Determine the Market Position for VTS Service Systems Based on Service Value Position Model Using Novel MCDM Techniques

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***Abstract*—With the development of information and communication technology, People are gradually replaced map with the Vehicles telematics system (VTS). In addition, navigation is not the only function of VTS nowadays, new generation VTS even provides various functions and system services. This study tries to discuss the development trend of VTS products/services and customers' needs of navigation and location services, audio-video and entertainment services, communication and information services and safety and security services. However, automobile manufacturers and VTS products/service providers need to determine the new product development strategy based on their customers' needs. Because customers' needs will influence the automobile sales and give an impact on the development of VTS service in the future. This study also proposes NRM to determine the service improvement path and the improvement strategy based on the NRM. The aspect of the Safety and Security Services (SS) is the primary dominating aspect, the aspect of Communications and System Services (CS) is the most important influencing aspect in the NRM of the VSI. The aspect of the Payment Channel (PC) is the primary dominating aspect and the aspect of the Payment Method (PM) is the most important influencing aspect of the PSI.**

Keywords-Vehicles telematics system (VTS); Service system; Market position; DEMATEL; VIKOR.

I. INTRODUCTION

The original purpose of the GPS technology was for the military. It was gradually released to private enterprises. The related map information systems were thoroughly built. The application service of GPS technology had begun to move toward diversification [1-3]. New generation automobile not only emphasizes the mechanical efficiency, but also the VTS system functions. In order to satisfy the service needs of mobile environment for different customer groups, the VTS service system needs to be integrated and offers diverse service functions. Therefore some integrated functions have been appeared, such as the information and communication service, vehicles monitor service. According to the U.S.A., navigation devices can be classified as vehicle, aviation and marine navigation devices. Vehicle navigation devices are widely applied to END (Embedded Navigation Device), PND (Portable Navigation Device), PDA (Personal Digital Assistants) smart phones and a diversity of mobile devices [4, 5]. The car has become an open mobile service system from a closed transportation tool. The automobile has increased the added value of navigation, safety, security, information, communication, and entertainment functions. The VTS service system can aid drivers and passengers to contact with call center and access the navigation information. The VTS service system can not only improve driving convenience but also ensure the safety of vehicles under the appropriate monitoring. The innovation of ICT technologies has attributed to the diverse system service, and devices have become more and more thinner and lighter. Besides the VTS service system continually increase service functions, and the VTS service devices generally become similar to customers. This kind of trend attributes the VTS service system/device to become more and more popular in the current year, and to become the necessary goods from luxury goods. The navigation technology and electric service function of VTS service system has rapid progress continually for achieving the satisfaction level of customer needs. In the highly competition market of vehicle telematics service, the customers can't only be pleased by the improvement of the device hardware and electronic map software services. It is important for VTS service operators to identify what is consumers' needs develop new generation VTS service system to satisfy customers' needs. Because this will not only influence sales volumes for automobile operators but also impact the service market of end user for automobile market.

The remainder of this paper is organized as follows. In Section 2, product development and market position for VTS service system are reviewed and discussed. In Section 3, the evaluation model of market position for VTS service system is built. In Section 4, a novel MCDM technique is used to solve the market position decision problem (i.e., customers' preferences). The performance of the VTS service system is then discussed and an empirical study is demonstrated for the novel MCDM model. Finally, in Section 5, the conclusions and remarks are presented.

II. THE DISCUSSION OF PRODUCT DEVELOPMENT AND MARKET POSITION FOR VTS SERVICE SYSTEM

The GPS applications are quite extensive. According to the use environment, the navigation devices can be classified into many navigation devices of vehicle, aviation

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and marine and so on. The vehicle navigation devices are widely applied to END (Embedded Navigation Device), PND (Portable Navigation Device), PDA (Personal Digital Assistants) Smart phone and diverse mobile devices [4, 5]. This study discusses the service needs of customers, defines the functions/utilities of VTS service system, and analyzes the difference of customer needs. Besides, this study also arranges the service functions based on different customers' attributes, and generalizes five main value evaluation aspects (Location and navigation and services, LN; Safety and security services, SS; Communications and system Services, CS; Multimedia and entertainment services, ME; Image and customer relationship, IR) and four price evaluation aspect (Service Fee Rate, SF; Package Pricing, PP; Payment Method, PM; Payment Channel, PC) for VTS service systems/devices. This study determines the customer preference of VTS service systems using user questionnaire survey, and builds the network relation map by DEMATEL (Decision Making Trial and Evaluation) technique. Then this study uses the ANP (Analytic Network Process) technique to determine the aspect weights and builds the group component among the aspect by PCA (Principal Component Analysis) technique. Finally, this study uses the VIKOR (VlseKriterijumska Optimizacija I Kompromisno Resenje, VIKOR) [6] to analyze the VSI (Value satisfaction index) and PSI (Price satisfaction index) for VTS service systems/devices [7]. This study proposes an integrated evaluation model to analyze the current service gap of VTS service systems/devices, and illustrates four real commercial types VTS services/devices to test the proposed model. This proposed model can aid VTS system service operators to determine the market position of VTS service systems/devices by MPM (market position map) approach, determine the service improvement paths using network relation map (NRM) approach and can provide product/service development strategy of VTS systems/devices for the VTS service providers and automobile operators in the future. In the VTS service systems/devices, the system service providers need to play the integrated role to provide the user various vehicle navigation and mobile services applications (Table I).

TABLE I. DESCRIPTION OF CRITERIA AND ITS CODEWORD FOR EVALUATING VTS'S FUNCTIONS

Aspects / Criteria	Descriptions
Value Satisfaction Index (VSI)	
Location and Navigation and Services (LN)	
Voice-Guided Navigation Services (LN1)	The more precise voice-guided navigation services improves the efficiency of driving and reduces driving time.
Traffic Information (LN2)	More correct traffic situation information and more driving time to save, helps users realize the immediate road conditions, and comply with traffic signals.
Electronic Map Information (LN3)	More accurate map information allows drivers to handle and estimate the distance to the destination.
Safety and Security Services (SS)	
Safety and Emergency Services (SS1)	To prevent accidents and provide rescue assistance. Also clarifies the responsibilities for investigations after an accident.
Remote Central Control Services (SS2)	Remote door lock or unlock services to assure the safety of passengers and car security.
Vehicle Location Services (SS3)	To search and locate a stolen vehicle or a towed car.
Car Security Services (SS4)	To prevent the vehicle from being stolen and provide prior warning.
Vehicle Diagnosis and Maintenance Services (SS5)	To handle the operating conditions of vehicle devices, and provide maintenance suggestions.
Communications and System Services (CS)	
Mobile Information Services (CS1)	Enable consumers to manage e-commerce, get real-time information and access the Internet while moving.
User Interface (CS2)	Friendlier and more numerous choices will increase the convenience of use.
Platform Integration Services (CS3)	Integrating different platforms will increase compatibility of systems, and save replacement costs.
Information Security Protection (CS4)	Stricter security protection, more safeguards for the privacy of personal data, to prevent the criminal use of personal data.
Information Update Frequency (CS5)	More immediate and quick information updates to ensure more accuracy and precision.
Multimedia and Entertainment Services (ME)	
Real-Time Multimedia Services (ME1)	More choices for real-time multimedia services, enabling more current access to fashion and entertainment.
Vehicle Multimedia Playing System (ME2)	Larger screen size, support for various multimedia formats, and larger storage capacity enables consumers to enjoy more comfortable audio-video services.
Game Services (ME3)	Various choices of game services allow for more fun.
Personal Platform Services (ME4)	Personalized set-up functions of multimedia. Consumers can enjoy personalized services.
Image and Customer Relationship (IR)	
Product Design (IR1)	More popular product design that is more selective and easier to carry can stimulate the desire to buy the product.
Brand Image (IR2)	Better brand image, more confidence in the quality of the services provided.
After-Sales Services (IR3)	More after-sales service locations and wider channels, consumers will feel confident about maintenance and warranty services.
Privacy Policy (IR4)	More stringent privacy protection policies can avoid the leakage of credit and personal information for criminal use.
Price Satisfaction Index (PSI)	
Fee Rate and Payment Method	
Service Fee Rate (SF)	The service fee rate and promotion terms.
Package Pricing (PP)	The different pricing items and pricing methods which users prefer.
Payment Method (PM)	Flexible payment methods can satisfy consumers with different spending habits.
Payment Channel (PC)	More payment channels can enhance consumers' convenience.

III. THE EVALUATION MODEL OF MARKET POSITION FOR VTS SERVICE SYSTEMS

The analysis process of the service development strategy model for VTS service system is based on a novel MCDM technique as the following five steps: (1) introduces the research idea and market position map, (2) applies FCM to construct the network relations map (NRM); (3) constructs the motivation of needs by using PCA; (4) uses ANP to analyze the group weights; and (5) evaluates the performance gaps of digital music service systems using the FIM , discussing the development trend and related studies suggestion on the VTS services system.

A. *The concept of market position map*

Some studies have pointed out a trade-off relation between price and value [7, 8]. Some researchers used regression analysis to come out the relation between benefit and price [8]. The advantage of regression analysis is to handle the location analysis and to extract the price data easily. However, the position analysis of a multi-benefit/function is hard to be handled by a regression analysis, and we need to consider the value and price respectively. Some study adopted the value satisfaction index and price satisfaction index to solve the multi-benefit/function problems, and used the MCDM technique to evaluate varying tangible and invisible benefit/functions in the mobile phone market [7]. Therefore, this research adopts the MCDM techniques to analyze our research problem and extend the value-price map into the market position map (Figure 1).

The axes of the market position map include the value satisfaction index and price satisfaction index. The value satisfaction index consists of the aspects increasing the customer value satisfaction, while the price satisfaction index consists of aspects improving customer price satisfaction. As shown in Figure 1, the X axis is the value satisfaction index (VSI) and the Y axis is the price satisfaction index (PSI). In this study, the value satisfaction index includes four aspects: Location and navigation and services (LN), Safety and security services (SS), Communications and system Services (CS), Multimedia and entertainment services (ME) and Image and customer relationship (IR), and the price satisfaction index includes four aspects: Service Fee Rate (SF), Package Pricing (PP), Payment Method (PM) and Payment Channel (PC). The market position map is divided into four sections or market segmentations [Common and luxurious, (H, H); high price and gorgeous, (H, L); Low price to penetrating market (L, H); No or limited choice (L, L)].

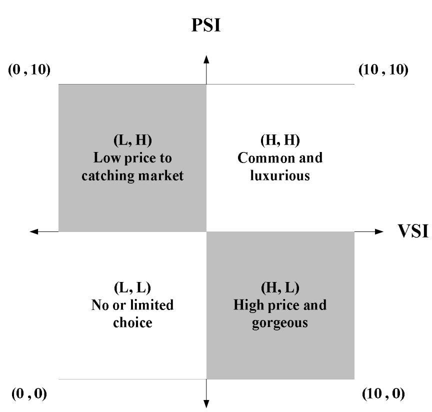

Figure 1. The concept of the market position map model.

B. *Builds the DEMATEL model*

The basic concept of DEMATEL technique was initiated for the Science and Human Affairs Program by Battelle Memorial Institute of Geneva between 1972 and 1976 to solve complex problems. This study uses the concept DEMATEL method to build the evaluation structure of network relation map (NRM) for creating an e-era VTS system. When making decisions, the decision-maker has to consider the criteria in detail and all the interrelations between them. What the decision-maker has to do is to find out the key criteria, modify them and then the whole performance of satisfaction will be enhanced. Therefore, when the decision-maker copes with lots of criteria being changed, the best solution is to determine the key criteria that affect the other criteria mostly and modify them. Eventually, the results of the evaluation will become more and more precise. Therefore, some recent studies considered the DEMATEL techniques for solving complex studies, such as the expectation model of service quality [9], and value-created system of science (technology) park [10]. The steps of the DEMATEL method are described as follows: (1) Calculates the original influence matrix by average of expert-respondents, (2) Calculates the degree of direct influence matrix, (3) Calculates the total degree of indirect influence matrix, (4) Calculates the total degree of direct and indirect influence matrix, and (5) Determines the Network Relation Map (NRM).

(1) Calculates the initial average matrix

Respondents were asked to indicate the influence that they believe each aspect exerts on each of the others; according to scoring scales ranging from 0 to 4, where "0" means no influence and "4" means "extremely strong influence." For the question between aspect/criterion; "1", "2", and "3" mean "low influence", "medium influence" and "high influence," respectively. As the data shows in Table II, the influence of Multimedia and entertainment services (ME) on "Image and customer relationship (IR)" is 2.300, which means "medium influence". On the other hand, the influence of Image and customer relationship (IR) on Multimedia and entertainment services (ME) is 1.950, which means "low influence".

TABLE II. ORIGINAL INFLUENCE MATRIX.

Aspects	LN	SS	CS	ME	IR	Total
Location and navigation and services (LN)	0.000	1.625	2.825	1.575	2.300	8.325
Safety and security services (SS)	1.725	0.000	2.525	1.350	2.300	7.900
Communications and system Services (CS)	2.975	2.350	0.000	2.075	2.350	9.750
Multimedia and entertainment services (ME)	1.575	1.350	2.200	0.000	2.300	7.425
Image and customer relationship (IR)	2.250	2.025	1.950	1.950	0.000	8.175
Total	8.525	7.350	9.500	6.950	9.250	-

(2) Calculates direct influence matrix

The initial direct influence matrix (*D*) can be calculated by Eq. (1) and Eq. (2). (*A*) is the initial average influence matrix, and can produce the initial direct influence matrix (*D*) through the process of Eq. (1) and Eq. (2). Matrix *D* represents each direct influence, and in the Matrix, the numbers on the diagonal are 0 and the sum of each column and row is 1 in maximum (only one equals 1). Adding the sums of each row and column in the Matrix results in the direct influence value:

$$\boldsymbol{D} = s\boldsymbol{A}, \quad s > 0 \tag{1}$$

where

$$s = \min_{i,j}\,[1/\max_{1\le i\le n}\sum_{j=1}^{n} a_{ij},\, 1/\max_{1\le j\le n}\sum_{i=1}^{n} a_{ij}],\ \ i, j = 1, 2, ..., n \tag{2}$$

and $\lim_{m\to\infty} \boldsymbol{D}^m = [0]_{n\times n}$, where $\boldsymbol{D} = [x_{ij}]_{n\times n}$, when $0 < \sum_{j=1}^{n} x_{ij}, \sum_{i=1}^{n} x_{ij} \le 1$ at least one $\sum_{j=1}^{n} x_{ij}$ or $\sum_{i=1}^{n} x_{ij}$ equal one, and only one row sum or column sum equal one .So we can guarantee $\lim_{m\to\infty} \boldsymbol{D}^{m-1} = [0]_{n\times n}$.

From Table II, we processed the "original influence matrix (*A*)" by using Eq. (1) and Eq. (2) and obtained the "direct influence matrix (*D*)". As shown in Table III, the diagonal items of *D* are all 0, and the sum of a row is 1, at most. Then we calculated Table IV by adding up the rows and columns. In Table IV, the sum of the rows and columns for "Communications and system Services (CS)" is 1.974, which is the most important influence aspect. On the other hand, the sum of the rows and columns for Multimedia and entertainment services (ME) is 1.474, which is the least important influence aspect.

TABLE III. DIRECT INFLUENCE MATRIX (***D***)

Aspects	LN	SS	CS	ME	IR	Total
Location and navigation and services (LN)	0.000	0.167	0.290	0.162	0.236	0.854
Safety and security services (SS)	0.177	0.000	0.259	0.138	0.236	0.810
Communications and system Services (CS)	0.305	0.241	0.000	0.213	0.241	1.000
Multimedia and entertainment services (ME)	0.162	0.138	0.226	0.000	0.236	0.762
Image and customer relationship (IR)	0.231	0.208	0.200	0.200	0.000	0.838
Total	0.874	0.754	0.974	0.713	0.949	

TABLE IV. COMPARISON TABLE OF DIRECT INFLUENCE MATRIX.

Aspects	Sum of row	Sum of column	Sum of row and column	Importance of Influence
Location and navigation and services (LN)	0.854	0.874	1.728	3
Safety and security services (SS)	0.810	0.754	1.564	4
Communications and system Services (CS)	1.000	0.974	1.974	1
Multimedia and entertainment services (ME)	0.762	0.713	1.474	5
Image and customer relationship (IR)	0.838	0.949	1.787	2

(3) Calculates Indirect Influence Matrix

The indirect influence matrix can be derived from Eq. (3), as shown in Table V.

$$\boldsymbol{IT} = \sum_{i=2}^{\infty} \boldsymbol{X}^i = \boldsymbol{X}^2(\boldsymbol{I}-\boldsymbol{X})^{-1} \tag{3}$$

TABLE V. INDIRECT INFLUENCE MATRIX (***ID***)

Aspects	LN	SS	CS	ME	IR	Total
Location and navigation and services (LN)	1.126	0.965	1.137	0.916	1.131	5.275
Safety and security services (SS)	1.047	0.943	1.092	0.879	1.077	5.037
Communications and system Services (CS)	1.191	1.060	1.351	1.013	1.275	5.890
Multimedia and entertainment services (ME)	0.990	0.874	1.038	0.846	1.015	4.762
Image and customer relationship (IR)	1.044	0.920	1.133	0.875	1.142	5.115
Total	5.399	4.762	5.750	4.528	5.640	-

(4) Calculates full influence matrix

Full influence matrix *T* can be derived from Eqs. (4) or (5). Table VI is the calculated full influence matrix. As shown in Table VI, the full influence matrix *T*, consists of multiple elements, indicated as Eq. (6). The sum vector of the row value is { d_i }, and the sum vector of the column value { r_i }; then, let $i = j$, the sum vector of row value plus column value is { $d_i + r_i$ }, which means the full influence of the matrix *T*. As the sum of the row value plus the column value { $d_i + r_i$ } is higher, the relationship of the dimension or criterion is stronger. The sum of the row value minus the column value is { $d_i - r_i$ }, which means the net influence relationship. If $d_i - r_i > 0$, it means the degree of influencing others is stronger than the degree to be influenced; otherwise, $d_i - r_i < 0$. Formulations show as follows:

$$\boldsymbol{T} = \boldsymbol{X} + \boldsymbol{IT} = \sum_{i=1}^{\infty} \boldsymbol{D}^i \tag{4}$$

$$\boldsymbol{T} = \sum_{i=1}^{\infty} \boldsymbol{D}^i = \boldsymbol{D}(\boldsymbol{I}-\boldsymbol{D})^{-1} \tag{5}$$

$$\boldsymbol{T} = [t_{ij}], \quad i, j \in \{1, 2, ..., n\} \tag{6}$$

$$\boldsymbol{d} = \boldsymbol{d}_{n\times 1} = [\sum_{j=1}^{n} t_{ij}]_{n\times 1} = (d_1, ..., d_i, ..., d_n) \tag{7}$$

$$\boldsymbol{r} = \boldsymbol{r}_{n\times 1} = [\sum_{i=1}^{n} t_{ij}]'_{1\times n} = (r_1, ..., r_j, ..., r_n) \tag{8}$$

As shown in Table VII, the aspect of Communications and system Services (CS) has the highest degree of full influence ($d_3 + r_3$ =13.62) and the aspect of Multimedia and entertainment services (ME) has the lowest degree of full influence ($d_4 + r_4$ =10.77). The aspect of Safety and Security Services (SS) has the highest degree of net influence [($d_3 - r_3$)=0.331]. The order of other net influences is listed as follows: the Multimedia and entertainment services (ME) aspect ($d_1 - r_1$ =0.283), Communications and system Services (CS) aspect ($d_1 - r_1$ = 0.165), Location and navigation and services (LN) aspect ($d_3 - r_3$ = -0.144), and the last one, the Product Image (PI) aspect ($d_5 - r_5$ = -0.635).

TABLE VI. FULL INFLUENCE MATRIX

Aspects	LN	SS	CS	ME	IR	Total
Location and navigation and services (LN)	1.126	1.132	1.427	1.078	1.367	6.130
Safety and security services (SS)	1.224	0.943	1.351	1.017	1.313	5.847
Communications and system Services (CS)	1.496	1.301	1.351	1.226	1.516	6.890
Multimedia and entertainment services (ME)	1.152	1.012	1.264	0.846	1.251	5.524
Image and customer relationship (IR)	1.275	1.128	1.333	1.075	1.142	5.954
Total	6.274	5.516	6.725	5.241	6.589	-

TABLE VII. DEGREE OF FULL INFLUENCE

Aspects	{ d_i }	{ r_i }	{ $d_i + r_i$ }	{ $d_i - r_i$ }
Location and navigation and services (LN)	6.130	6.274	12.40	-0.144
Safety and security services (SS)	5.847	5.516	11.36	0.331
Communications and system Services (CS)	6.890	6.725	13.62	0.165
Multimedia and entertainment services (ME)	5.524	5.241	10.77	0.283
Image and customer relationship (IR)	5.954	6.589	12.54	-0.635

(5) Determines the network relationship map (NRM)

According to the aspects/criteria defined in Table I, some experts were invited to discuss the relation and influence levels of criteria under the same aspects/ criteria and to score the relation and influence among criteria based on the DEMATEL technique. Aspects/criteria are divided into different types, so the experts could answer the questionnaire in areas/fields with which they were familiar. The net full influence matrix, T_{net}, is determined by the Eq. (9).

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$$T_{net} = [t_{ij} - t_{ji}], \qquad i, j \in \{1, 2, \ldots, n\} \tag{9}$$

The diagonal items of the matrix are all 0. In other words, the matrix contains a strictly upper triangular matrix and a strictly lower triangular matrix. Moreover, while values of strictly upper triangular matrix and strictly lower triangular matrix are same, their symbols are opposite. This property helps us that we only have to choose one of strictly triangular matrix.

TABLE VIII. THE NET INFLUENCE MATRIX FOR VTS SERVICE SYSTEM

Aspects	LN	SS	CS	ME	IR
Location and navigation and services (LN)	-				
Safety and security services (SS)	0.092	-			
Communications and system Services (CS)	0.069	-0.050	-		
Multimedia and entertainment services (ME)	0.075	-0.005	0.038	-	
Image and customer relationship (IR)	-0.092	-0.185	-0.183	-0.176	-

We can understand the related influence structure of NRM for the VTS service system from Figure 2, the figure shows that the aspects of Safety and Security Services (SS), Communications and system Services (CS) and Multimedia and entertainment services (ME) are mainly influencing aspects, and the aspect of Location and navigation and services (LN) and Image and customer relationship (IR) are mainly influenced aspect. Therefore, this study wants to assist decision-makers to build an improvement process, and conducts calculus on the net (be received) influence matrix using the full influence matrix (TABLE VIII). The evaluated method can integrate the degree of influence of the aspect, sand gain the net influence relation of the five aspects. From TABLE VIII and Figure 2, the IR aspect has net influence on the aspect of SR, PM and PF, the aspect of SR had net influence on the aspect of PM, PF and PP. The aspect of PM had net influences on the aspect PF and PP, and the aspect of PF influences the aspect of PP. The aspect of IR should be improved firstly, then the aspect of SR, PM and PF should be improved secondly. The aspect of PP is the least improvement item among all aspects. It's indirect for improving the service performance of the system.

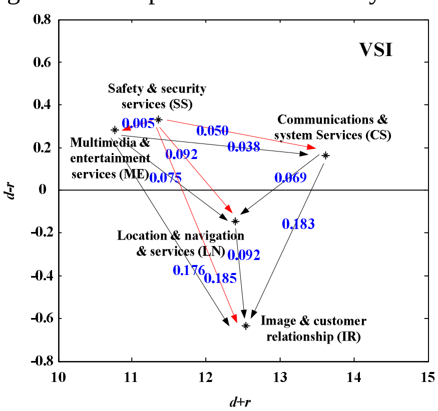

Figure 2. The improvement strategy map for VTS service system based on VSI

C. Principal Component Analysis (PCA)

This study uses PCA to analyze the original data of importance degree. It can be used to simplify the large number of criteria and it also can satisfy the hypothesis of AHP/ANP on the independence/dependence of criteria included in system aspect. However, the founder of ANP, Professor Saaty, didn't explicitly define it [11]. From the paper analysis of AHP/ANP, it can be figured out that the hypothesis is that criteria in aspects are independent /dependent. That's why we use this technique in this study. There are two components that can be extracted: PM (Platform design and maintenance) and the square sum (88.092%), and named the major elements, as shown in TABLE IX. Support of device system (PM3), frequencies of content update (PM2), and system protection (PM1) can be integrated into the first major component PMP1 (Platform design and maintenance). System stability (PM5) and system protection (PM4) can be integrated into the second component PMP2 (System stability and security).

TABLE IX. THE PCA ANALYSIS OF NAVIGATION AND LOCATION SERVICES (NL) ASPECT

Aspects	Components	Criteria	Components 1	Community
Location and navigation and services (LN)	Traffic Information and Navigation Services (NLP1)	Voice-Guided Navigation Services	0.908	0.825
		Traffic Information	0.861	0.742
		Electronic Map Information	0.824	0.678
Engen-value λ			2.245	
% of Variance (contribution)			74.843	
Cumulative contribution (%)			74.843	
Cronbach's α			0.831	

D. Analytic network procedure model (ANP)

Saaty (1996) proposed the concepts of ANP in 1996, to solve the issue that the AHP method is too ideal to evaluate the problems correctly. The ANP method [12-14] can cope with the dependence and feedback relation in the problems. The evaluation is closer to the actual adoption. The following three steps are undertaken to evaluate the decision problems with the ANP method: (1) builds the network hierarchical structure, (2) calculates the weighing of factors in each hierarchy, and (3) calculates the weighting of the whole hierarchy structure. In this study, the ANP steps are introduced as follows: (1) clarifies the problems and build the structure based on NRM, (2) designs the questionnaire and survey, (3) builds the weightings of pair-wise comparisons, calculates the weightings of factors, and test the consistency, (4) calculates the super-matrix.

E. Vlse Kriterijumska Optimizacija I Kompromisno Resenje (VIKOR)

After establishing the evaluation model, including criteria and given weights in each criterion, the next step is to evaluate and improve the performance of benchmarked alternatives. The more utilities/functions of the service system of VTS, the more expensive it is. Thus, among the evaluation model of service system for VTS, the functional criteria are mutually conflicted with the cost criteria. The VIKOR method is used to evaluate, improve and rank the performance of benchmarked alternatives. The VIKOR method is a multi-criteria decision making (MCDM)

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method, and is applied to solve a discrete decision problem with non-commensurable and conflicting criteria. This method focuses on ranking, improving and selecting the best alternative from a set of alternatives, and determines the compromise solution for a problem with conflicting criteria, which can help the decision-makers to reach a final best decision. Here, the compromise solution is a feasible solution closest to the ideal point (or closest to the aspired/desired levels in each criterion), and a compromise means an agreement established by mutual concessions. Thus, the VIKOR method would be applied to rank, evaluate and improve the performance of the best service systems of VTS. The basic concept of VIKOR is to identify the positive-ideal solution (the aspired/desired level) and the negative-ideal solution (the worst level). The positive solution is the best solution that satisfies the most required criteria, and the opposite is the negative-ideal solution. The VIKOR method could rank, improve and determine the difference of negative and positive ideal solutions between services/utilities of the existing service systems of VTS. When calculating the distance between the ideal solution and the proposed service systems of VTS, the scores of each criterion should be summarized. The gaps between the consumers' most satisfied one and most unsatisfied one is also analyzed, with respect to services/utilities of the existing service systems of VTS. The VIKOR method was started with the form of the $L_p - metric$, which was used as an aggregating function in a compromise programming method and it developed the multi-criteria measure for compromise ranking [15, 16]. VIKOR provided a maximum group utility of the "majority" and a minimum individual regret of the "opponent". The compromise solutions could be the base for negotiation, involving the decision makers' preferences by criteria weights (Figure 3).

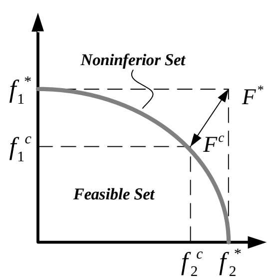

Figure 3. Ideal and compromise solutions

where: F^* is the ideal solution. f_1^* represents the ideal value (or called the aspired/desired level) of criterion 1. f_2^* represents the ideal value (the aspired/desired level) of criterion 2. The compromise solution, F^c, is a feasible solution that is "closest" to the ideal F^*. A compromise means an agreement established by mutual concessions. The VIKOR method is presented with the following steps:

(1) Determines the best f_k^* value and the worst f_k^- value in criterion i.

$$f_k^* = \left\{ \left(\max_k f_{ik} \mid k \in I_1 \right), \left(\min_k f_{ik} \mid k \in I_2 \right); \text{or setting the aspired level for } i \text{ criterion} \right\}, \ \forall k \quad (10)$$

$$f_k^- = \left\{ \left(\min_k f_{ik} \mid k \in I_1 \right), \left(\max_k f_{ik} \mid k \in I_2 \right); \text{or setting the worst level for } i \text{ criterion} \right\}, \ \forall k \quad (11)$$

where: k is the kth alternative; i is the criterion; f_{ik} is the performance value of the ith criterion of kth alternative; I_1 is the cluster of utility-oriented criteria; I_2 is the cluster of cost-oriented criteria; f_i^* is the positive-ideal solution (or setting the aspired level); and f_i^- is the positive-ideal solution (or setting the worst level).

(2) Computes the values S_k and Q_k, $k = 1, 2, \cdots, m$, using the relations.

Let r_{ik} be $r_{ik} = (|f_i^* - f_{ik}|)/(|f_i^* - f_i^-|)$. Before we formally introduce the basic concept of the solutions, let us define a class of distance functions.

$$d_k^p = \left\{ \sum_{i=1}^{n} [w_i(|f_i^* - f_{ik}|)/(|f_i^* - f_i^-|)]^p \right\}^{1/p} = \left\{ \sum_{i=1}^{n} [w_i r_{ik}]^p \right\}^{1/p}, p \geq 1 \quad (12)$$

$$S_k = d_k^{p=1} = \sum_{i=1}^{n} w_i r_{ik} \quad (13)$$

$$Q_k = d_k^{p=\infty} = \max_k \{ r_{ik} \mid i = 1, 2, ..., n \} \quad (14)$$

where S_k shows the average gap for achieving the aspired/desired level; Q_k shows the maximal degree of regret for prior improvement of gap criterion. w_i is the weight of the criterion i and $i = 1, 2, ..., n$, expressing the relative importance value of the criteria gained via the application of the ANP method, based on NRM.

(3) Computes the index values R_k, $k = 1, 2, \cdots, m$, using the relation.

$$R_k = v(S_k - S^*)/(S^- - S^*) + (1-v)(Q_k - Q^*)/(Q^- - Q^*) \quad (15)$$

$$S^* = \min_k S_k, \ S^- = \max_k S_k$$

$$Q^* = \min_k Q_k, \ Q^- = \max_k Q_k$$

where $S^* = \min_k S_k$ (showing the minimal average gap is the best, we also can set $S^* = 0$), $S^- = \max_k S_k$ (we can set $S^- = 1$), $Q^* = \min_k Q_k$ (showing the minimal degree of regret is the best, we also can set $Q^* = 0$), $Q^- = \max_k Q_k$ (we can set $Q^- = 1$). We also can re-write Eq. (15), $R_k = vS_k + (1-v)Q_k$.

(4) Ranks the alternatives.

In addition, $0 \leq v \leq 1$ when $v > 0.5$, this indicates S is emphasized more than Q in Eq. (15), whereas when $v < 0.5$ this indicates Q is emphasized more than S in Eq. (15). More specifically, when $v = 1$, it represents a decision-making process that could use the strategy of maximum

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group utility; whereas when $v = 0$, it represents a decision-making process that could use the strategy of minimum individual regret, which is obtained among maximum individual regrets/gaps of lower level dimensions of each project (or aspects/objectives). The weight (v) would affect the ranking order of the dimensions/aspects/criteria and it is usually determined by the experts or decision making. In this paper, R_k (here, v =0.5) is applied to determine the customer satisfaction index (CSI). R_k could also consider the index of the maximum group utility and the minimum individual regret of the “opponent”, where R_k smaller is better and $0 \leqq R_k \leqq 1$.

IV. THE EMPIRICAL ANALYSIS OF MARKET POSITION FOR VTS SERVICE SYSTEMS

As shown in Table X and Figure 4, the Type-G (0.524, 0.549) is the highest value in VSI and PSI, and Type-G is located in the common and luxurious (H, H). The Type-A (0.426, 0.492) and Type-O (0.423, 0.492) are the lowest value of PSI, the Type-O (0.423, 0.759) is the lowest value of VSI. Besides, the Type-T is located in the low price to catching market (L, H) and the Type O and Type-A are located in the no or limited choice (L, L). Accounting research result, the development trend of VTS service systems/device that generally move from the no or limited choice (L, L) to the low price to catching market by improving the PSI (Price satisfaction index), then move to the common and luxurious (H, H) through improving the VSI (Value satisfaction index). The development strategy of VTS service systems is to reduce the price of VTS service system, and to increase the value of VTS service system. Therefore, Continuing conducting product design innovation and service process improvement can increase the customers’ satisfaction degree and create new value position helping VTS service operators to leave red sea market of high price competition into the blue sea market of low price competition.

TABLE X. THE VSI AND PSI OF VTS PRODUCTS UNDER v =0.5

v=0.5	Type-T Taiwan	Type-O America	Type-A Europe	Type-G Japan
R_{vk}	0.556	0.577	0.574	0.476
VSI	0.444	0.423	0.426	0.524
VSI Rank	(2)	(4)	(3)	(1)
R_{pk}	0.475	0.508	0.508	0.451
PSI	0.525	0.492	0.492	0.549
PSI Rank	(2)	(3)	(3)	(1)

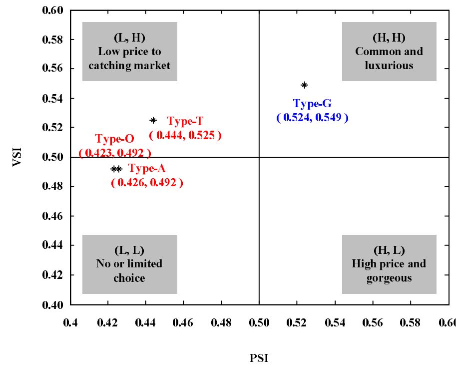

Figure 4. The map of service value position based on VSI and PSI

V. CONCLUSIONS

Vehicles telematics system (VTS) market includes five service operators (hardware suppliers, software operators, vehicles telematics system service operators, digital content service providers and telecommunications service operators), and the VTS service operators pay a key role in systems integration for diverse VTS system services. In some successful experience of service operators, there is a huge challenge about how to understand customers’ needs. In the service system of VTS, the European and American VTS service operators laid particular stress on the service function regarding safety and security services, while the Japanese VTS service operators focus on navigation and map information services. VTS system service operators gradually strengthen the service function about communication and information services, and multimedia and entertainment services in the recent years. Taiwan's VTS service operators adopt open hybrid system based on Japanese navigation technologies and on Taiwanese users’ needs such as high rate of car theft, frequent stowaway execution. Therefore, Taiwan's VTS service operators provide various service functions with location and navigation services and safety and security utilities such as guarding against burglary, assuring the safety, detection of vehicles towing. Considering the regional differences of market characteristics, the users’ needs will be differed based on their environment. This study deliberates about the VTS service system development of some developed regions such as America, Europe, Japan, and analyzes the local condition and attributes of Taiwan. This study tries to find a suitable direction of VTS service market based on the VTS service system survey, and compares four regions commercial VTS service systems including America, Europe, Japan and Taiwan.

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