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Research Article

User Satisfaction Based Vehicle Navigation System Design

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Abstract: The main objective of this study is to investigate real factors affecting the user satisfaction of VND so as to find solutions for the above mentioned issues. In order to achieve such objective, this research has integrated factor analysis, fuzzy theory and Decision Making Trial and Evaluation Laboratory (DEMATEL) to construct innovative and stringent data analysis architecture. Such structure can effectively sort out factors and delete fuzzy factors during human decision making process, in other words, the information needed for R&D decision making can be more accurately provided. Empirical experimental results show that the investment on the reduction of the failure rate of the product and the providing of more convenient and accurate map data updating service will all be helpful to the enhancement of brand image and such business operation strategy of moving towards the right end of smile curve is the key for an enterprise to keep innovative and to keep competitive.

Keywords: Decision making, DEMATEL, factor analysis, fuzzy theory, utilizing satisfaction, vehicle navigation device

INTRODUCTION

The evolution of technology has expanded human's daily life scope, meanwhile, along with the fast setup and complication of traffic network, people have to use the massive assistance from navigation device to be able to avoid crowdedness in changeable road situation or strange area and to reach the destination safely and quickly.

However, the progress in information technology has stimulated again vehicle driver's need on security (Magnusson *et al*., 2002), video entertainment and communication and information service (Golob and Regan, 2001) during the driving period, hence, traditional navigation device that only provides information services such as real time road condition and shortest route can no longer enhance the driver's willingness to purchase this device. To cope with this issue, in one aspect, the supplier has to make a strategy of developing multi-function Vehicle Telematics Systems (VTS) that integrates dynamic navigation, burglar proofing, video entertainment and anti-collision control system and it is hoped that this can be used as niche product in the future vehicle electronic system market. In another aspect, it is important to construct mathematical model and to enhance the forecasting capability of the road condition. Meanwhile, the route selection preference of the driver is further referred to and the model output data is referred to also to plan the driving route in advance and the main objective is to use accurate road condition forecast and adaptive route planning to enhance the driving effectiveness of the driver. It is especially true for the latter because it has been listed as important research items for technology to provide "individual commuting" service.

As mentioned above, the widespread use of smart navigation system that can provide adaptive route planning, accurate road condition prediction and real time information is the necessary trend. Therefore, the related system suppliers should think how to develop product of the next generation to gain competitive advantage in the future market and to obtain above average return and this would be a test of the supplier's capability of accurate seizing of the trend and the integration of R&D resource. Generally speaking, the marketing department mostly considers the satisfaction of the user through the new product as much as possible, however, the decision maker must consider the business operation strategy of the company as well as factors such as cost and technological limitations before decision is made on new product development. Therefore, there might be difference for the recognition on the R&D factors on the same product from both of them and different opinions would be the inevitable result. In order to improve such phenomenon, how to shorten the recognition difference between both of them

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on R&D decision has become the issue that decision maker and this research have to face and solve.

US master of marketing, McCathy, had pointed out that the manufacturing objective of product was to satisfy the need and desire of the user. Kotler (1991) also thought that user satisfaction can increase enterprise's profit. Therefore, after the product or service is launched into the market, user satisfaction will naturally become the index that the enterprises focuses on and the study of factors affecting user satisfaction has naturally become research fields that lots of scholars get involved in. However, in lots of related past literature for the study of factors affecting user satisfaction on a product, most of them still emphasize on the study of the significance of positive or negative influence of user satisfaction of factor on target product and the mutual influential strength among factors is usually neglected; meanwhile, the cause and effect relation among factors is not analyzed; furthermore, there are very few researches studying factors affecting user satisfaction from the point of view of the supplier, not to say further understanding of the cause of existence of the opinion difference existed between the supplier and the user as well as the giving of management meaning. Therefore, in actual decision making, its reference value is then relatively insufficient.

In order to provide solutions for the above mentioned issues, this research, in one aspect, starts from questionnaire survey and the extraction of factors affecting the user satisfaction of navigation system, in another aspect, sets up the assessment data of each decision maker on each factor so as to process the data with Decision Making Trial and Evaluation Laboratory (DEMATEL), then both of them are merged to investigate difference between them and to gain the principle and method for shortening the recognition difference.

Important contents of the rest of this research are described respectively as in the followings. The second part will be introduction of methods used in this research, which include factor analysis, fuzzy logic and DEMATEL. Moreover, the characteristics of the issues will be considered and the above mentioned methods will be applied to construct integrated and analytical model to be used as operation mechanism and platform for processing data and obtaining solutions for the issues. In the case study aspect and in third part, we will use Taiwan's VND user and manufacturing and sale companies as targets to describe data acquisition and processing process and result and the practical meaning will be provided too. The final part will be conclusions of this research.

METHODOLOGIES

Factor analysis: The main objective to perform factor analysis is to use fewer variables to represent massive variables or items in the survey questionnaire, that is, to define each perspective of the architecture and the forming variable of each perspective. Its steps can be divided into:

Step 1: The applicability judgment of factor analysis: In this research, two methods are used to judge if factor analysis is applicable to the survey questionnaire data, one is Bartlett's test of sphericity, if significance is shown in the test, it means that sufficient correlation exists among a set of variables and factor analysis can be used to extract common factors. That is, there are common factors in the correlation matrix of the mother population and factor analysis is thus applicable.

Another one is Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and KMO is a number with value in the range of 0 ~1. The larger its value, the more common factors among the variables and factor analysis is more applicable; otherwise, factor analysis is not applicable. Generally speaking, KMO must be larger than 0.7, it would then be more appropriate to perform factor analysis.

Step 2: Factor extraction: This research takes Principal Component Analysis to simplify the dimension, that is, after factor extraction, if the percentage that fewer new variables to explain the total variance is large enough, then new variables would be adopted to explain the original data so as to achieve the objective of simplifying the number of variable.

Step 3: Decision of the number of factor: For the decision of common factor in this research, Kaiser method is adopted. In the method, eigenvalue is used as judgment standard, that is, only common factor with eigenvalue larger than 1 will be preserved. After the selection of factor, Scree Test is used for verification.

Step 4: Factor rotation: The main objective of factor rotation is to make the loading of individual variable on common factor easier to be explained, hence, after rotation, the loading of variable on each factor either becomes larger or smaller and this will facilitate the judgment of the attribute of variable and common factor. In this study, Varimax method is adopted to perform factor rotation.

Step 5: Factor naming:

Fuzzy DEMATEL: DEMATEL analysis method originated from Battelle Memorial Institute of Geneva of Switzerland in 1971 for the implementation of Science and Human Affairs Program. It was used to solve the issue between technology and human beings (for example, race, hunger, environmental protection and energy issues) and its main function is to structure complicated issues and to display the correlation among influential factors in visible way, hence, the essence of the issues would be more easily to be understood and the solutions can then be found. The subsequent

scholars continuously associated it with other methods and applied it in the decision making and analysis processes of different fields. For example, Analytic Network Process (ANP) was used to decide the level of influence of factors among different level architectures, or Back-Propagation Neural Network (BPNN) was used to deduce the importance of quality feature; furthermore, they are massively used in the fields such as marketing, knowledge management strategy selection, equity investment and market analysis for computer industry, etc. (Wu, 2008; Lee *et al*., 2011; Hu *et al*., 2009; Tsai and Chou, 2009; Yang and Tzeng, 2011).

Since the application of DEMATEL in Multi-Criteria Decision Making (MCDM) must rely massively on the assessment from the experts, however, fuzzy factors exist among human's decisions and the accuracy of final data is affected in turn, finally, the decision quality is affected. To handle the vagueness of human assessments in making decisions, recently, the academy tends to use fuzzy theory to provide an improvement route for this issue.

According to Opricovic and Tzeng (2003), in the past researches, there are two ways to associate fuzzy logic and DEMATEL: One is additive model, that is, defuzzification points are adopted as the components of initial influence matrix, or the components of total influence matrix are treated with fuzzification; such researches include Wu and Lee (2007), Tseng (2010), Zhou *et al*. (2011) and Chang *et al*. (2011). However, no matter it is direct or indirect influence among standards, there is usually vague factor exits in the human decision making process and the above method does not totally include this factor into DEMATEL operation, hence, drawbacks could easily be generated and it could easily be doubted. Another model is to put fuzzy numbers into the operation process of DEMATEL so as to improve the drawbacks of the former and the related researches include Hsu *et al*. (2007), Lin and Wu (2008), Jassbi *et al*. (2011), Dalalah *et al*. (2011) and Kuo (2011) etc.

From the above mentioned past decision-making related researches using DEMATEL, the following issues mostly existed, for example, the assessment affecting problem factor and its level is too subjective, the error existed in the human decision making process is not included in the operation mechanism of DEMATEL, hence, the data generated from the model is naturally in very large difference to the real value and its value in practical application is then reduced. In this study, for the above issues, innovative and practical analytical architecture is constructed so as to deal with VND R&D decision making issues.

THE PROPOSED FRAMEWORK

This research is mainly to investigate the recognition difference of the quality satisfaction factor of new product or service between Vehicle Navigation System supplier and user and it is hoped that a project that can effectively reduce the difference can be proposed. In order to achieve such research objective, we first use user questionnaire survey to understand the preference from the user on the quality of new product, then through DEMATEL analysis, the total influential level of each product among satisfaction factors is obtained. In obtaining the supplier's opinion on developing new product, we have organized an expert's team and used focus group interview way to discuss the quality issue of new generation of VND from the R&D, manufacturing and marketing view point of the supplier; meanwhile, the influential level assessment among different quality perspectives is provided by the experts; however, in order to delete the fuzzy factors existed in human decision making process, we have used fuzzy DEMATEL to calculate the total influential level among product satisfaction factors in expert's assessment opinions. The operation result of the above two sets of data can be further applied to the investigation of the issue of recognition difference.

Mathematically, the solving steps of the structure model can be further narrated as follows:

Step 1: Buildhierarchy structure: Conduct questionnaire factor analysis.
Suppose that k = 1, 2 represent user and expert, respectively.
We have used the data obtained from questionnaire survey, then we have used statistical software SPSS v18.0 in the operation to sort out factors which really affect the user satisfaction of VNS, meanwhile, the correlation coefficients among factors are calculated to be used for further analysis.
For k = 1, based on the correlation among factors, initial-relation matrix $\widetilde{X}_1 = [\tilde{x}_{1ij}]$ is then set up and then go to Step 7

Step 2: Establish a committee composed by *p*experts based on marketing or R&D managers of five major suppliers such as GARMIN, etc.

Step 3: Follow factor analysis result to set up user satisfaction factor and to design fuzzy linguistic scale.

In this research, triangular fuzzy number is adopted, hence, the following definition is made first.

Definition: A fuzzy number A is a triangular fuzzy number if its membership function has $0 < l \le m \le u \le \infty$:

$$\mu_A = \begin{cases} (x-l)/(m-l) \\ (u-x)/(u-m), \\ 0 \end{cases}$$

$l \le x \le m$
$m \le x \le u$
otherwise

Table 1: The correspondence of linguistic terms and linguistic values

Linguistic terms	Linguistic values
Very high influence (VH)	(0.75, 1.0, 1.0)
High influence (H)	(0.5, 0.75, 1.0)
Low influence (L)	(0.25, 0.5, 0.75)
Very low influence (VL)	(0, 0.25, 0.5)
No influence (No)	(0, 0, 0.25)

For the assessments need to be acquired from the experts, we have adopted five classes of No, VL, L, H and VH, which have representative meaning and corresponding linguistic values as in Table 1.

Step 4: Acquire the assessments of experts.
After conducting focus group meeting, the pair-wise comparisons of each factor are provided by the experts.

Step 5: Generate the initial direct-relation matrices.

Denote $\mathrm{Z}_2^{(\mathrm{n})} = \left[\mathrm{z}_{2\mathrm{ij}}^{(\mathrm{n})}\right] = \left[\left(\mathrm{l}_{2\mathrm{ij}}^{\mathrm{n}}, \mathrm{m}_{2\mathrm{ij}}^{\mathrm{n}}, \mathrm{u}_{2\mathrm{ij}}^{\mathrm{n}}\right)\right]$ to be the degree of direct influence of the i^{th} factor to the j^{th} factor evaluated by the n^{th}expert, $\mathrm{n} = 1,2,\ldots,\mathrm{p}_{\mathrm{i}}$, $\mathrm{i,j} = 1,2,\ldots,p$ $\widetilde{\mathrm{X}}_2 = \left[\tilde{\mathrm{x}}_{2\mathrm{ij}}\right] = \left[\left(\tilde{\mathrm{l}}_{2\mathrm{ij}}, \tilde{\mathrm{m}}_{2\mathrm{ij}}, \tilde{\mathrm{u}}_{2\mathrm{ij}}\right)\right]$ meansinitial direct-relation matrix based on expert's opinions.

Step 6: Decomposition: According to the linearity of matrix algebra, we decompose $\widetilde{\mathrm{X}}_2 = \left[\tilde{\mathrm{x}}_{2\mathrm{ij}}\right] = \left[\left(\tilde{\mathrm{l}}_{2\mathrm{ij}}, \tilde{\mathrm{m}}_{2\mathrm{ij}}, \tilde{\mathrm{u}}_{2\mathrm{ij}}\right)\right]$ into the following three matrices:

$$\tilde{L}_2 = \left[\tilde{l}_{2ij}\right],\ \widetilde{M}_2 = \left[\tilde{m}_{2ij}\right],\ \widetilde{U}_2 = \left[\tilde{u}_{2ij}\right]$$

Step 7: Normalization: Calculate $\gamma_1$andγ_2 through the following formulas:

$$\gamma_1 = Min\left(\frac{1}{Max\left(\sum_{i=1}^{\square} \tilde{x}_{1ij}\right)}, \frac{1}{Max\left(\sum_{j=1}^{\square} \tilde{x}_{1ij}\right)}\right), \qquad \gamma_2 = Min\left(\frac{1}{Max\left(\sum_{i=1}^{\square} \tilde{u}_{2ij}\right)}, \frac{1}{Max\left(\sum_{j=1}^{\square} \tilde{u}_{2ij}\right)}\right)$$

Then, we have the normalized matrices by multiplying γ_k and the initial-relation matrices:

$$\tilde{X}_k^{norm} = \gamma_k \tilde{X}_k = \left[\tilde{x}_{kij}^{norm}\right]$$

For k = 2, the following matrices can also be computed:

$$\tilde{L}_2^{norm} = \gamma_2 \tilde{L}_2 = \left[\tilde{l}_{2ij}^{norm}\right], \widetilde{M}_2^{norm} = \gamma_2 \widetilde{M}_2 = \left[\tilde{m}_{2ij}^{norm}\right],$$
$$\widetilde{U}_2^{norm} = \gamma_2 \widetilde{U}_2 = \left[\tilde{u}_{2ij}^{norm}\right]$$

Step 8: Compute thetotal-relation matrices:

$$X_k^T = \tilde{X}_k^{norm}\left(I - \tilde{X}_k^{norm}\right)^{-1} = \left[x_{kij}\right],$$

For k = 2, the decomposed total-relation matrices are:

$$\tilde{L}_2^T = \tilde{L}_2^{norm}\left(I - \tilde{L}_2^{norm}\right)^{-1} = \left[\tilde{l}_{2ij}^T\right],$$
$$\widetilde{M}_2^T = \widetilde{M}_2^{norm}\left(I - \widetilde{M}_2^{norm}\right)^{-1} = \left[\tilde{m}_{2ij}^T\right],$$
$$\widetilde{U}_2^T = \widetilde{U}_2^{norm}\left(I - \widetilde{U}_2^{norm}\right)^{-1} = \left[\tilde{u}_{2ij}^T\right],$$

where, I is a$h\times$ $h$identity matrix.
For k=*1*, go to Step 10

Step 9: Defuzzification: We use the principle of finding the center of gravity of a triangular shape to find out the center value of fuzzy set to represent the entire fuzzy set. The defuzzification operation method is as shown in the followings:

Defuzzification point:

$$X_{2ij} = \frac{1}{3}\left[\left(\tilde{l}_{2ij}^T - \tilde{u}_{2ij}^T\right) + \left(\tilde{m}_{2ij}^T - \tilde{u}_{2ij}^T\right)\right] + \tilde{u}_{2ij}^T$$

Step 10: Plot and combine the causal diagrams.

Step 10.1: Compute $D_{ki,}R_{kj,}D_{ki} + R_{kj}, D_{ki} - R_{kj}$

$$D_{ki} = \sum_{j=1}^{h} x_{kij} \quad , \quad R_{kj} = \sum_{i=1}^{h} x_{kij}$$

Step 10.2: Plot and combine the causal diagrams

Step 11: Perform distance based similarity measure: The recognition difference between expert and user on the utilizing satisfaction factor of VNS can be obtained from the following equation:

$$d = \sqrt{((D_{1i} + R_{1j}) + (D_{2i} + R_{2j}))^2 + ((D_{1i} - R_{1j}) - (D_{2i} - R_{2j}))^2}$$

Step 12: Do the analysis according to cause and effect chart and recognition difference data.

INVESTINGATING THE VND UTILIZING SATISFATION FACTORS IN TAIWAN

Currently, the areas of services provided by Traffic Message Channel (TMC) for real time road condition in Taiwan is mostly on western Taiwan, which covers an area about more than 75% the total area of the entire island. Within this scope, the Vehicle Navigation System provided by the supplier has included TMC into dynamic vehicle flow planning function and the main objective is to meet the user's need to avoid the crowdedness and to shorten the travel time; such act is helpful to the enhancement of the user's effectiveness. However, due to continuous innovation, breakthrough and development in technology, traffic network gets continuously improved and more complicated. The supplier, in addition to considering the cost and to applying the strategy and technology in the

Table 2: VND user satisfaction factor (after sorting)

Factors	Descriptions	Factor loading
Reliability (F1)	The level of product failure rate.	0.967
User interface (F2)	The level of difficulty of interface operation.	0.832
Route planning function (F3)	Dynamic route planning function, that is, whether shortest route, fewest time, super highway, fewest curves, fewest road signs, etc. are considered.	0.786
Brand image (F4)	The recognition image from the driver on the VND brand.	0.860
Expandability (F5)	The capability to expand the functions of digital TV, music player and driving recorder, etc.	0.862
System stability (F6)	Positioning after machine start and the stability during the utilization process.	0.786
Service quality (F7)	After-sale service quality, which includes graphs and information updating, warranty and maintenance and repair efficiency and speed, etc.	0.690

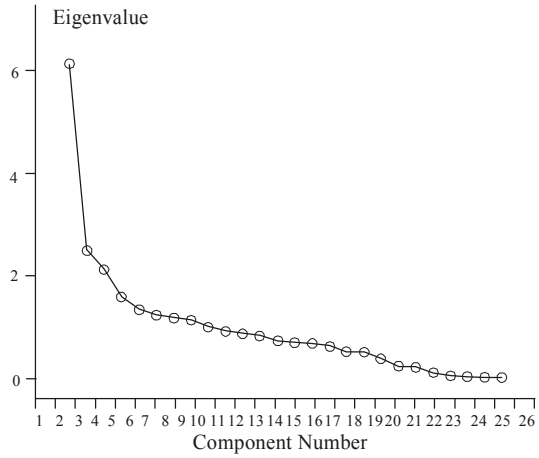

Fig. 1: Scree plot

development of new product, has to consider the user's preference on the product and service quality too, only by doing so, the product can be favored by most of the users, the market share can be increased and the competitive advantage can then be created.

This research, based on three assessment items such as efficiency, effectiveness and satisfaction as specified by International Standard Organization (ISO) in ISO9241, designs the user's survey questionnaire content. The implementation period was from July 01 2010 to December 31 2010, during the period of time, the rest stations in the super highway were selected randomly as the sites for issuing the survey questionnaires and the drivers with experiences using Vehicle Navigation System were used as the research targets. The implementation targets of expert's questionnaire survey were selected from the current famous VND suppliers in Taiwan, for example, GARMIN, MIO, GlobalSat, PAPAGO and ASUS, etc. and the marketing managers and product R&D managers were also invited to provide opinions.

Survey questionnaires for users were issued in a total of 649 copies, with effective survey questionnaire of 555 copies, after summarization, the data are analyzed by statistical software SPSS18.0. According to the results of questionnaire reliability analysis, Cronbach's $\alpha = 0.804$, which means that this survey questionnaire has very good reliability level. KMO = 0.754 and Bartlett' test (χ^2= 9611.764, d.f. = 325, significance = 0.000) show that this questionnaire is suitable to be used in factor analysis.

We have adopted Principal Component Analysis to extract factors and Varimax method is used for factor rotation, finally, 9 factors are sorted out. In addition, from Fig. 1, since the elbow point is not clear enough to be identified, yet the location of eigenvalue larger than 1 is a about 9th factor, we can then know that the first 9 factors have larger contribution for explaining the original variables, hence, we can select 9 factors for analysis. This also proves the appropriateness using principal component analysis in extracting 9 components.

Furthermore, in the above 9 factors, we have used whether Factor Loading is larger than or equal to 0.6 as threshold (Hair, 1998) to sort out the following 7 factors, which is shown in Table 2.

Through the correlation coefficients of factors, we have obtained pair-wise comparisons between factors, hence, we have also constructed initial matrix. Through DEMATEL operation procedure, we can obtain the Table 3 and 4.

In the supplier's opinion aspect, a total of 11 experts have participated in and have provided pair-wise comparisons between factors. In multiple assessment data, we then take the median to set up initial-relation influence matrix. Then we follow the above mentioned operation procedures step 3 to 9 to obtain the following data.

Table 3: The initial-relation influence matrix-perspectives of VND users

Factors	F1	F2	F3	F4	F5	F6	F7
F1	0	2	0.5625	3.8125	1.25	4.6875	3.75
F2	0.375	0	3.125	3.3125	0.875	3	2.9375
F3	0.375	2.375	0	3.6875	0.6875	3.375	1.5625
F4	2.75	2.9375	3.25	0	2.3125	3.8125	4.6875
F4	0.1875	2.0625	0.5	2.75	0	1.3125	1.5
F6	3.625	2.375	4.0625	3.75	1.8125	0	1.8125
F7	3.4375	3.125	3.625	4.625	1.875	3.75	0

Table 4: The total influence matrix-perspectives of VND users

Factors	F1	F2	F3	F4	F5	F6	F7	D+R	D-R
F1	0.254079	0.381236	0.359649	0.564255	0.245094	0.569423	0.475409	4.855898	0.842391
F2	0.222901	0.248807	0.403975	0.476288	0.194764	0.440898	0.385611	4.894954	-0.14847
F3	0.203647	0.321001	0.251588	0.453561	0.172869	0.422217	0.310558	4.85435	-0.58347
F4	0.387744	0.458325	0.501079	0.476101	0.307425	0.591323	0.548624	6.794365	-0.25312
F4	0.136493	0.241598	0.197046	0.324222	0.098921	0.254816	0.235189	3.067103	-0.09053
F6	0.381373	0.395234	0.480275	0.562963	0.261578	0.392235	0.405527	6.156331	-0.39796
F7	0.420516	0.475511	0.525297	0.666356	0.298167	0.606234	0.385829	6.124656	0.631163

Table 5: The initial-relation influence matrix – perspectives of VND experts

Factors	F1	F2	F3	F4	F5	F6	F7
F1	—	L	VH	VH	NO	VH	H
F2	VL	—	L	VH	NO	L	VL
F3	NO	VL	—	VH	H	NO	VL
F4	L	VL	L	—	NO	H	H
F4	NO	NO	L	VH	—	L	L
F6	VH	H	VH	VL	NO	—	VH
F7	VH	L	L	VH	L	VH	—

Table 6: The total influence matrix – perspectives of VND experts

Factors	F1	F2	F3	F4	F5	F6	F7	D+R	D-R
F1	0.46434	0.47037	0.74287	0.82123	0.28016	0.71639	0.66664	7.25012	1.073921
F2	0.32520	0.25354	0.44390	0.57658	0.18488	0.42942	0.37616	5.16535	0.014075
F3	0.25317	0.24628	0.31156	0.54495	0.31149	0.31485	0.33901	6.22063	-1.577951
F4	0.45746	0.34732	0.53105	0.49545	0.22508	0.56497	0.55465	7.74679	-1.394750
F4	0.31372	0.26184	0.45759	0.59859	0.19367	0.44904	0.44549	4.54900	0.890933
F6	0.61210	0.50661	0.72008	0.67905	0.27290	0.52353	0.66892	7.73745	0.228982
F7	0.66208	0.48965	0.69222	0.85488	0.36083	0.75600	0.56609	7.99879	0.764788

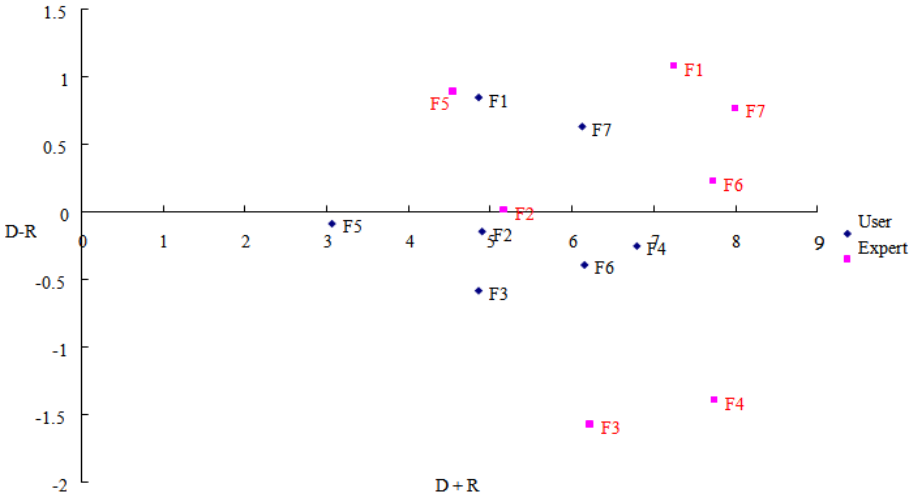

Fig. 2: The integrated causal diagram

Table 5 contains the assessments from experts which represent the direct influence between each factor.

According to Table 4 to 6, we plotted integrated causal diagram displayed in Fig. 2. One could obviously see that the distances between two corresponding factors were not the same. In addition, to explore the explanations to the existence of the gaps, we computed and plotted the distances as Fig. 3.

DISCUSSION AND IMPLICATIONS

When high speed rail between Taipei and Kaohsiung is started, the one day life circle of Taipei resident has been extended for several hundreds of kilometers. And this is an example of the expanding of people's scope of life due to the progress in transportation technology. However, although advanced transport carrier make fast movement possible, yet if you want to reach the destination quickly, it has to rely on accurate route planning and navigation function. Asurvey on Taiwan's car drivers regarding the issue of "When you get lost in new place, what kind of method would you choose to get to the destination?", according to more than 5000 returned effective samples, it was found that the first choice after person under test got lost was to "check GPS satellite navigation" and the proportion is about 36.69% of the total effective

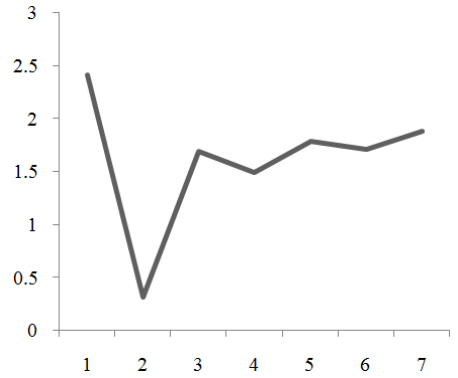

Fig. 3: Distances between the corresponding factors

sample, hence, it can be seen that in Taiwan, there is about 40% of drivers wanted to purchase VND to be used as assisted tool during the driving time. From another view point, why there is as high as 55% of drivers wanted to give up using VND at the time when they needed the route planning most? According to an observation made by our research team in recent years on VND market, it was found that driver's low utilizing satisfaction on VND has led to low purchase and utilization motive, hence, how to enhance the utilizing satisfaction of VND should be the top issue for the related suppliers in developing new generation of product.

This study first performed cluster analysis and factor analysis on the questionnaire survey result and seven factors that have more influence on user satisfaction are sorted out, by doing so, the problems can be simplified and the suppliers can have more time to focus on important issues. Moreover, factor analysis results were adopted as basis for subsequent analysis, by doing so, it not only gets closer to the real need, but also improves too-subjective drawbacks in the criteria preparation of general research. Next, for the view points of users and experts, we have treated them respectively with DEMATEL and fuzzy DEMATEL. As different than the past treatment of treating defuzzification point as the input of DEMATEL, or the past research of defuzzification treatment on DEMATEL result, we have referred to Lin and Wu (2008) to use matrix algebraic linearity and to put the triangular fuzzy number into the operation of DEMATEL. The main reason is that the error caused by fuzzy factor in the human decision making process will affect the entire operation process instead of just affecting initial relation or full influence. Furthermore, integrated causal diagram can clearly display the difference between users and experts and the causes for the generation of such difference and the methods to shorten the difference are the keys to be studied in this research. To sum up, this research is mainly based on VND utilizing satisfaction data and market characteristic to integrate and set up a set of complete and stringent analysis structure, not only the original complicated thing is simplified and the function of key factor can be more easily identified, but also the generation of reference data for decision making becomes more reasonable, eventually, the decision making quality is enhanced. And this is also one of the major contributions of this research.

Referring to Fig. 2, we can find that it is helpful to VND development by the suppliers. For the opinions of users and experts, F1 (reliability) and F7 (service) are usually the most influential factors among the 7 factors. This means that no matter the supplier or the user, the major concern is usually the practical application. In other words, the normal operation of the system is the first priority and its other functions are the second things. And these two are the factors that affect F4 most (brand image). The meaning of the finding to the supplier is, the actions such as the investment in the reduction of the product failure rate, the providing of more accurate and more convenient map data updating service, the setup and integration of video player and security burglar proof system platform and the further advancement into VTS are all helpful to the enhancement of the brand image; such business operation strategy towards the right end of smile curve is indeed the key for an enterprise to keep continuous innovation and to keep competitive advantages. In another aspect, the major function of navigation is F3 (route planning function) and both the supplier and the user all think that this factor is the most influential factor; the major reason is that because route planning is the basic function of VND, the product of the suppliers is usually planned based on the shortest route or the shortest travel time and there is not too much difference among them; hence, as long as the system does not fail, VND will then generate the route planning to achieve the destination. However, due to the gradual increase in adaptive and individual commuting need, the importance of route planning function will for sure to increase greatly and the supplier's view point on this factor will be changed accordingly.

In the different view point part between the supplier and the user, please refer to Fig. 2 again, what need to be noticed is that for F6 (stability), although the users think that stable system is the key for a purchase, yet as long as there is not too much problem in the software, this goal can be achieved; however, if we take a look from R&D, manufacturing and marketing view point, the supplier's efforts in the enhancement of system manufacturing technology so as to provide product of high quality, stability and endurance is just enough to explain the recognition and standing point difference to the user. Refer to Fig. 3, it can be seen that the one with smallest difference is F2 (user interface), which means that the user and the supplier has more consensus on this factor. The one with the largest difference is F1 and this part is the result of different user and manufacturing view point. In other words, the

user thinks that during care driving process, the system should not fail, but the supplier further hopes to use high quality product to seize the eye of the user. This also shows that during the purchase process, the user does not care about other second brand, what the user care is, during the driving process while the road condition, temperature and humidity has such high fluctuation, the product that can more accurately transmit data and perform operation is more important. Therefore, when the supplier is preparing marketing plan, it seems very important for the supplier to emphasize on the reliability aspect of its product. In addition to increasing the cognitive proximity of the user in this part and increasing the subsequent purchase probability, the effect of differentiation business operation strategy can also be achieved.

CONCLUSION

The trend for people to use assisted system during the car driving process to help them to reach the destination quickly and safety cannot be violated and VND, among all kinds of assisted systems, is the first priority choice and is the device in the market with the largest demand. The main objective of this research is to investigate the user satisfaction factor of VND so as to analyze further the recognition difference on each factor between the user and the supplier, in the mean time, practical meaning is also given. As different than the past researches, this study had proposed a set of innovative, stringent and effective data processing and analysis structure so that the output data will have better reference value to the R&D decision making in the supplier's side.

In this study, an empirical study aiming at the utilizing satisfaction of VND made on Taiwan's drivers was successfully presented. The findings clearly disclose the key of R&D decision making and the business operation direction of the supplier. The major findings include that the supplier's investment in the enhancement of system reliability and continuous improvement of service quality will have major contribution to the enhancement of brand image. In addition, since the user has very vague concept on the system reliability, which leads to the result that product of low failure rate does not catch too much purchase attention from the user. Therefore, under the guidance of differentiation strategy, the supplier should emphasize that its product can still function pretty good under multivariate environment, meanwhile, the low failure rate and the product's capability to meet customer's need should also be emphasized.

Finally, this research team is also going to investigate continuously the driving preference of drivers in countries or areas other than Taiwan, for example, Europe and USA, Japan and Mainland China, etc.; It is hoped that the result can be used as reference for the development of new product as well as the sale of the product to that area. In addition, in the analysis method, how to set up innovative model so as to handle many uncertain factors, for example, technological breakthrough, regulation change, or the increase or decrease of income, etc., is also a future development trend.

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