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Strategies for improving cruise product sales using hybrid 'multiple criteria decision making' models

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As airlines have shifted to decommission policies, selling cruise products has become a growing trend in the travel industry. However, few studies have discussed this issue or proposed strategies to help improve sales for travel agencies. The purpose of this study is to address this problem, using the novel method of hybrid multiple criteria decision making, including decision making trial and evaluation laboratory (DEMATEL), the DEMATEL-based analytic network process and VIKOR (VlseKriterijumska Optimizacija I Kompromisno Resenje), to present optimal improvement models, which are superior in identifying both an influential network and a priority sequence of dimensions/criteria related to selling cruises. The findings provide useful schemes for decision makers according to the priorities of influential weightings from high to low or the sequence of gap values to aspired level from low to high.

Keywords: sales performance; selling skills; travel agency

Introduction

Since airlines in North America have announced a commission cap in 1995, travel agencies have turned to selling cruise products (Morrison, 2006). The commission from the sales of cruise products reportedly composes 35% of the total profit of travel agencies' sales (Dickinson & Vladimir, 2006). According to the Cruise Line International Association, the cruise industry continues to grow enormously and rapidly, with an average annual growth rate of 7.4% since 1994 and an increase of 400% over the past 10 years. Cruise products are a large potential market segment for travel agents, now and in the future (Gibson, 2006). The issue has received attention from researchers in the field of sales, but few studies have focused on the context of the travel industry, or proposed strategies to improve sales performance for travel agencies (Liu, Lin, & Lee, 2010; Liu, Tzeng, Lee, & Lin, 2011).

Because a cruise is a defined package, a cruise operator traditionally uses travel agents as a primary distribution channel (Gibson, 2006). Travel agencies can retail the product using in-depth product knowledge, highly personalised service, and direct relationships with clients, to efficiently complete each sale and, ideally, reach their estimated sales performance (Hatton, 2004; Walle, 1996). Therefore, sales skills are essential for sales performance (Wachner, Plouffe, & Grégoire, 2009). Studies show that the sales skill and

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sales performance are positively correlated (Churchill, Ford, Hartley, & Walker, 1985; Wu, 2006). Previous studies of cruise product sales from the perspective of sales consultants have determined that the sales skill and specific self-efficacy (SSE) are influential and powerful determinants of sale performance (Lin, 2010; Liu et al., 2010). Liu et al.'s (2011)'s recent work using the decision making trial and evaluation laboratory (DEMATEL) approach confirms the influential network relationship between the sales skills, SSE, and sales performance in cruise product sales. However, this study lacks an improved model that addresses gap distances, which would provide useful strategies for decision makers to improve sales performance.

The purpose of the present study is to address this problem using the method of multiple criteria decision making (MCDM) to examine the dependent relationships among various dimensions and criteria of cruise product sales and, ultimately, to suggest optimal improvement models. A DEMATEL is used to construct a network relation map (NRM), which then is used to illustrate the influential network of the determinants related to cruise product sales. Subsequently, the DEMATEL-based analytic network process (called DANP) is employed to determine the exact influential weights of the criteria for further analysis, VIKOR (VlseKriterijumska Optimizacija I Kompromisno Resenje), to address to the previous gap distances to the aspired level.

The remainder of this paper is organised as follows. In the next section, the literature on travel agencies' sales of cruise products and the connection between individuals' sales skills, SSE, and sales performance is reviewed. Then, a new hybrid MCDM evaluation model for cruise product sales is developed, and an empirical case analysis of cruise sales performance illustrates the proposed model. Finally, the conclusion is presented.

Literature review on cruise product sales in travel agencies

This section attempts to clarify the mutually beneficial relationship between travel agencies and cruise product sales and the interrelationship between the specific sales skills, self-efficacy, and sales performance of salespeople in travel agencies. This section explains the measurement used to compose the questionnaire for assessing sales performance improvement models within the context of traditional travel agencies.

Travel agency and cruise product sales

Cruise products sales by travel agencies have become a growing trend in the travel industry (Lin, 2010; Liu et al., 2010; Liu et al., 2011). The American Society of Travel Agents states that a travel agent is an individual or a firm that is authorised by one or more principals to sell travel and related services. Therefore, travel agents, as a part of service industry, sell travel-related products and expect to earn a commission from each service delivery (Huang, 2008). However, the airline decommissioning of 1995 (Siebenaler & Groves, 2002) caused a 36% decline in conventional US travel agencies between 1997 and 2004 (Goeldner & Ritchie, 2006). Since then, cruise companies have proposed good commission offers to travel agencies. Carnival Cruise Lines announced a 6-month trial period increase in commission, from 10% to 12%, for more than 12,000 travel agencies that had not previously sold a Carnival Cruise. The idea was to jump-start agencies that were financially affected by the cap situation to begin selling cruises (Dickinson & Vladimir, 2006).

Travel agencies use in-depth product knowledge to retail products, in an attempt to complete each sale efficiently and to reach their estimated sales performance (Hatton,

2004). However, cruise operators traditionally use travel agents as a primary distribution channel (Gibson, 2006) and rely heavily on travel agencies. Because the cruise product is a defined package that includes travel to the port of embarkation, a lengthy itinerary, inclusive services and facilities (such as meals, entertainment and leisure areas), accommodation, and various other services (Gibson, 2006), purchasing a cruise is far more complicated than, for example, buying an airline ticket. Deciding which cruise is right for a particular person is a complex and sensitive task (Hatton, 2004; Mancini, 2003). Traditional travel agencies meet these requirements by providing highly personalised service and developing direct relationships with clients (Gibson, 2006). Consequently, selling the cruise product becomes a potential market and a main venue for the travel agency, which hopes to improve sales performance to gain a profit that is as large as possible (Lin, 2010; Liu et al., 2010; Liu et al., 2011).

Sales skill, SSE, and sales performance

In the service industry, sales skill has been identified as an individual's learned proficiency at performing the necessary tasks for the sales job (Rentz, Shepherd, Tashchian, Dabholkar, & Ladd, 2002; Walker, Churchill, & Ford, 1977). Selling cruise products requires a travel agent to have analysing, consulting, and professional skills (Hatton, 2004; Mancini, 2003), in-depth product knowledge, highly personalised service, and the ability to manage client relationships (Liu et al., 2011) to achieve successful service interactions with customers (Ekinci & Dawes, 2009). Rentz et al. (2002) developed a comprehensive three-part measure of sales skills, including interpersonal skills, salesmanship skills, and technical skills. This measure is useful in predicting the skills of sales consultants in selling cruise products (Lin, 2010; Liu et al., 2010; Liu et al., 2011).

According to Bandura (1986), the term SSE can be defined as the inner ability to pursue goals towards the completion of a specific task (Ryerson, 2008; Smith, Kass, Rotunda, & Schneider, 2006). A similar concept is general self-efficacy (GSE), which is a general belief in one's ability to perform a given task (Bandura, 1977, 1986; Sherer et al., 1982). Unlike GSE, SSE involves situation-specific cognition and a concept of behaviour motivation that is highly focused on a particular task (Eden, 1988) and the faith of implementing process and action (Bandura, 2001; Gist & Mitchell, 1992). Because self-efficacy itself is inherently task specific, the specificity of self-efficacy has been adopted by a number of studies to examine individual task performance (e.g. Gist & Mitchell, 1992; Gist, Schwoerer, & Rosen, 1989; Ryerson, 2008). Because selling cruise products is an inherently specific, complex, and sensitive task (Hatton, 2004), attention to SSE thus can examine the inner abilities of salespeople engaged in this specific task in travel agencies. The measure developed by Plank and Reid (1994) has been recently adopted by Tabbiner (2000), Reid, Pullins, and Plank (2002), and Ryerson (2008). This measure is useful for predicting the SSE of sales consultants based on four learned abilities: getting, giving, using, and planning (Lin, 2010; Liu et al., 2011).

Sales performance can be understood as the continuously reciprocal interaction between a salesperson and a customer's activities to help an organisation effectively meet goals or objectives as they implement sales tasks (Babakus, Cravens, Grant, Ingram, & LaForge, 1996; Churchill et al., 1985). Sales performance is associated with the responsibilities and job performance of individuals and organisations (Johnston & Marshall, 2003) and it has typically been measured using the scale developed by Behrman and Perreault (1982), which has been proven effective by various studies (e.g. Babakus et al. 1996; Baldauf & Cravens, 2002; Barker, 1999; Park & Holloway, 2003).

Table 1. The dimensions of influence and criteria associated with selling cruise products.

Dimensions	Criteria	Items for criteria	Source/α-value
Sale skills (D_1)	Interpersonal skills (C_1)	• I can communicate with customers face to face or by phone • I can do a good job controlling my emotions • I would recommend that friends and relatives buy the cruise product • In addition to my mother tongue, I have expertise in a second language	Rentz et al. (2002)/0.86
	Salesmanship skills (C_2)	• I have the ability to identify and explore potential cruise clients • I can detect whether the customer will decide to purchase • I am happy to assist customers and provide immediate services • I can clearly convey the message of the cruise product to the customer • I have confidence in my ability to sell	Rentz et al. (2002)/0.88
	Technical skills (C_3)	• I can introduce the ship's facilities, and other relevant knowledge • I understand the priority of the sales of cruise brands • I know the competitors' cruise products, services, prices, etc. • I know the cruise product classification and can explain its characteristics • I continually update product information and participate in cruise education and training to maintain my professional knowledge	Rentz et al. (2002)/0.91
SSE (D_2)	Getting (C_4)	• I can find answers for customers' cruise-related issues • I can guide the customer to state their demand for purchasing cruise products • I can absorb different cruise information from customers • I can understand what cruise product the customer wants to buy based on his/her reaction	Ryerson (2008)/0.95
	Giving (C_5)	• I can make the cruise sales performance attractive • If necessary, I am ready to prepare secondary marketing tools for the cruise product • I invite potential customers to participate in the sales of cruise goods • I have a variety of sales tactics	Ryerson (2008)/0.93

(*Continued*)

Table 1. Continued.

Dimensions	Criteria	Items for criteria	Source/α-value
		• I can provide customers with the cruise product information they need • I can analyse competitors' cruise product sales methods	
	Using (C_6)	• I can customise the cruise product according to customer demand • I make use of customers' responses to determine whether the cruise product information previously provided is correct • I transfer a successful customer experience in other industries to cruise sales	Ryerson (2008)/0.94
	Planning (C_7)	• I have a plan for sales calls • I have an efficient arrangement of my working hours • I plan to achieve the tasks and design work that can create output value • I combine customers' needs and cruise products to create sales plans • For different customers, I conduct business visit in different ways	Ryerson (2008)/0.93
Sales performance (D_3)	Sales revenue (C_8)	• I create good cruise sales revenue for our company	Fermando and Marshall (2004)/0.81
	Profit contribution (C_9)	• I have sense of accomplishment in the company's cruise sales commissions earned	
	New customer development (C_{10})	• I am active in the development of new customers	
	Customer retention (C_{11})	• I can actively maintain existing customers	
	Sales amount (C_{12})	• I am very satisfied with my own cruise sales	

Note: These α-values are from previous studies.

Park and Holloway (2003) further modified the scale using the attributes of profit contribution, sales revenue and amount, customer retention, and new customer development. This measure was proven reliable in predicting salespeople's performance by Fermando and Marshall (2004).

The connection between firms' sales skill and sales performance has been well established in the literature. Previous studies have suggested that sales skill directly affect sales performance (e.g. Churchill et al., 1985; Rentz et al., 2002; Wachner et al., 2009), and sales skill and job performance are positively correlated (Liu et al., 2010; Wu, 2006). Recently, a number of studies have confirmed sales skill positively influence sales performance through SSE (Chen, 2001; Lin, 2010). These variables are interrelated in travel agencies' cruise product sales (Lin, 2010; Liu et al., 2011).

Given the above discussion, this study assumes an interdependent relationship between sales skill, SSE, and sales performance. The relationship can be examined by the hybrid MCDM techniques of DEMATEL, DANP, and VIKOR to present models with gap values that are useful for predicting strategies to improve the performance of cruise product sales within the context of the travel agency.

Methodology

Tzeng and Huang (2011) indicate that MCDM is a methodology that can consider multiple criteria at the same time (Lin & Wu, 2008) and helps the decision maker to estimate the best case according to the characteristics of limited available cases. The new hybrid MCDM analytical tools used in this research include the techniques of DEMATEL, DANP, and VIKOR. First, DEMATEL was used to confirm the effect on each criterion and to explore the relevance of the performance parameters. Subsequently, the DANP approach, a novel combination of DEMATEL and ANP methods based on the concepts of Saaty (1996), was adopted to calculate the influential weights of the criteria. Ou Yang, Shieh, Leu, and Tzeng (2008) proposed these methods to solve the dependence and feedback problems of criteria to suit the case (Kuan, Hsiang, & Tzeng, forthcoming). Finally, VIKOR was used to empirically evaluate the overall performance of a travel agency.

Building a network relationship by DEMATEL

The DEMATEL technique is an analytical method that uses a structural model to solve complex problems, using a matrix and related mathematical theories to calculate the cause and effect of each element (Chen & Tzeng, 2011; Huang, Shyu, & Tzeng, 2007; Huang & Tzeng, 2007; Huang, Tzeng, & Ho, 2011; Hung, Chou, & Tzeng, 2011; Tzeng & Huang, 2011; Yang & Tzeng, 2011). This method is widely applied by various fields, but it has seldom been used in service industries, such as tourism (Liu, Tzeng, & Lee, forthcoming) or hospitality (Tsai & Hsu, 2010; Tsai et al., 2010).

DEMATEL begins by confirming the criteria of the evaluation system and clarifying interrelations between the three variables (Yang & Tzeng, 2011). On the basis of the literature review in Section 2, a cruise product sales evaluation system, including 3 dimensions and 12 criteria within the context of the traditional travel agency, is established and presented in Table 1. Subsequently, a survey was conducted via questionnaires distributed to an expert group comprising 15 branch sales managers, with at least 15 years of experience in selling travel-related products. Among these expert sales managers, 12 individuals are from the branch companies in North America and the remaining 3 individuals are from

the Asia headquarters, including Taipei, Shanghai, and Hong Kong. The survey collected their ratings for each criterion using a five-point scale ranging from 0 (no effect) to 4 (extremely influential).

Finding the weights by DANP

After DEMATEL confirms the influential relationship of the criteria, the DANP is used to obtain their most accurate weights. The ANP presented by Saaty (1996) to decrease the limitations associated with the analytic hierarchy process creates a solution for determining nonlinear and complex network relationships. Saaty proposed a method for the analysis of the ANP by adopting the limiting process method of the powers of the supermatrix (Sekitani & Takahashi, 2001). Although the ANP can theoretically be used for the treatment of interdependencies, it is wise to first adopt the DEMATEL technique to generate an influential relationship in the unweighted supermatrix (Liu et al., forthcoming). Therefore, the research applies the strength of ANP onto DEMATEL to solve the dependence and feedback problems associated with the interrelation between the criteria (Chen, Hsu, & Tzeng, 2011; Kuan et al., forthcoming). The DANP is processed as shown in Appendix A.2.

Evaluating the total performance by VIKOR

VIKOR was developed by Opricovic (1998) using the concept of compromise to evaluate the standard of different projects among the competition from the MCDM model (Opricovic & Tzeng, 2002, 2004; Tzeng, Teng, Chen, & Opricovic, 2002). VIKOR is based on the concept of the positive-ideal (or the aspired level) solution and the negative-ideal (or the worst level) solution, and thus it can order the results (Lee, Tzeng, & Cheng, 2009; Tsai, Hsu, & Lin, 2011; Tzeng, Lin, & Opricovic, 2005).

Empirical case analysis for cruise product sales

This section assesses the overall cruise product sales to propose sales improvement strategies using an empirical case, an international travel agency with 43 branches across North America and East Asia. The data collected from their expert sales managers are analysed by a hybrid MCDM method, and the results are presented in useful models for decision making.

Problem descriptions

As stated previously, considering the abundant profits produced by selling cruise products in recent years, travel agencies have begun selling cruises as the airlines have shifted to a decommission policy. The case study agency is no exception. In recent years, the revenue from selling cruise products has increased, particularly in the area of the Asia Pacific. This conventional agency thus regards selling cruise travel as a vital segmentation in the new era. In 2009, the agency established a cruise product sales division for upgrading the performance of cruise sales and reaching an optimal level. The first training programme was launched and targeted at the most experienced sales managers, who were supervising the frontline cruise product sales in North America and East Asia. Traditionally, these supervisory or operation managers are responsible for frontline problem-solving (Paolillo, 1981) and are focused on short-term and realistic goals (Lacampvoc, 2010). Therefore, their perceptions are assumed to be particularly valuable and influential for overall performance improvement.

Six months after the first intensive cruise sales training programme, the decision makers would like to know a number of questions: When selling cruise products, how do these managers think about their own sales skill, learning abilities, and the perceptions of sales performance? What do they think are the most influential factors involving the job performance? What are the most efficient ways to improve their job performance and, ultimately, to reach optimal sales performance? The answers to these questions were expected to benefit the individuals and the firm. To this end, the research reviewed the literature, developed an evaluation system, and used a new hybrid MCDM method to identify the influential dimensions and criteria using NRM of DEMATEL, confirm the exact influential weights using DANP, and derive the values of performances and gaps using VIKOR. This data analysis process is used to propose useful problem-solving strategies for the travel agency.

Constructing the NRM by DEMATEL

This study has confirmed the DEMATEL decision making structure and analysed three dimensions using 12 criteria for cruise product sales. According to the experts' evaluations, the total effect matrix $\boldsymbol{T}$ of criteria was obtained with reliable agreed rate of 4.47% (<5%) (Table 2) and serves to derive the influential relation ($r_i - s_i$) in Table 3. Overall, it can be seen that Sales performance (D_3) has the strongest direct effect on other dimensions. Sales skill (D_1) is the most vulnerable to impact in Table 3.

This effect is further illustrated in Figure 1; the priority of influence can be sequenced as $D_3\_D_2\_D_1$. When considering the improvement, the expert managers all regarded sales performance as first and agreed that the first priority for improvement should be sales performance (D_3), which can have an influential effect on the remaining dimensions, SSE (D_2) and sales skill (D_1). The results suggest that the managers' top concern is sales performance, including sales revenue and amount, profit contribution, and customer retention/development. The experts believe that improving these factors would produce better sales skill and SSE.

The network relation can also be seen as influencing each dimension. For example, within the category of sales performance (D_3), it can be seen that customer retention (C_{11}) exerts a direct effect on the remaining criteria, including sales revenue (C_8), new customer development (C_{10}), sales amount (C_{12}), and profit contribution (C_9). Managers agree that customer retention is the most influential way to improve sales performance. Good 'customer retention' will bring more sales revenue and new customers, thus increasing the sales amounts and the contribution to the company. Furthermore, the contribution to the company is the least influential criterion or the last one to be improved. Therefore, the general improvement priority can be sequenced $(C_{11})\_(C_8)\_(C_{10})\_(C_{12})\_(C_9)$ in sales performance (D_3).

In addition, there are sub-networks within the individual dimension. For instance, new customer development (C_{10}) produces a direct effect on sales amount (C_{12}) and profit contribution (C_9), indicating that the improvement priority should be $(C_{10})\_(C_{12})\_(C_9)$. Such an influential sub-network emerges in the individual dimension as illustrated in detail in Figure 1. For the decision makers, this solution is not only intelligent but it also makes it easy to identify improvement priority based on complex criteria.

Calculating the influential weights by DANP

After the DEMATEL confirming the interfering relationship with the criteria, the research thus can proceed to obtain the most accurate weights by DANP. Through pairwise

Table 2. Total influential effect matrix $\boldsymbol{T}$ of criteria.

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_1	0.570	0.642	0.561	0.582	0.591	0.596	0.618	0.690	0.691	0.678	0.672	0.676
C_2	0.699	0.616	0.630	0.643	0.672	0.674	0.687	0.747	0.754	0.726	0.704	0.738
C_3	0.632	0.647	0.533	0.629	0.623	0.638	0.665	0.698	0.705	0.674	0.667	0.690
C_4	0.630	0.620	0.584	0.548	0.614	0.620	0.632	0.679	0.686	0.674	0.668	0.671
C_5	0.674	0.669	0.620	0.650	0.600	0.689	0.707	0.732	0.739	0.716	0.704	0.723
C_6	0.705	0.704	0.654	0.704	0.709	0.637	0.743	0.765	0.773	0.749	0.742	0.761
C_7	0.767	0.761	0.716	0.769	0.779	0.791	0.714	0.826	0.844	0.817	0.805	0.826
C_8	0.767	0.762	0.698	0.725	0.744	0.747	0.766	0.724	0.824	0.774	0.767	0.796
C_9	0.737	0.736	0.675	0.700	0.715	0.721	0.740	0.788	0.704	0.748	0.741	0.746
C_{10}	0.747	0.734	0.667	0.712	0.717	0.724	0.756	0.757	0.765	0.675	0.705	0.763
C_{11}	0.748	0.719	0.668	0.713	0.717	0.724	0.752	0.768	0.780	0.713	0.668	0.758
C_{12}	0.740	0.740	0.678	0.704	0.719	0.725	0.749	0.783	0.791	0.738	0.745	0.691

Note: $1/n^2 \sum_{i=1}^{n} \sum_{j=1}^{n} |t_{ij}^{n} - t_{ij}^{n-1}|/t_{ij}^{n} \times 100\% = 4.47\% < 5\%$, where t_{ij}^{n} and t_{ij}^{n-1} denote the average influence of i criterion to j by n samples and $n-1$ samples, respectively.

Table 3. Result of dimensions/criteria analysis.

Dimensions/criteria	r_i	s_i	r_i+s_i	r_i-s_i
Sales skill (D_1)	1.950	2.198	4.148	−0.248 (3)
Interpersonal skills (C_1)	1.773	1.902	3.675	−0.129
Salesmanship skills (C_2)	1.945	1.906	3.851	0.039
Technical skills (C_3)	1.813	1.724	3.537	0.089
SSE (D_2)	2.102	2.045	4.147	0.057 (2)
Getting (C_4)	2.415	2.671	5.086	−0.256
Giving (C_5)	2.646	2.702	5.347	−0.056
Using (C_6)	2.794	2.737	5.531	0.056
Planning (C_7)	3.053	2.797	5.850	0.255
Sales performance (D_2)	2.385	2.194	4.580	0.191 (1)
Sales revenue (C_8)	3.885	3.821	7.705	0.064
Profit contribution (C_9)	3.727	3.864	7.591	−0.137
New customer level (C_{10})	3.665	3.648	7.313	0.017
Customer retention (C_{11})	3.687	3.625	7.313	0.062
Sales amount (C_{12})	3.748	3.755	7.503	−0.007

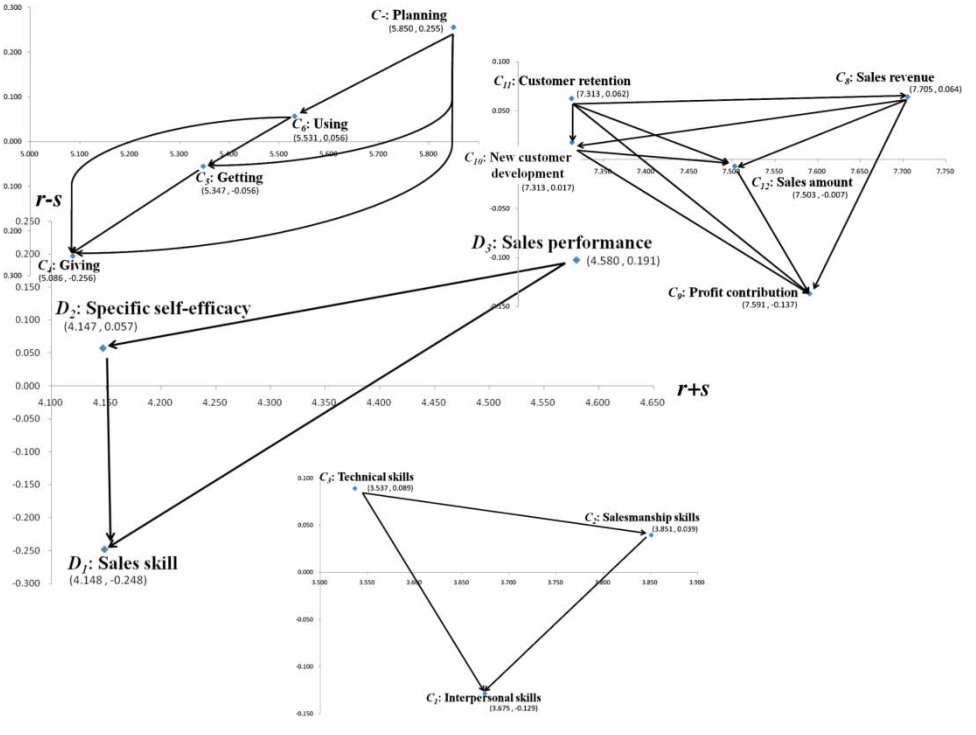

Figure 1. The NRM of relationships within the cruise product sales.

comparisons of the unweighted supermatrix and weighted supermatrix, the limiting power of the weighted supermatrix, $\lim_{z\to\infty}(\mathbf{W}^{\alpha})^{z}$, is obtained and a steady-state condition is reached, showing the weight of each criterion (Table 4) for further analysis by VIKOR.

Table 4. The stable matrix of DANP.

W^*	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_1	0.136	0.136	0.136	0.136	0.136	0.136	0.136	0.136	0.136	0.136	0.136	0.136
C_2	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135
C_3	0.124	0.124	0.124	0.124	0.124	0.124	0.124	0.124	0.124	0.124	0.124	0.124
C_4	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079
C_5	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081
C_6	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081
C_7	0.084	0.084	0.084	0.084	0.084	0.084	0.084	0.084	0.084	0.084	0.084	0.084
C_8	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057
C_9	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057
C_{10}	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055
C_{11}	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054
C_{12}	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056

Note: when power $\lim_{z\to\infty} (W^{\alpha})^z$.

Table 5. The performance evaluation of case study by VIKOR.

Dimension/criteria	Local weight (base on global weight)	Global weight (base on DANP)	Performance	Gap (by VIKOR)
Sales skill (D_1)	0.396		7.757	0.224(1)
Interpersonal skills (C_1)	0.343	0.136	2.896	0.039
Salesmanship skills (C_2)	0.342	0.135	2.586	0.057
Technical skills (C_3)	0.314	0.124	2.275	0.076
SSE (D_2)	0.325		6.914	0.309(3)
Getting (C_4)	0.244	0.079	1.869	0.056
Giving (C_5)	0.248	0.081	1.711	0.077
Using (C_6)	0.250	0.081	1.697	0.081
Planning (C_7)	0.258	0.084	1.638	0.084
Sales performance (D_3)	0.279		7.085	0.292(2)
Sales revenue (C_8)	0.203	0.057	1.272	0.087
Profit contribution (C_9)	0.205	0.057	1.490	0.076
New customer development (C_{10})	0.197	0.055	1.523	0.054
Customer retention (C_{11})	0.195	0.054	1.557	0.045
Sales amount (C_{12})	0.200	0.056	1.242	0.094
Total performance			**7.295**	
Total gap				**0.270**

Note: Relative gaps to aspired value: $f_{kj} = (x_j^* - x_{kj})/(x_j^* - x_j^-)$, where f_{kj} denotes the relative gap with k alternative in j criterion, x_{kj} denotes the performance value in each criterion j with k alternative and scales from 0 (complete dissatisfaction) to 10 (very very satisfaction), x_j^* denotes the aspired value (setting $x_j^* = 10$) in j criterion, and x_j^- denotes the worst value (setting $x_j^- = 0$) in j criterion.

Evaluating the total performance of gap by VIKOR

Using the scores derived by DANP, the overall cruise sales performance of gap can be obtained by VIKOR, as shown in Table 5. The decision makers can identify the problem-solving points according to this integrated index, either from the perspective of the criteria as a whole or from the perspective of the individual dimensions.

Using the overall criteria, the priority sequence for reaching the aspired level can be determined by the weights of the performance values, from high to low, and the gap value, from low to high. Interpersonal skills (C_1), with a high performance value of 2.896 and a low gap value of 0.039 is apparently the first criterion to be improved. This criterion is followed by customer retention (C_{11}), new customer development (C_{10}), and so on. The sales amount (C_{12}) is the last criterion, based on its lowest performance value (1.242) and the largest gap (0.094). Of all of the factors, these expert sales managers are most satisfied with their interpersonal skills and are least satisfied with their own cruise sales. This finding indicates the improvement priority sequence necessary for the overall criteria to reach the aspired/desired level, from the most satisfying criterion to the least satisfying one.

The rule can be applied to the individual dimension as well. In sales skill (D_1), for instance, the performance values of the priorities are ordered as follows: Interpersonal skills (C_1)_Salesmanship skills (C_2)_Technical skills (C_3). For decision makers, improving their abilities related to interpersonal interactions and a second language should be an easier way to achieve the desired level of cruise product sales skills. In SSE (D_2), the sequence is ordered as follows: Getting (C_4)_Giving (C_5)_Using (C_6)_Planning (C_7). Getting and understanding information are relatively closer to the desired level than the others and are the top priority for improvement. In sales performance (D_3), the priorities

for improvement can be sequenced as follows: Customer retention (C_{11})_New customer development (C_{10})_Profit contribution (C_9)_Sales revenue (C_8)_Sales amounts (C_{12}). Comparatively, maintaining existing customers is the most satisfying criterion and the easiest with which to reach the aspired level in this dimension.

Turning to the overall dimensions, sales skill (D_1) has a high performance value of 7.57 (to 10) and a low gap value of 0.224 (to 0), indicating that it is the first priority to be improved to reach the aspired level. The high performance value reveals that the dimension has been considered more essential, satisfying, and achievable, compared with the other dimensions. These expert sales managers agree that they are most confident in sales skill (D_1), followed by sales performance (D_3) and SSE (D_2). Comparatively, the dimension of SSE (D_2) is the least satisfying dimension and the last to be improved because of its lowest performance value (6.914) and largest gap value (0.309). Hence, the sequence priority can be ordered for sales decision makers: D_1_D_3_D_2 if the strategic target is the aspired level. With 10 as the aspired level, all performance values average 7.295, while the gap for improvement averages 0.270 (to 0). This value indicates the gap that this travel agency needs to bridge. Using the values given by the panel experts, the schemes for improvement priority can be unique, comprehensive, and inspirational, both from the individual respective and from the overall point of view (as shown in Table 5).

Discussions and implications

For the empirical case agency, the dimensions and criteria of influence are calculated and illustrated using an NRM (Figure 1). According to the degree of influence of Figure 1, the improvement priorities are sequenced as sales performance, SSE, and sales skill. This is an important point for decision makers. The expert sales managers recognise that the sales performance must come first. Efforts in that direction will produce network effects on the remaining dimensions and will spontaneously resolve multiple issues. This finding is consistent with Lacampvoc's (2010) description of sales managers as determined and practical thinkers who are focused on short-term and realistic goals, using regulations and procedures to evaluate performances. Moreover, these new findings improves upon previous causal findings on sales skills and/or SSE or findings that suggest that sales skills via SSE influence sales performance (e.g. Churchill et al., 1985; Lin, 2010; Liu et al., 2010). The strength of the NRM presented here is that it allows us to illustrate influential networks beyond a linear relationship, from the perspective of the dimensions or the criteria.

The criteria, such as customer retention (C_{11}), planning (C_7), and technical skills (C_3), are confirmed to have a more influential effect on the other criteria in the individual dimension (Figure 1). Notably, retaining existing customers is the first priority. As suggested by most service quality studies, retention costs the agency less because they do not have to recruit new patrons (e.g. Bolton, Kannan, & Bramlett, 2000; Kyle, Absher, & Chancellor, 2005; Zeithaml, Berry, & Parasuraman, 1996). Planning (C_7) also deserves further attention. The ability to create specific plans for cruise sales has an influential effect on the remaining inner abilities of using, getting, and giving related to cruise sales. This finding is important for decision makers to manage SSE, an individual faith and behaviour motivation. Furthermore, more attention should be given to technical skills (C_3), including in-depth professional knowledge about cruise product sales, competitors, and training (Hatton, 2004; Ryerson, 2008), than interpersonal or salesmanship skills.

Table 6. Strategic planning for improving cruise product sales.

Formula	Strategy (sequence of improvement priority)
F1: Influential network of dimensions	$D_3\_D_2\_D_1$
F2: Influential network of criteria within individual dimensions	D_1: $(C_3)\_(C_2)\_(C_1)$ $(C_2)\_(C_1)$ D_2: $(C_7)\_(C_6)\_(C_5)\_(C_4)$ $(C_6)\_(C_5)\_(C_4)$ $(C_5)\_(C_4)$ $(C_6)\_(C_4)$ $(C_7)\_(C_5)$ $(C_7)\_(C_4)$ D_3: $(C_{11})\ \_(C_8)\_(C_{10})\_(C_{12})\_(C_9)$ $(C_8)\_(C_{10})\_(C_{12})\_(C_9)$ $(C_8)\_(C_{12})\_(C_9)$ $(C_{10})\_(C_{12})\_(C_9)$
F3: Sequence of dimensions to rise to aspired/desired level (by gap value, from low to high)	$D_1\_D_3\_D_2$
F4: Sequence of criteria to rise to aspired/desired level within individual dimensions (by gap value, from low to high)	D_1: $(C_1)\_(C_2)\_(C_3)$ D_2: $(C_4)\_(C_5)\_(C_6)\_(C_7)$ D_3: $(C_{11})\_(C_{10})\_(C_9)\_(C_8)\_(C_{12})$

In addition, the overall performance values, as shown in Table 5, have an average of 7.295, with 10 as the desired level. The average gap, indicating room for improvement, is 0.270 (this value is the distance to 0). Sales skill (D_1), with the smallest gap value (0.224), should be the first priority for improvement if decision makers attempt to achieve the desired level. This finding reflects the traditional emphasis on interpersonal skills (gap value = 0.039) and salesmanship skills (gap value = 0.057) in service industries, in which the delivery of services often involves frontline employees' interactions with customers that must be effectively managed (Ekinci & Dawes, 2009; Ekinci, Dawes, & Massey, 2008). This effect is also relevant in the real world. Because a cruise product is a defined package, selling skills are basic requirements (Gibson, 2006; Walle, 1996) for common sales consultants to perform sales jobs in travel agencies.

Sales amount (C_{12}), with largest gap value of 0.094, is the most unsatisfying and unachievable criterion, implying that the appropriate amount standard must be reset. Furthermore, it is notable that SSE (D_2), with the largest gap value of 0.309, is the least confident dimension. This finding suggests that these experienced sales managers are in need of enhancing their faith and motivation to complete the task of cruise sales. For long-term improvement, the decision makers should manage this inner motivation carefully, as mentioned above.

Given these empirical findings, our results as holistically formulated in Table 6 fulfil the purpose of this research.

Conclusions

This research modelled the improvement strategies that should be pursued as part of cruise product sales in travel agencies. A novel hybrid MCDM method was used to address dependent relationships among the various criteria together with DEMATEL (used to construct the NRM), the DANP (used to decide the influential weights of the criteria), and VIKOR (used to determine the improvement priority in reducing gaps). Of the various

evaluations of cruise sales in this study, those provided by the domain experts, the experienced sales managers, produced useful results. The sequence of improvement priorities was as follows: sales performance, sales skill, and SSE. The average gap between the actual and the aspired/desired levels of sales performance was 0.270, denoting the level that must be bridged by the test agency. The implications of these results for management and improvement strategies were presented in Table 6. The underlying concepts applied here are found to be relevant to decision makers and expert sales managers as well, and the computation required is straightforward and simple, using the Excel program. Most importantly, the findings can help conventional travel agencies use strategic planning as a means of gaining a competitive advantage in the segmented market of cruise product sales and in an increasingly uncertain, dynamic, and complex world. This empirical test of our approach, conducted using a case study of an international travel agency, illustrated the usefulness of the approach in dealing with complex sales and the meaningful implications of our study for decision makers.

However, there are some limitations. First, this study was conducted with relatively expert sample groups. A larger sample that brought more explanatory power would have allowed more sophisticated evaluation analysis and verified the current findings to increase generalisability (Tseng, 2010). Second, the measurement scale developed in this study may not have the generalisability for cross-industry application because it is industry specific and captures a narrow domain by definition (Luk & Layton, 2002). Finally, the content and focus of the present study has been essentially manager oriented. A comparison between management staff and frontline employees would have deepened the discussion. Further research is thus needed in the field of developing more elaborated multi-criteria structure incorporating a large size for both the management sample and the frontline sample using the hybrid MCDM methods in the future.

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Appendix. A hybrid MCDM model combined with DEMATEL, ANP, and VIKOR

A.1. DEMATEL

The DEMATEL method is used to construct the interrelations between criteria to build an NRM. The method can be summarised as follows:

Step 1: Calculate the initial matrix using pair comparison to obtain the direct influence matrix $\boldsymbol{Z} = [z_{ij}]_{n\times n}$, where z_{ij} represents the degree of effect of factor i on factor j:

$$\boldsymbol{Z} = \begin{bmatrix} z_{11} & \cdots & z_{1j} & \cdots & z_{1n} \\ \vdots & & \vdots & & \vdots \\ z_{i1} & \cdots & z_{ij} & \cdots & z_{in} \\ \vdots & & \vdots & & \vdots \\ z_{n1} & \cdots & z_{nj} & \cdots & z_{nn} \end{bmatrix} \tag{A1}$$

Step 3: Normalise the matrix by Equations (A2) and (A3). Its diagonal is 0, and the maximum sum of row or column is 1:

$$\boldsymbol{X} = d\boldsymbol{Z}, \tag{A2}$$

$$d = \min\left[\frac{1}{\max_i \sum_{j=1}^{n} |z_{ij}|}, \frac{1}{\max_j \sum_{i=1}^{n} |z_{ij}|}\right], , \quad i, j = 1, 2, \ldots, n. \tag{A3}$$

Step 4: Obtain the total influence matrix $\boldsymbol{T}$, which can be obtained by $\boldsymbol{T} = \boldsymbol{X} + \boldsymbol{X}^2 + \cdots + \boldsymbol{X}^h = \boldsymbol{X}(\boldsymbol{I} - \boldsymbol{X})^{-1}$, when $\lim_{h\to\infty} \boldsymbol{X}^h = [0]_{n\times n}$, where $\boldsymbol{I}$ is the identity matrix.

Step 5: Obtain prominence and relation by totalling. To sum each row and column of the total influence matrix $\boldsymbol{T} = [t_{ij}]$ to obtain the sum of all rows (vector $\boldsymbol{r} = [r_i]_{n\times 1} = \left[\sum_{j=1}^{n} t_{ij}\right]_{n\times 1} = (r_1, \ldots, r_i, \ldots, r_n)'$) and the sum of all columns (vectors $\boldsymbol{s} = [s_j]_{1\times n} = \left[\sum_{i=1}^{n} t_{ij}\right]_{1\times n} = (s_1, \ldots, s_j, \ldots, s_n)$).

A.2. Based on DEMATEL technique to find ANP weights

The DANP is processed as follows:

Step 1: Develop the unweighted supermatrix and to normalise each level with the total degree of influence from the total influence matrix $\boldsymbol{T}$ of DEMATEL as shown in Equation (A4):

$$\boldsymbol{T}_c = \begin{array}{c} \\ D_1\ c_{11}\ c_{12}\ \vdots\ c_{1m_1} \\ \vdots \\ D_i\ c_{i1}\ c_{i2}\ \vdots\ c_{im_i} \\ \vdots \\ D_n\ c_{n1}\ c_{n2}\ \vdots\ c_{nm_n} \end{array} \begin{array}{c} \begin{array}{cccccc} D_1 & & D_j & & D_n \\ c_{11}\ldots c_{1m_1} & \cdots & c_{j1}\ldots c_{jm_j} & \cdots & c_{n1}\ldots c_{nm_n} \end{array} \\ \begin{bmatrix} \boldsymbol{T}_c^{11} & \cdots & \boldsymbol{T}_c^{1j} & \cdots & \boldsymbol{T}_c^{1n} \\ \vdots & & \vdots & & \vdots \\ \boldsymbol{T}_c^{i1} & \cdots & \boldsymbol{T}_c^{ij} & \cdots & \boldsymbol{T}_c^{in} \\ \vdots & & \vdots & & \vdots \\ \boldsymbol{T}_c^{n1} & \cdots & \boldsymbol{T}_c^{nj} & \cdots & \boldsymbol{T}_c^{nn} \end{bmatrix} \end{array} \tag{A4}$$

Step 2: Normalise $\boldsymbol{T}_c$ with the total degree of effect and obtain $\mathbf{T}_c^{\alpha}$, as shown in Equation (A5):

$$\boldsymbol{T}_C^{\alpha} = \begin{array}{c} \\ D_1\ c_{11}\ c_{12}\ \vdots\ c_{1m_1} \\ \vdots \\ D_i\ c_{i1}\ c_{i2}\ \vdots\ c_{im_i} \\ \vdots \\ D_n\ c_{n1}\ c_{n2}\ \vdots\ c_{nm_n} \end{array} \begin{array}{c} \begin{array}{cccccc} D_1 & & D_j & & D_n \\ c_{11}\ldots c_{1m_1} & \cdots & c_{j1}\ldots c_{jm_j} & \cdots & c_{n1}\ldots c_{nm_n} \end{array} \\ \begin{bmatrix} \boldsymbol{T}_c^{\alpha 11} & \cdots & \boldsymbol{T}_c^{\alpha 1j} & \cdots & \boldsymbol{T}_c^{\alpha 1n} \\ \vdots & & \vdots & & \vdots \\ \boldsymbol{T}_c^{\alpha i1} & \cdots & \boldsymbol{T}_c^{\alpha ij} & \cdots & \boldsymbol{T}_c^{\alpha in} \\ \vdots & & \vdots & & \vdots \\ \boldsymbol{T}_c^{\alpha n1} & \cdots & \boldsymbol{T}_c^{\alpha nj} & \cdots & \boldsymbol{T}_c^{\alpha nn} \end{bmatrix} \end{array} \tag{A5}$$

Then, normalise $\mathbf{T}_c^{\alpha 11}$ using Equations (A6) and (A7), and repeat to obtain $\mathbf{T}_c^{\alpha nn}$.

$$d_i^{11} = \sum_{j=1}^{m_1} t_{cij}^{11}, \quad i = 1, 2, \ldots, m_1, \tag{A6}$$

$$\mathbf{T}_c^{\alpha 11} = \begin{bmatrix} t_{c11}^{11}/d_1^{11} & \cdots & t_{c1j}^{11}/d_1^{11} & \cdots & t_{1m_1}^{11}/d_1^{11} \\ \vdots & & \vdots & & \vdots \\ t_{ci1}^{11}/d_i^{11} & \cdots & t_{cij}^{11}/d_i^{11} & \cdots & t_{im_1}^{11}/d_i^{11} \\ \vdots & & \vdots & & \vdots \\ t_{m_1 1}^{11}/d_{m_1}^{11} & \cdots & t_{m_1 j}^{11}/d_{m_1}^{11} & \cdots & t_{m_1 m_1}^{11}/d_{m_1}^{11} \end{bmatrix} = \begin{bmatrix} t_{c11}^{\alpha 11} & \cdots & t_{c1j}^{\alpha 11} & \cdots & t_{1m_1}^{\alpha 11} \\ \vdots & & \vdots & & \vdots \\ t_{ci1}^{\alpha 11} & \cdots & t_{cij}^{\alpha 11} & \cdots & t_{im_1}^{\alpha 11} \\ \vdots & & \vdots & & \vdots \\ t_{m_1 1}^{\alpha 11} & \cdots & t_{m_1 j}^{\alpha 11} & \cdots & t_{m_1 m_1}^{\alpha 11} \end{bmatrix}. \tag{A7}$$

The total effect matrix is normalised into the supermatrix according to the dependent relationships in the group. This allows us to obtain the unweighted supermatrix, as shown in Equation (A8):

$$\boldsymbol{W} = (\boldsymbol{T}_c^{\alpha})' = \begin{array}{c} \\ D_1 \\ \vdots \\ D_j \\ \vdots \\ D_n \end{array} \begin{array}{c} \begin{array}{cccccc} & D_1 & & D_i & & D_n \\ & c_{11}\ldots c_{1m_1} & \cdots & c_{i1}\ldots c_{im_i} & \cdots & c_{n1}\ldots c_{nm_n} \end{array} \\ \begin{bmatrix} \boldsymbol{W}^{11} & \cdots & \boldsymbol{W}^{i1} & \cdots & \boldsymbol{W}^{n1} \\ \vdots & & \vdots & & \vdots \\ \boldsymbol{W}^{1j} & \cdots & \boldsymbol{W}^{ij} & \cdots & \boldsymbol{W}^{nj} \\ \vdots & & \vdots & & \vdots \\ \boldsymbol{W}^{1n} & \cdots & \boldsymbol{W}^{in} & \cdots & \boldsymbol{W}^{nn} \end{bmatrix} \end{array} \quad (A8)$$

Furthermore, matrixes $\boldsymbol{W}^{11}$ and $\boldsymbol{W}^{12}$ can be obtained by Equation (A9). If a blank space or 0 appears in the matrix, then the group or criterion is independent. In the same way, the matrix $\boldsymbol{W}^{nn}$ is obtained:

$$W^{11} = (\boldsymbol{T}^{11}) = \begin{array}{c} \\ c_{11} \\ \vdots \\ c_{1j} \\ \vdots \\ c_{1m_1} \end{array} \begin{array}{c} \begin{array}{ccccc} c_{11} & \cdots & c_{1i} & \cdots & c_{1m_1} \end{array} \\ \begin{bmatrix} t_{c11}^{\alpha 11} & \cdots & t_{ci1}^{\alpha 11} & \cdots & t_{cm_1 1}^{\alpha 11} \\ \vdots & & \vdots & & \vdots \\ t_c 1 j^{\alpha 11} & \cdots & t_{cij}^{\alpha 11} & \cdots & t_{cm_1 j}^{\alpha 11} \\ \vdots & & \vdots & & \vdots \\ t_{c1m_1}^{\alpha 11} & \cdots & t_{cim_1}^{\alpha 11} & \cdots & t_{cm_1 m_1}^{\alpha 11} \end{bmatrix} \end{array}. \quad (A9)$$

Step 3: Obtain the weighted supermatrix by deriving the matrix of the total effect of dimensions $\boldsymbol{T}_D$ using Equation (A10). Then, $\boldsymbol{T}_D$ is normalised to obtain $\boldsymbol{T}_D^{\alpha}$, as shown in Equation (A11).

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

$$\boldsymbol{T}_D = \begin{bmatrix} t_D^{11} & \cdots & t_D^{1} & \cdots & t_D^{1n} \\ \vdots & & \vdots & & \vdots \\ t_D^{i1} & \cdots & t_D^{ij} & \cdots & t_D^{in} \\ \vdots & & \vdots & & \vdots \\ t_D^{n1} & \cdots & t_D^{nj} & \cdots & t_D^{nn} \end{bmatrix} \quad (A10)$$

$$\boldsymbol{T}_D^{\alpha} = \begin{bmatrix} t_D^{11}/d_1 & \cdots & t_D^{1j}/d_1 & \cdots & t_D^{1n}/d_1 \\ \vdots & & \vdots & & \vdots \\ t_D^{i1}/d_j & \cdots & t_D^{ij}/d_j & \cdots & t_D^{in}/d_j \\ \vdots & & \vdots & & \vdots \\ t_D^{n1}/d_n & \cdots & t_D^{nj}/d_n & \cdots & t_D^{nn}/d_n \end{bmatrix} = \begin{bmatrix} t_D^{\alpha 11} & \cdots & t_D^{\alpha 1j} & \cdots & t_D^{\alpha 1n} \\ \vdots & & \vdots & & \vdots \\ t_D^{\alpha i1} & \cdots & t_D^{\alpha ij} & \cdots & t_D^{\alpha in} \\ \vdots & & \vdots & & \vdots \\ t_D^{\alpha n1} & \cdots & t_D^{\alpha nj} & \cdots & t_D^{\alpha nn} \end{bmatrix}. \quad (A11)$$

Then, the normalised $\boldsymbol{T}_D^{\alpha}$ is transformed into the unweighted supermatrix W to obtain the weighted

supermatrix W^{α}, as shown in Equation (A12):

$$\boldsymbol{W}^{\alpha} = \boldsymbol{T}_D^{\alpha}\boldsymbol{W} = \begin{bmatrix} t_D^{\alpha 11} \times \boldsymbol{W}^{11} & \cdots & t_D^{\alpha i1} \times \boldsymbol{W}^{i1} & \cdots & t_D^{\alpha n1} \times \boldsymbol{W}^{n1} \\ \vdots & & \vdots & & \vdots \\ t_D^{\alpha 1j} \times \boldsymbol{W}^{1j} & \cdots & t_D^{\alpha ij} \times \boldsymbol{W}^{ij} & \cdots & t_D^{\alpha nj} \times \boldsymbol{W}^{nj} \\ \vdots & & \vdots & & \vdots \\ t_D^{\alpha 1n} \times \boldsymbol{W}^{1n} & \cdots & t_D^{\alpha in} \times \boldsymbol{W}^{in} & \cdots & t_D^{\alpha nn} \times \boldsymbol{W}^{nn} \end{bmatrix}. \tag{A12}$$

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

A.3. Evaluating the total performance by VIKOR

VIKOR can be divided into the following steps (Kuan et al., forthcoming; Opricovic, 1998; Opricovic & Tzeng, 2002, 2004, 2007; Ou Yang et al., 2008; Tzeng et al., 2002, 2005):

Step 1: Check the best value f_j^* and the worst value f_j^- in assessment criteria of the sales criteria. There f_j^* , the positive-ideal point, represents the best value (aspired levels) in each criterion evaluated by the experts. By contrast,f_j^-, the negative-ideal point, represents the worst values in each criterion. Equations (A13) and (A14) are then used to obtain the results:

$f_j^* = \max_k f_{kj}, j = 1, 2, \ldots, n$(traditional approach)

or setting the aspired levels (our proposal), *vector* $\boldsymbol{f}^* = (f_1^*, f_2^*, \ldots, f_n^*)$ (A13)

$f_j^- = \min_k f_{kj}, \quad j = 1, 2, \ldots, n$ (traditional approach)

or setting the worst values (our propose), *vector* $\boldsymbol{f}^- = (f_1^- \quad, f_2^- \quad, \cdots, f_n^- \quad)$. (A14)

Development of the VIKOR method began with the following form of the L_p–metric:

$$L_k^p = \left\{ \sum_{j=1}^{n} \left[\frac{w_j(|f_j^* - f_{kj}|)}{(|f_j^* - f_j^-|)} \right]^p \right\}^{1/p}, \tag{A15}$$

where $1 \le p \le \infty$; $k = 1, 2, \ldots, m$, and influential weight w_j is derived from the ANP. To formulate the ranking and gap measure, $L_k^{p=1}$ (as S_k) and $L_k^{p=\infty}$(as Q_k) are used by VIKOR:

$$S_k = L_k^{p=1} = \sum_{j=1}^{n} \left[\frac{w_j(|f_j^* - f_{kj}|)}{(|f_j^* - f_j^-|)} \right], \tag{A16}$$

$$Q_k = L_k^{p=\infty} = \max_j \left\{ \frac{(|f_j^* - f_{kj}|)}{(|f_j^* - f_j^-|)} | j = 1, 2, \ldots, n \right\}. \tag{A17}$$

Step 2: Calculate the mean of the group utility S_k (which represents the synthesised average gap for all criteria) and maximal regret Q_k (which represents the maximal gap in k alternative of special criterion for improvement priority). w_j represents the influential weights of the criteria from DANP; $r_{kj} = (|f_j^* - f_{kj}|)/(|f_j^* - f_j^-|)$ represents the normalised gap (the normalised ratios of distance to the aspired level) of k alternative in j criterion. Those values can be computed by Equations (A18) and

(A19), respectively:

$$S_k = \sum_{j=1}^{n} w_j r_{kj},$$

$$= \sum_{j=1}^{n} \frac{w_j(|f_j^* - f_{kj}|)}{(|f_j^* - f_j^-|)}, \tag{A18}$$

$$Q_k = \max_j \{r_{kj} = 1, 2, \ldots, n\}. \tag{A19}$$

Step 3: Obtain the comprehensive indicator R_k and sort out the results. The values can be computed by Equation (A20):

$$R_k = \frac{v(S_k - S^*)}{(S^- - S^*)} + \frac{(1-v)(Q_k - Q^*)}{(Q^- - Q^*)}. \tag{A20}$$

Equation (A20) can be rewritten as $Rk = vS_k + (1-v)Q_k$, when $S^* = 0$ and $Q^* = 0$ (i.e. all criteria have been achieved to the aspired level) and $S^- = 1$ and $Q^- = 1$ (i.e. the worst situation).