cim_1}^{\alpha 11} & \cdots & t_{cm_1 m_1}^{\alpha 11} \end{bmatrix} \end{array} \qquad (12)$$

Step 3: Obtain the weighted supermatrix by deriving the matrix of the total effect of dimensions using Eq. (13).

$$d_i=\sum_{j=1}^{n} t_D^{ij}\ ,\ i=1,2,\ldots,n \qquad (13)$$

$$\boldsymbol{T}_D = \begin{bmatrix} t_D^{11} & \cdots & t_D^{1j} & \cdots & t_D^{1n} \\ \vdots & & \vdots & & \vdots \\ t_D^{i1} & \cdots & t_D^{ij} & \cdots & t_D^{in} \\ \vdots & & \vdots & & \vdots \\ t_D^{n1} & \cdots & t_D^{nj} & \cdots & t_D^{nn} \end{bmatrix}$$

Then, $\boldsymbol{T}_D$ is normalized to obtain $\boldsymbol{T}_D^{\alpha}$, as shown in Eq. (14).

$$\boldsymbol{T}_D^{\alpha} = \begin{bmatrix} t_D^{11}/d_1 & \cdots & t_D^{1j}/d_1 & \cdots & t_D^{1n}/d_1 \\ \vdots & & \vdots & & \vdots \\ t_D^{i1}/d_2 & \cdots & t_D^{ij}/d_2 & \cdots & t_D^{in}/d_2 \\ \vdots & & \vdots & & \vdots \\ t_D^{n1}/d_n & \cdots & t_D^{nj}/d_n & \cdots & t_D^{nn}/d_n \end{bmatrix} = \begin{bmatrix} t_D^{\alpha 11} & \cdots & t_D^{\alpha 1j} & \cdots & t_D^{\alpha 1n} \\ \vdots & & \vdots & & \vdots \\ t_D^{\alpha i1} & \cdots & t_D^{\alpha ij} & \cdots & t_D^{\alpha in} \\ \vdots & & \vdots & & \vdots \\ t_D^{\alpha n1} & \cdots & t_D^{\alpha nj} & \cdots & t_D^{\alpha nn} \end{bmatrix} \quad (14)$$

Then, the normalized $\boldsymbol{T}_D^{\alpha}$ is transformed into the unweighted supermatrix $\boldsymbol{W}$ to obtain the weighted supermatrix $\boldsymbol{W}^{\alpha}$, as shown in Eq. (15).

$$\boldsymbol{W}^{\alpha} = \boldsymbol{T}_D^{\alpha}\boldsymbol{W} = \begin{bmatrix} t_D^{\alpha 11} \times \boldsymbol{W}^{11} & \cdots & t_D^{\alpha i1} \times \boldsymbol{W}^{i1} & \cdots & t_D^{\alpha n1} \times \boldsymbol{W}^{n1} \\ \vdots & & \vdots & & \vdots \\ t_D^{\alpha 1j} \times \boldsymbol{W}^{1j} & \cdots & t_D^{\alpha ij} \times \boldsymbol{W}^{ij} & \cdots & t_D^{\alpha nj} \times \boldsymbol{W}^{nj} \\ \vdots & & \vdots & & \vdots \\ t_D^{\alpha 1n} \times \boldsymbol{W}^{1n} & \cdots & t_D^{\alpha in} \times \boldsymbol{W}^{in} & \cdots & t_D^{\alpha nn} \times \boldsymbol{W}^{nn} \end{bmatrix} \quad (15)$$

Step 4: Obtain the limit supermatrix by DANP. Let the weighted spuermatrix $\boldsymbol{W}^{\alpha}$ multiply itself multiple times to obtain the limit supermatrix. Then, the DANP weights of each criterion can be obtained by $\lim_{z \to \infty} (\boldsymbol{W}^{\alpha})^z$, where z represents any number for power (Yang *et al*., 2008).

Using VIKOR to find the best alternative

VIKOR a method proposed by Opricovic, is a method of decision making on compromise solution programming. In this research, it uses a compromise concept to sort the multiple alternatives to see how close the project is to Positive-ideal solution (setting the aspiration level). The closer the alternative is to the ideal solution (aspiration level), the better. On the contrary, the closer it is to the Negative-ideal solution, the worst. VIKOR could be divided into 3 steps:

Step 1: To confirm the ideal solution (aspiration level) and negative ideal solution (the worst level), and to confirm the best and worst value, which can be could obtained from Eqs. (7) and (8). f_j^* is the aspiration level of criterion j, and f_j^- is the worst value of criterion j. If every criterion in the project gets the aspiration level, it means that the project gets best performance in every criterion and approaches the aspiration level. Equations (16) and (17) are then used to obtain the results.

$f_j^* = \max_k f_{kj},\ \ j = 1,2,...,n$ (traditional approach) or as method in this research: setting the aspiration levels vector.

$$\boldsymbol{f}^* = (f_1^*,...,f_j^*,...,f_n^*) \quad (16)$$

$f_j^- = \min_k f_{kj},\ j = 1,2,...,n$ (traditional approach) or as method in this research: setting the worst values vector.

$$\boldsymbol{f}^- = (f_1^-,...,f_j^-,...,f_n^-) \quad (17)$$

Development of the VIKOR method begins with the following form of the L_p _metric:

$$L_k^p = \left\{ \sum_{j=1}^{n} [w_j (\left| f_j^* - f_{kj} \right|) / (\left| f_j^* - f_j^- \right|)]^p \right\}^{1/p} \quad (18)$$

where $1 \le p \le \infty$; $k = 1,2,...,m$ and the influential weights w_j is derived from the DANP. VIKOR method is used to formulate the ranking and gap measure, $L_k^{p=1}$ (as S_k) and $L_k^{p=\infty}$ (as Q_k **)**.

$$S_k = L_k^{p=1} = \sum_{j=1}^{n} [w_j (\left| f_j^* - f_{kj} \right|) / (\left| f_j^* - f_j^- \right|)] \quad (19)$$

$$Q_k = L_k^{p=\infty} = \max_j \left\{ (\left| f_j^* - f_{kj} \right|) / (\left| f_j^* - f_j^- \right|) \,\middle|\, j = 1,2,...,n \right\} \quad (20)$$

Step 2: Calculate the mean of the group utility S_k (which represents the integrated average gap for all criteria) and maximal regret Q_k (which represents the maximal gap in k alternative of special criterion for improvement priority). Where w_j represents the influential weights of the criteria from DANP.

$$r_{kj} = (\left| f_j^* - f_{kj} \right|) / (\left| f_j^* - f_j^- \right|) \quad (21)$$

which represents the normalized gap (the normalized ratios of distance to the aspired level) of *k* alternative in *j* criterion. These values can be computed by Eqs. (18) and (19), respectively.

$$S_k = \sum_{j=1}^{n} w_j r_{kj} = \sum_{j=1}^{n} w_j \left(\left| f_j^* - f_{kj} \right| \right) \Big/ \left(\left| f_j^* - f_j^- \right| \right) \quad (22)$$

$$Q_k = \max_j \left\{ r_{kj} \mid j = 1, 2, ..., n \right\} \quad (23)$$

Step 3: Obtain the comprehensive indicator and sort out the results. The values can be computed by Eq. (24).

$$R_k = v\left(S_k - S^*\right) \Big/ \left(S^- - S^*\right) + (1-v)\left(Q_k - Q^*\right) \Big/ \left(Q^- - Q^*\right) \quad (24)$$

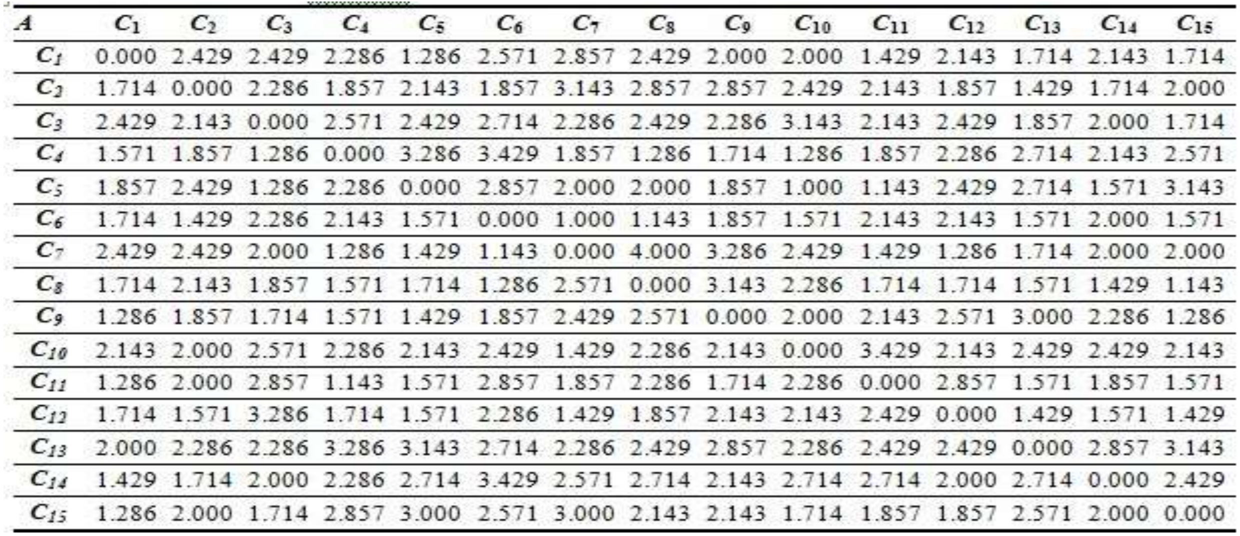
Eq. (20) can be re-written as $R_k = vS_k + (1-v)Q_k$, when $S^* = 0$ and $Q^* = 0$ (i.e., all criteria have achieved the aspired level) and $S^- = 1$ and $Q^- = 1$ (i.e., the worst situation).

Empirical evaluation of case panel company

This section aims to operationally the evaluation method of the new products commercialization strategy evaluation criteria to the case company. The reasons for this are first, the case firm continues to improve production processes and face challenges concerning how they manage the environmental practices in panel industry in the competitive environment. Second, the case company has to sustain reform panel commercialization performance in the R&D sector in order to face high-tech market competition and social responsibility. The expert team is composed of three experts, one president and six management professions with extensive experience consulting in this study.

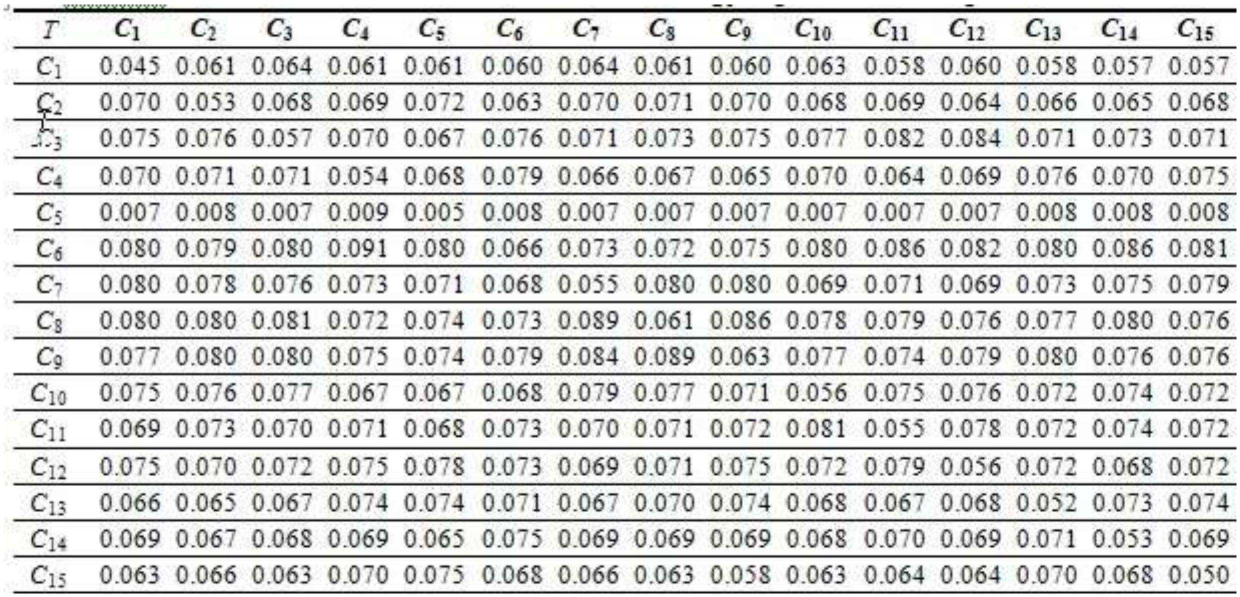
The DEMATEL method introduced in Section 3.1 will be utilized in the decision problem structure. First, the direct-influence matrix **A** for criteria was presented (see Table 1). Then, the normalized direct-influence matrix S for criteria can be calculated by Eq. (10). Third, the total direct-influence matrix **T** for criteria/dimensions was derived based on Eq. (14). Finally, the NRM was constructed by the r and d in the total direct-influence matrix **T** for each criterion, respectively. (see Table 2) and for each aspect(see Table 2) which shown in Figure 2.

Table 1. The initial influence matrix A for criteria



A	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}	C_{15}
C_1	0.000	2.429	2.429	2.286	1.286	2.571	2.857	2.429	2.000	2.000	1.429	2.143	1.714	2.143	1.714
C_2	1.714	0.000	2.286	1.857	2.143	1.857	3.143	2.857	2.857	2.429	2.143	1.857	1.429	1.714	2.000
C_3	2.429	2.143	0.000	2.571	2.429	2.714	2.286	2.429	2.286	3.143	2.143	2.429	1.857	2.000	1.714
C_4	1.571	1.857	1.286	0.000	3.286	3.429	1.857	1.286	1.714	1.286	1.857	2.286	2.714	2.143	2.571
C_5	1.857	2.429	1.286	2.286	0.000	2.857	2.000	2.000	1.857	1.000	1.143	2.429	2.714	1.571	3.143
C_6	1.714	1.429	2.286	2.143	1.571	0.000	1.000	1.143	1.857	1.571	2.143	2.143	1.571	2.000	1.571
C_7	2.429	2.429	2.000	1.286	1.429	1.143	0.000	4.000	3.286	2.429	1.429	1.286	1.714	2.000	2.000
C_8	1.714	2.143	1.857	1.571	1.714	1.286	2.571	0.000	3.143	2.286	1.714	1.714	1.571	1.429	1.143
C_9	1.286	1.857	1.714	1.571	1.429	1.857	2.429	2.571	0.000	2.000	2.143	2.571	3.000	2.286	1.286
C_{10}	2.143	2.000	2.571	2.286	2.143	2.429	1.429	2.286	2.143	0.000	3.429	2.143	2.429	2.429	2.143
C_{11}	1.286	2.000	2.857	1.143	1.571	2.857	1.857	2.286	1.714	2.286	0.000	2.857	1.571	1.857	1.571
C_{12}	1.714	1.571	3.286	1.714	1.571	2.286	1.429	1.857	2.143	2.143	2.429	0.000	1.429	1.571	1.429
C_{13}	2.000	2.286	2.286	3.286	3.143	2.714	2.286	2.429	2.857	2.286	2.429	2.429	0.000	2.857	3.143
C_{14}	1.429	1.714	2.000	2.286	2.714	3.429	2.571	2.714	2.143	2.714	2.714	2.000	2.714	0.000	2.429
C_{15}	1.286	2.000	1.714	2.857	3.000	2.571	3.000	2.143	2.143	1.714	1.857	1.857	2.571	2.000	0.000

Table 2. The total-influence matrix T for the strategy aspects in the respective criterions



T	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}	C_{15}
C_1	0.045	0.061	0.064	0.061	0.061	0.060	0.064	0.061	0.060	0.063	0.058	0.060	0.058	0.057	0.057
C_2	0.070	0.053	0.068	0.069	0.072	0.063	0.070	0.071	0.070	0.068	0.069	0.064	0.066	0.065	0.068
C_3	0.075	0.076	0.057	0.070	0.067	0.076	0.071	0.073	0.075	0.077	0.082	0.084	0.071	0.073	0.071
C_4	0.070	0.071	0.071	0.054	0.068	0.079	0.066	0.067	0.065	0.070	0.064	0.069	0.076	0.070	0.075
C_5	0.007	0.008	0.007	0.009	0.005	0.008	0.007	0.007	0.007	0.007	0.007	0.007	0.008	0.008	0.008
C_6	0.080	0.079	0.080	0.091	0.080	0.066	0.073	0.072	0.075	0.080	0.086	0.082	0.080	0.086	0.081
C_7	0.080	0.078	0.076	0.073	0.071	0.068	0.055	0.080	0.080	0.069	0.071	0.069	0.073	0.075	0.079
C_8	0.080	0.080	0.081	0.072	0.074	0.073	0.089	0.061	0.086	0.078	0.079	0.076	0.077	0.080	0.076
C_9	0.077	0.080	0.080	0.075	0.074	0.079	0.084	0.089	0.063	0.077	0.074	0.079	0.080	0.076	0.076
C_{10}	0.075	0.076	0.077	0.067	0.067	0.068	0.079	0.077	0.071	0.056	0.075	0.076	0.072	0.074	0.072
C_{11}	0.069	0.073	0.070	0.071	0.068	0.073	0.070	0.071	0.072	0.081	0.055	0.078	0.072	0.074	0.072
C_{12}	0.075	0.070	0.072	0.075	0.078	0.073	0.069	0.071	0.075	0.072	0.079	0.056	0.072	0.068	0.072
C_{13}	0.066	0.065	0.067	0.074	0.074	0.071	0.067	0.070	0.074	0.068	0.067	0.068	0.052	0.073	0.074
C_{14}	0.069	0.067	0.068	0.069	0.065	0.075	0.069	0.069	0.069	0.068	0.070	0.069	0.071	0.053	0.069
C_{15}	0.063	0.066	0.063	0.070	0.075	0.068	0.066	0.063	0.058	0.063	0.064	0.064	0.070	0.068	0.050

Table 3. The total-influence matrix T for aspects.

Aspects	Total influence criteria	Criteria	submatrix weights	Weighting rank	supermatrix weights	r+d
D_1	0.2	C_1	0.298	3	0.060	6.055
		C_2	0.335	2	0.067	6.429
		C_3	0.368	1	0.073	6.926
D_2	0.156	C_4	0.444	2	0.069	6.295
		C_5	0.048	3	0.008	3.609
		C_6	0.508	1	0.079	6.429
D_3	0.228	C_7	0.320	3	0.073	6.649
		C_8	0.339	2	0.078	6.511
		C_9	0.341	1	0.078	6.775
D_4	0.215	C_{10}	0.337	1	0.072	6.866
		C_{11}	0.332	2	0.071	6.403
		C_{12}	0.331	3	0.071	6.312
D_5	0.201	C_{13}	0.341	1	0.068	7.066
		C_{14}	0.340	2	0.068	6.768
		C_{15}	0.319	3	0.064	6.283

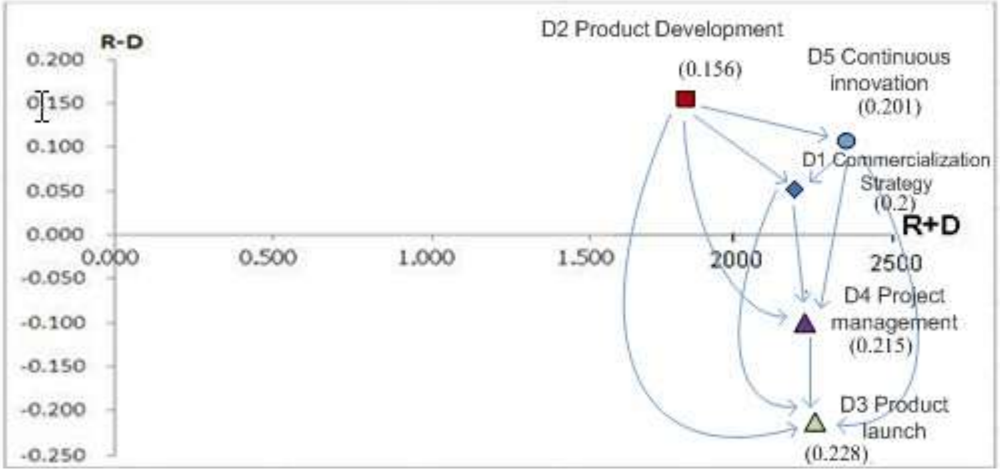


Figure 2. The impact NRM of commercialization strategy performance evaluation

The VIKOR technique was applied for compromise ranking after the weights of determinants was calculated by ANP in Section 3.3. The results (in figure 3.) of VIKOR evaluation value indicated that case TFT LCD panel company had the best strategy performance: design capacity (C5) performance (the bigger the value is, the better it is). In contrast, staff training strategy (C14) had the worst performance

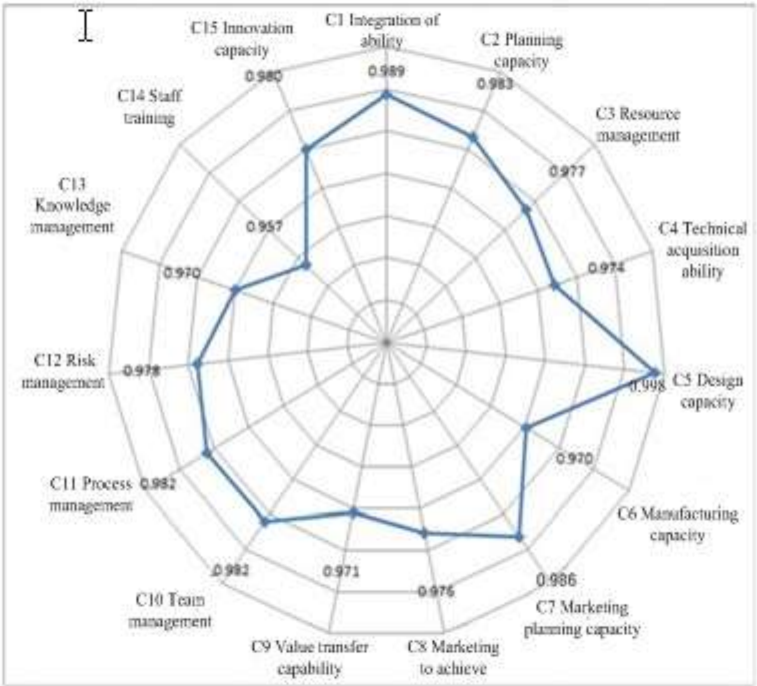


Figure 3. Performance values of 15 criteria for case company

New products commercialization strategy assessment has become a key factor for the survival and development of enterprises. The commercialization strategy performance can be used to evaluate the performances and thus provide a mechanism to monitor and establish a measurement platform for the case company. In particular, the evaluation framework can provide managers and researchers with a better understanding of the differences in activity needs and of specific management interventions that would improve the likelihood of excellent and useful research through the examination of the five aspects and fifteen criteria. These aspects and criteria serve as bridging mechanisms and are helpful in new products commercialization strategy performance evaluation.

Conclusions

There are different approaches to evaluate the new products commercialization strategy of enterprises, including the performance ranking. For this paper, a MCDM approach by the integration methods of DEMATEL , ANP, and VIKOR were proposed to develop the evaluation of new products commercialization strategies framework and rank the selected the case company. This evaluation framework will be a useful solution to assist the management in the self-assessment that can indicate the most important criteria which are needed to be improved. It also enables the third independent parties e.g. auditing or consulting firms to apply framework as a systematic tool in their auditions or consultations because it can render the better solution. Research in the future could take more objective information on the applicability of the proposed assessment framework, thus proving the practicality of the evaluation procedure proposed in this study.

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