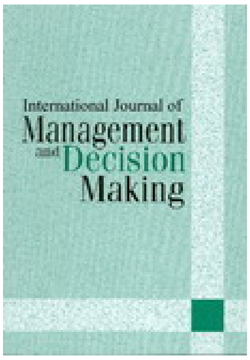

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Applying SWARA approach and refined Kano model to classify and rank customer requirements, case study: automotive industry in Portugal

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Abstract: Companies aim to increase the quality of products and competitiveness to gain and retain customers. This study proposes a new approach for identifying and prioritising customer requirements (CRs) to improve black uniformity as a luminance characteristic on the surface of a display by evaluating the CRs. The refined Kano and stepwise weight assessment ratio analysis (SWARA) was applied to rank the 112 CRs identified into main categories: 1) technical; 2) quality; 3) delivery; 4) sustainability; 5) cost to develop the product. To validate the approach, an example is performed on automotive display' CRs. The findings showed that mechanical and delivery CRs are critical. Today, climate change is a significant challenge and a severe customer concern. Although sustainability of CRs is not classed as essential items in the production process, suppliers must be diligent in providing them. The results help to improve the automotive industry and other production systems.

Keywords: customer requirements; refined Kano model; stepwise weight assessment ratio analysis; SWARA; automotive industry; Portugal.

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1 Introduction

Nowadays, it is significant for companies to retain current customers, share in profitability and improve profit margins. Companies need to meet customers' requirements and even go beyond that (Witell et al., 2013). Customer satisfaction can be considered one of the aspects that play an important role in the success or failure of a business (Erdem and Gundogdu, 2018). Therefore, companies strive to meet customer expectations and beyond these expectations to gain their loyalty. A dissatisfied customer is a challenging problem that can negatively affect the business. Dissatisfying customers can lead to escape the customer and result in business failure. Retaining current customers and keeping them satisfied is more important than gaining new customers (Al Rabaiei et al., 2021). Therefore, the real goal of any business is not to offer, sell or provide services, but to meet the needs that meet customer satisfaction. Organisations that can recognise the customer requirements (CRs) rapidly and have up-to-date mechanisms to understand and meet them are more profitable than organisations that are lagging in meeting them (Amin et al., 2017).

Understanding the mental image and perception of customers towards the goods and services provided has particular significance and while revealing the strengths and weaknesses of an organisation, provides an infrastructure for adopting sufficient strategies and improving the performance. Therefore, customer satisfaction has become the operational goal of many organisations. Not surprisingly, companies invest significant resources in increasing customer satisfaction, and the customer satisfaction assigned budget is almost the majority part of the annual marketing budget. In addition, Business marketing costs about 50% of total annual costs (Sun and Kim, 2013). Identifying and measuring customer satisfaction is not enough. Meanwhile, the processes that have caused dissatisfaction, must identify, and modify. Therefore, the implementation of a system that can measure customer satisfaction seems vital (Akmal et al., 2020).

The Kano model helps determine the characteristics that should be included in a product or service to improve customer satisfaction. This model focuses on highlighting the most relevant features of a product or service along with customers' estimation of how to use the existence of these features to predict satisfaction with specific services or products (Al Rabaiei et al., 2021). This approach helps managers better understand customer needs (Avikal et al., 2020). Kano's models provide an accurate classification of customer needs such as attractive, performance, basic, indifferent, or reverse (Chen, 2012).

By focusing on customer need analysis, Xu et al. (2009) incorporated quantitative measures into customer satisfaction and proposed an analytical Kano model. Accordingly, they proposed two alternative mechanisms to provide decision support to product design. Lin et al. (2010) proposed a moderated regression approach that corrects the flaws of the dummy regression method and produces more accurate attribute classification. They validated their proposed method using data collected from an online tax declaration service. Chen et al. (2010) proposed a so-called creativity-based Kano model (C-Kano model) by integrating the creativity techniques, TRIZ and SCAMPER, into the traditional Kano model. Their proposed C-Kano model not only can discover CRs, but also creates attractive quality elements. They assessed the performance of their proposed method via massively multiplayer online role-playing game (MMORPG) and compared it with the traditional Kano model. Sharif Ullah and Tamaki (2011) proposed a method for analysing customers' preferences obtained by using the Kano model. To address the uncertain (unknown or missing) customer answers, they presented an approach to simulate the unknown customer answers.

Yeboah et al. (2014) combined the two models of Kano and service quality (SERVQUAL). They aimed to increase customer satisfaction and make competition between hospitals. They presented that paying attention to must-be needs alone is not enough to improve customer satisfaction, and management should consider other criteria such as globalisation and developing the service quality standards. Južnik Rotar and Kozar (2017) applied the Kano model to improve customer satisfaction in the home appliance industry. They introduced significant factors in customer satisfaction, including sales environment, price, user attributes, design features, and technical characteristics. According to Kano's model, marketers should focus on attractive features such as broad vendor knowledge, vendors' professional skills, home appliance design, and home appliance brand. Chan and Chang (2018) proposed an analytical vehicle KANO model, called V-KANO Model, to improve vehicle technical characteristics and performance target setting more precisely at the early stage during design and development process.

Akmal et al. (2020) proposed the Kano model to determine the technical requirements of an oven to increase customer satisfaction. For this purpose, the Kano questionnaire was delivered to 384 respondents to identify CRs and customer satisfaction. The questionnaire was designed based on the functions, mechanisms, and characteristics of the oven. Kano model was applied to determine the quality characteristics related to customer satisfaction. Al Rabaiei et al. (2021) integrated the Kano model with data mining to predict customer satisfaction. The study aimed to develop a method for integrating the Kano model and data mining approaches to select related features that increase customer satisfaction. In their research, they used XGBoost regression and decision tree regression approaches. Montenegro et al. (2021) integrated the Kano model into the business model canvas in the aviation and metalworking industry in Bogota, Colombia. Shen et al. (2021) also adapted the Kano model to assess perceived importance and customer satisfaction in sailing tourism experiences. Then, based on the Kano model, features were classified into must-be one-dimensional, attractive, and indifferent groups. Bhardwaj et al. (2021) studied the Kano model analysis to increase customer satisfaction with automotive products for the Indian market. The objective is to examine the features available in the current Indian automotive sector for the targeted hatchback market to classify the attributes into priority groups based on customer perception. Feedback on twenty features of a hatchback car was obtained from customers and analysed by the Kano model. They aimed to gain insight into the customer's feelings or obligations about any product-related feature and to answer the question of whether there is a specific need or requirement for particular features, all of which ultimately play a decisive role in customer behaviour.

Please refer to review paper presented by Mikulić, and Prebežac (2011) for more information regarding the Kano model. Lo (2021) considered the air-cushioned casual shoe production example and proposed a refined Kano model to evaluate the product attributes that improves the customers' satisfaction. He aimed to present a new method by introducing the model of sustainable product development to facilitate the sustainable development of the industry and proposed the modified Kano model to examine the characteristics of products that improve customer satisfaction. Yin et al. (2022) proposed the Kano model to analyse the influence of gamification's elements on user satisfaction in health and fitness applications. They categorised general electric into various qualitative classifications using questionnaires based on the Kano model. Normando et al. (2022) investigated the effect of matching owners' preferences on satisfaction in different types of adopted dogs using the Kano model alongside more traditional methods on 392 dogs. Chen et al. (2022) applied a modified Kano model and decision trees to explore learners' needs for instructional videos, multimedia tools, and applications.

According to the evaluation of the internet of things (IoT) adoption barriers in the circular economy, Cui et al. (2021) identified barriers to adapting to the IoT by weighing the degree of the barriers. They introduced a novel framework considering the stepwise weight assessment ratio analysis (SWARA) and combined compromise solution (CoCoSo) methods based on Pythagorean fuzzy sets (PFSs) performed to rank the various organisations under the barriers which SWARA applied to estimate the weight of the barriers.

As a result, the present paper aims to categorise and prioritise the CRs to increase customer satisfaction in the product from the automotive industry to improve Black Uniformity (BU) as a feature that refers to luminance differences on the surface of a display by identifying and ranking the most significant criteria in producing this item in different aspects including five main categories:

1 technical

2 quality

3 delivery

4 sustainability

5 cost.

Additionally, the motive behind the study is to provide case studies regarding the vastly different aspects of the production system. Especially sustainable requirements are one of the concerns of customers nowadays. Also, appropriate opportunities for conducting more studies into such an innovative production area. Consequently, the Kano model and SWARA were taken into consideration as two different tools, one as multi-criteria decision-making (MCDM) and the other one quality management tool. These tools are capable to address the BU challenge as the main cause of customer dissatisfaction [namely original equipment manufacturer (OEM) or automotive manufacturer, or final customers] from display supplier.

In this paper, the refined Kano model is applied to classify the designed mirror camera system (DMCS) single display characteristics based on the customer's point of view. This model can comprehensively analyse the CRs and obtain the specific model of the needs to design the product according to the CRs.

The rest of this paper is organised as follows: in Section 2, the Kano model has been discussed. Then, in another subsection SWARA method is addressed. Afterward, the application of a questionnaire to quantify the CRs obtained and then the refined Kano and SWARA have discussed concerning their practical applications. In the methodology section, the research questions, more details about the case study, and the main cause of customer dissatisfaction as BU low rate have presented. Finding remarks are presented in Section 4; including data gathering results and results from two applied approaches. Finally, conclusions and directions for future research are given in Section 5.

2 Literature review

2.1 Kano model

Kano emerged in the 1980s; Kano (1984) introduced a model called the Kano customer satisfaction model, which can distinguish three types of requirements of a product that affect customer satisfaction in different manners. These three types of needs are:

1 *Must-be needs (M)*: these needs are typically 'unspoken'. If these needs are not fulfilled, the customer will be extremely dissatisfied. However, they must be identified because they are important to customers. This attribute is the existential philosophy of service/goods. For instance, the wheels are a primary requirement for a car. Customers do not mention wheels as a necessity, as this feature belongs to the machine's existential concept.

2 *Performance or one-dimensional (O) needs*: the more of these requirements that are met, the more a client is satisfied by improving performance. Better performance leads to a happier customer. These needs are usually articulated by the customer. For instance, the consumption of gasoline at a certain distance in the car is a performance need. One-dimensional features are often identified by scrolling.

3 *Attractive needs (A)*: these are customers' wishes, so they are not stated. The absence of this feature does not cause dissatisfaction because they are not aware of these needs. If these needs are met product/service will delight the customer. Satisfying attractive needs provides a competitive advantage for the organisation as an opportunity to differentiate itself from competitors. For instance, customers will not be dissatisfied if the cars do not use solar energy. Satisfying these needs makes the organisation a market leader.

Kano proposes an effective tool for classifying the requirements and understanding their nature (Matzler and Hinterhuber, 1998). Kano model explains how customer satisfaction changes as its needs are met by the organisation. This model is shown in Figure 1.

In addition to these three main quality dimensions of the Kano model, the consequences of 'indifferent', 'reverse' and 'questionable or skeptical' can also appear which is depicted as an evaluation of the Kano model in Table 1 (Berger et al., 1993; Kano, 1984):

1 *Indifferent (I)*: it means the customer is not worried about this feature of the product and is not very interested in its existence or non-existence.

2 *Questionable or skeptical (Q)*: this situation occurs when there is a discrepancy in the customer's answers to the positive and negative questions. The skeptical rating indicates an incorrect question phrase, misunderstanding of a question, or incorrect answer.

3 *Reverse (R)*: this means that the satisfaction of the respondents decreases despite this requirement, but they also expect the opposite.

To expand the basic Kano model, Yang (2005) proposed a refined Kano model and extended the four main quality features to eight (Figure 2): highly attractive quality, low attractive quality, high value-added quality, low value-added quality, critical quality, necessary quality, potential quality, and care-free quality.

Figure 1 Classification of CRs in Kano model

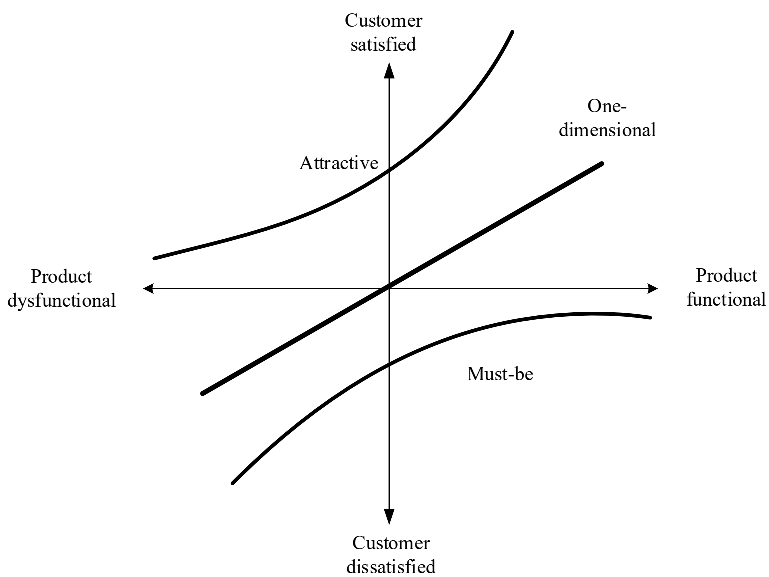
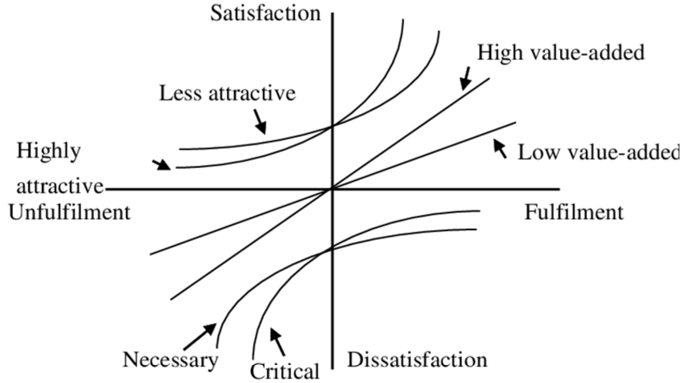


Table 1 The evaluation of the Kano model quality attributes

Customer preference		*Dysfunctional form of the questions (negative questions)*				
		Like	*Must-be*	*Neutral*	*Live with*	*Dislike*
Functional form of the questions (positive questions)	Like	Q	A	A	A	O
	Must-be	R	I	I	I	M
	Neutral	R	I	I	I	M
	Live with	R	I	I	I	M
	Dislike	R	R	R	R	Q

Figure 2 Refined Kano model



Therefore, a refined Kano model is applied to classify customer needs. The refined Kano model refers to the mean importance as the cut-off point for classification. If a feature in the basic Kano is considered an attractive quality in case if importance value is higher than the mean value of all attractive quality features, it will classify by the refined Kano as a highly attractive quality; otherwise, is considered a low attractive quality feature. Table 2 is shown the different classifications of the features in the basic and refined Kano model.

Table 2 The classification of the Kano model attributes and refined Kano model attributes

Kano model	*Refined Kano model*	
Quality attribute	*High important attributes*	*Low important attributes*
Attractive quality	High attractive quality	Low attractive quality
One-dimensional quality	High value-added quality	Low value-added quality
Must-be quality	Critical quality	Necessary quality
Indifferent quality	Potential quality	Care-free quality

Source: Chen et al. (2018)

2.2 SWARA method

Keršuliene et al. (2010) introduced SWARA method which is a multi-attribute decision-making (MADM) that aims to calculate the weight of criteria and sub-criteria. The performance of this method is similar to the best-worst method (BWM), Shannon's entropy, and the linear programming technique for multidimensional analysis of preference (LINMAP), which weigh the criteria. SWARA express the analysis of the gradual weighting ratio. In this method, the criteria are ranked based on value and the most important criterion is given the first rank and the least important criterion is given the last rank. The steps of this method are as follows (Alinezhad and Khalili, 2019):

Step 1 The first step of SWARA is to identify the criteria and sub-criteria and, the dependent criteria should be eliminated (all should be independent).

Step 2 This step provides the final criteria to the experts to rank in order of importance, and then those rankings are merged.

Step 3 To determine the relative importance weight (s_j), each criterion should be compared with its higher-hierarchy (s_j is the importance of criterion j than criterion $j - 1$, which is obtained from the values of the previous step). The value of the coefficient k_j calculating as follows:

$$k_j = \begin{cases} 1 & j = 1 \\ s_j + 1 & j > 1 \end{cases} \quad (1)$$

Step 4 Calculating the weight of criteria using the s_j:

$$q_j = \begin{cases} 1 & j = 1 \\ \dfrac{q_{j-1}}{k_j} & j > 1 \end{cases} \quad (2)$$

Step 5 Calculating the final weight of criteria (w_j):

$$w_j = \frac{q_j}{\sum q_j} \quad (3)$$

3 Methodology

This study aimed to determine the momentous CRs for DMCS display. In addition, we intend to distinguish between the identified CRs according to the customer satisfaction correspondingly. In this regard, refined Kano and SWARA methods are to be applied. The objective is to categorise the needs of customers using the refined Kano model and rank them using a MCDM method. The SWARA approach is adapted to calculate the weight of requirements.

The research questions are as follows:

- What are the CRs and needs of the DMCS display?
- Each of the requirements should be placed in which category of must-be, one-dimensional, attractive, or indifferent?
- What is the weight of each requirement?

The contribution of the work using SWARA among the other MCDM tools which is simpler tool in terms of computational calculations. Although methods like AHP are applied widely to estimate the weight of the criteria whereas new methods including SWARA, best worst method (BWM) (Rezaei, 2015) are remarkable examples of new methods. Considering the large number of criteria that are studied in this research is complicated to use the other MCDM methods because the SWARA is different from other methods which use pairwise comparisons. For this purpose, considering the high volume of criteria in the case study, it is necessary to use a tool with fewer calculations, more practical, and less complex.

3.1 Case study

The DMCS display is a raw display of the final product which is outsourced for a heavy vehicle manufactured by an OEM company in Portugal. The production phases show how to satisfy CRs in each step and which gaps might be covered by the supplier during the processes. This product goes through various steps in the production process, which include the following:

Step 1 The display components are received from the supplier; the main part is the DMCS single display which is the focus of this study.

Step 2 The bonding process is performed on a single display to bind a single display, and another part called cover glass.

Step 3 In the gluing step, the main frame is glued with special glues. Also, the plasma process and several tests are done to check if the materials are applied properly and aligned with the patterns. All these sequences are briefly mentioned as the gluing step.

Step 4 The screwing process is performed on the electronic chip called a printed circuit board (PCB) attached to the product by different types of screws.

Step 5 The supplier supplies the rear cover behind the display and assembles the whole product in the last step.

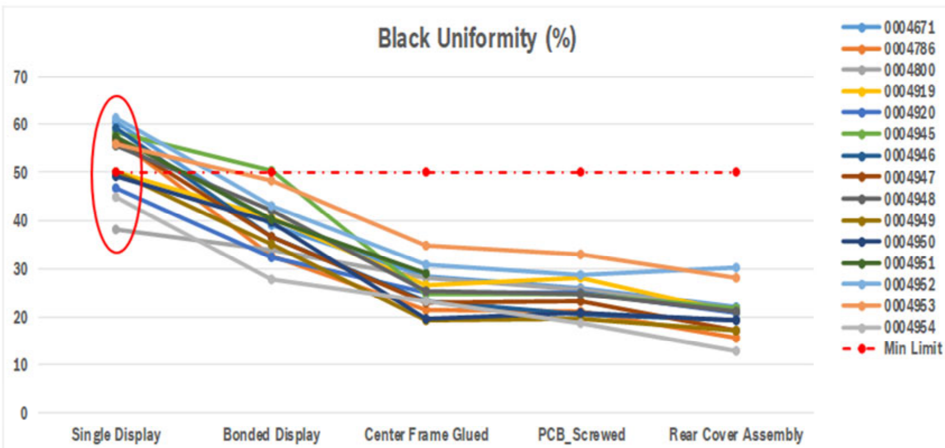
The BU feature represents the ability of a display to have a solid black appearance across the entire screen. This characteristic refers to luminance differences on the surface of a display. A display with perfect BU does not produce white spots or clouding areas that represent defects on the screen and that in extreme cases can affect the transmission of information from the display to the user (Rotscholl and Krüger, 2021).

BU is one of the image features that are significant for the customer of the desired product and many defects has been caused by rejection due to not considering the desired BU rate. It is worth mentioning that the acceptable BU index for product acceptance by the customer is 50%. According to Figure 3, the rate of BU index shows a significant deviation in the BU which is due to the large gap observed in the display DMCS from the supplier in the tests performed in the display delivered to the OEM Company. This reduction in the rate led to customer dissatisfaction. Also, the rate of BU has decreased in the subsequent steps, including bonding; gluing, screwing, and rear cover assembly. The product line has been activated continuously for the last two years; thereupon, some problems have been solved simultaneously by experts in the internal processes of the OEM, and some defects have improved. Therefore, the focus of study is on the needs of OEM, automakers' requirements, and final customers' latent needs from the display DMCS delivered from the supplier. Since the scope was limited to semi-product delivered by the supplier, several tests and inspections were performed to validate the processes in each step, which are not mentioned in detail. The needs of the steps after display DMCS delivery, such as the bonding process (the first step of manufacturing the final product) addressed by experts as principal requirements to perform the operations and meet the technical needs.

To obtain the CRs, the main categories of these needs have been extracted from the literature review. To explore the sub-categories, specifications list, and manufacturing requirement documents investigated and considering the production launch for some time, experts face many defects and deviations from the customer expectations. Many tickets opened for claims, and comments have been sent to suppliers by various experts to improve product specifications. The customer's voice is adapted to study the feedback and reactions of suppliers to translate them to the engineering characteristics of the product.

Due to the implementation of Kano model, all CRs from DMCS display, including critical and basic requirements as well as indifferent and delighted ones from the supplier and the customer, must be considered for classification.

Figure 3 The rate of BU index in different stages of DMCS production (see online version for colours)



3.2 A statistical sample

Table 3 shows the expert's distribution in the survey:

Table 3 The expert's distribution in different CR categories

Area	*Max (Person)*	*Min (Person)*	*Number of samples*
Technical	17	13	9
Quality	13	9	9
Cost	13	11	9
Delivery	13	9	9
Sustainability	20	15	9

The experts participating in this study were technical (simultaneous engineers, process specialists, mechanical developers, hardware engineers, product line responsible, manufacturing production responsible, optics and mechanics), quality (quality managers, testing specialists, production test engineer, supplier quality engineer, PFMEA moderator, display developer, supplier quality engineer, purchasing quality assurance, customer claim analysis), cost (project managers, program manager, process managers, project manager purchasing) delivery (logistic engineers), sustainability (various proficient above, sustainability experts).

Among the experts, nine people with the most work experience were willing to cooperate and answer the questionnaire is chosen considering the max and min availability in each category. The survey was carried out in two weeks, and in total 45 questionnaires was collected.

Table 4 The structure of CRs and number of questions of the survey

Row		*Category*	*Number of CRs (Number of questions)*
1	Technical	Mechanical	23
		Electrical	8
		Optical	6
2	Quality	Definition of standard conditions	7
		Measurements conditions	7
		Customer rejection rate	2
3	Cost		12
4	Sustainability	Globalisation	3
		Pollution production	5
		Urbanisation and eco-design energy	7
		Health and safety	3
		Water	2
5	Delivery		27
6	Total		112

3.3 Questionnaire survey with refined Kano quality model

In this paper, 112 CRs were identified, which are classified into technical, quality, cost, sustainability, and delivery. After identifying the CRs, the Kano questionnaire consisting of five sections that correspond to the mentioned dimensions was designed. These sections covered the sentences that were used to categorise the requirements according to Kano's model. Table 4 shows the distribution of CRs in each category. Consequently, requirements are asked in both negative and positive spectrums. Firstly, the positive question asks the feelings of a person if there is a particular quality attribute. Secondly, the negative question asks about a person's feelings in the absence of that quality attribute. As a result, each section of the questionnaire consists of sentences that describe the requirements positively and negatively, which show the functional and non-functional forms of the requirements in general. The scale used was a five-dimension scale that included 1 = Like it, 2 = Expect it, 3 = Indifferent, 4 = Tolerate it, and 5 = Unhappy proposed by Berger et al. (1993).

3.4 Data analysing

The Frequency analysis is prepared as a table used to calculate the number of responses to the Kano questions. Due to the highest frequency of requirements, each CR determined which belongs to the corresponding attribute of the Kano. Afterward, by the SWARA, the main categories of CRs are ranked. Consequently, their relative importance is obtained.

4 Findings

To conduct this study, first, using expert opinion and interviews with statistical samples, the CRs determined, and the required data to form the Kano model is collected. The CRs are classified by applying the simple Kano and the refined Kano model and weighted. Afterwards, The CRs weighted using the SWARA approach in each category.

4.1 Data gathering results

Recently, many studies in the organisations presented and extremely valued sustainable characteristics of the products. First, the variety of categories of requirements extracted from the literature review and dimensions of the case study. The manufacturing and development of the product are considered the technical and quality categories, and Delivery necessary parts of the production chain to deliver to the customer.

The cost category is one of the critical categories that impact customer satisfaction, profit of the company, and classification of the requirements.

Afterward, the main categories discussed above were selected from literature and interview with experts of the organisation. The empirical results, lessons learned from the project launch, and products' technical info was surveyed to specify the CRs. Tools for data gathering include observation, expert interviews, literature review, questionnaires, and numerous meetings with experts. The observation is used as the production line screening and better understanding to identify the deviations caused by supplier delivery to the company.

The number of CRs include technical (mechanical, electrical, optical) 45 items, cost 14 items, quality (definition of standard conditions, measurements conditions, customer rejection rate) 21 items, delivery 30 items and sustainability (globalisation, pollution production, urbanisation, and eco-design energy, health, and safety, water) 22 items.

The three experts from the company and two consultants from outside who have cooperation with the organisation participated to obtain the final requirements to form the questionnaire. Some items were irrelevant and eliminated from the list. In this phase, the 112 final CRs have remained. Then a pre-test survey had done by five experts for one week.

4.2 Kano results

At this stage, the CRs are classified using Kano model.

In this study, we applied a refined Kano approach which uses the total satisfaction index based on Kano responses (Timko, 1993). This method calculates better and worse values to understand the level of customer satisfaction and dissatisfaction with the features using the following formulas (Shahin and Shahiverdi, 2015; Go and Kim, 2018).

$$better = \frac{A+O}{A+O+I+M} \tag{4}$$

$$worse = \frac{M+O}{(A+O+I+M)\times(-1)} \tag{5}$$

Table 5 The frequency of CRs and their classifications based on Kano model

Category		*CRs*	*M*	*O*	*A*	*I*	*R*	*Q*	*Kano classification*
Technical	Mechanical	Double side foam which is connect the LCD to backlight frame	2	3	2	2	0	0	O
		Enough DAM space	4	3	2	0	0	0	M
		Rigidity of backlight unit housing	0	2	4	2	1	0	A
		Optical alignment features definition	2	2	3	2	0	0	A
		De-coupling of backlight unit and panel	0	0	8	1	0	0	A
		Sealant double side tape design	2	3	2	2	0	0	O
		Propensity to leakage of foam tape	5	3	1	0	0	0	M
		Dimension of the backlight frame	3	2	2	2	0	0	M
		GAP between rear glass and black housing	0	0	8	1	0	0	A
		Formation air bubbles on LCD panel	5	4	0	0	0	0	M
		Alignment features on back housing of LCD to align centre frame	2	2	3	2	0	0	A
		Height difference between the display frame and bonding surface	4	1	1	3	0	0	M
		Parallelism of display polariser to support elements on the KIT	2	2	0	5	0	0	I
		Gap between backlight frame and LCD	0	2	0	7	0	0	I
		Light leakage due to mechanical lay out on the frame and back light	5	2	0	2	0	0	M
		Thickness of the inner glass	0	1	1	6	0	1	I
		Thickness of the polariser	0	0	3	5	1	0	I
		Type of polariser	4	3	1	1	0	0	M
		Backlight reflection sheet shape	4	3	0	2	0	0	M
		Shield film shape	2	0	0	6	1	0	I
		Flatness of backlight housing	2	3	2	2	0	0	O
		Contamination of the display	4	5	0	0	0	0	O
		Thickness of TFT-/colour filter glass	2	1	1	5	0	0	I
	Electrical	Foil banding material of the side of the display	4	2	1	2	0	0	M
		Foil banding width	0	1	0	7	0	1	I
		Position of the LEDs	4	2	0	3	0	0	M
		Thickness of the driver IC	1	1	1	6	0	0	I
		Softness of FPC material	2	1	4	2	0	0	A

Table 5 The frequency of CRs and their classifications based on Kano model (continued)

Category		*CRs*	*M*	*O*	*A*	*I*	*R*	*Q*	*Kano classification*
Technical	Electrical	Chip on glass (COG)/foil on glass (FOG) bonding-chip bonding with anisotropic conductive film (ACF)	1	0	1	7	0	0	I
		Resistance of the track material	1	2	0	6	0	0	I
		LED power consumption	1	1	2	5	0	0	I
	Optical	Stability regarding the contrast at higher temperatures	2	2	2	3	0	0	I
		Thermal reliability	3	2	0	4	0	0	I
		DARK DOT rate	2	1	2	4	0	0	I
		BU percentage	2	5	1	1	0	0	O
		Type of LED material	2	2	1	4	0	0	I
		Nit of brightness of screen	0	3	2	4	0	0	I
Quality	Definition of standard conditions	Digital PWM rate	3	2	0	4	0	0	I
		Repeatability due to sensitivity of the display	4	2	1	2	0	0	M
		Parameter settings of equipment (e.g., print screen of equipment GUI with settings)	2	1	1	5	0	0	I
		Touch Mura evaluation	2	4	2	1	0	0	O
		Respect to PRE	5	2	1	1	0	0	M
		Stability of the MSA	3	0	1	4	1	0	I
		Register active display area measurement	3	1	1	4	0	0	I
	Measurements conditions	Water absorption rate	1	1	1	4	2	0	I
		Definition of the defects scale	3	4	0	2	0	0	O
		Difference between measurements LMK and TOPcon	2	2	1	4	0	0	I
		Reaching temperature for glass NTC during the measurement	4	2	0	3	0	0	M
		Measurement method regarding the part status (free or on the jig)	3	1	0	5	0	0	I
		High temperature/high humidity storage condition	3	0	2	4	0	0	I
		Position of tracks on FPCs	4	2	0	3	0	0	M
	Customer rejection rate	Sample size for measurement	3	2	2	2	0	0	M
		Material of the metal frame	3	5	1	0	0	0	O
Cost		Consignment contract	0	0	1	6	2	0	I
		Cost breakdown sheet (CBDS) for tooling	0	1	1	4	3	0	I

Table 5 The frequency of CRs and their classifications based on Kano model (continued)

Category		*CRs*	*M*	*O*	*A*	*I*	*R*	*Q*	*Kano classification*
Cost		Packaging cost	0	2	2	4	1	0	I
		Equipment set up requirements	0	2	0	4	3	0	I
		Tool strategy	1	2	4	2	0	0	A
		The optical measurement report	4	2	1	2	0	0	M
		Timeline to sourcing decision	2	1	1	5	0	0	I
		The amount of volume scenario	2	4	2	1	0	0	O
		Availability of the whole component	0	1	3	4	1	0	I
		Sampling agreement	1	1	0	7	0	0	I
		Raw material definition	0	1	1	7	0	0	I
		Target price	1	0	2	5	1	0	I
Sustainability	Globalisation	Safe and sustainable transport systems	0	8	1	0	0	0	O
		Commitment to health and safety of employees	2	6	1	0	0	0	O
		Take responsibility of sustainability and create transparency	2	5	1	1	0	0	O
	Pollution production	CO_2 emissions	0	6	2	1	0	0	O
		Product environmental performance footprint	2	5	1	1	0	0	O
		Potential toxicity to human	2	6	1	0	0	0	O
		Climate pledge friendly products	0	5	2	2	0	0	O
		Quality of water discharges	2	5	1	1	0	0	O
	Urbanisation and eco-design energy	Reduce operational water and energy consumption	0	6	3	0	0	0	O
		New sustainable materials implementation	0	5	4	0	0	0	O
		Reduce material through eco-design	0	5	3	1	0	0	O
		Water consumption	1	6	2	0	0	0	O
		Waste avoidance (zero waste to landfill)	0	5	3	1	0	0	O
		Strengthen the circular economy strategy	1	5	1	2	0	0	O
		The energy supply from renewable sources	0	5	2	2	0	0	O
	Health and safety	Amount of emission of hazardous material (RoHS compliance)	2	5	2	0	0	0	O
		Road safety	1	4	1	3	0	0	O
		Accident rate per hours of the work	2	6	0	1	0	0	O

Table 5 The frequency of CRs and their classifications based on Kano model (continued)

Category		*CRs*	*M*	*O*	*A*	*I*	*R*	*Q*	*Kano classification*
Sustainability	Water	Water quality	2	6	1	0	0	0	O
		Water scarcity	1	6	2	0	0	0	O
Delivery		Order lead-time	2	5	2	0	0	0	O
		Better delivery flexibility	0	1	8	0	0	0	A
		Communication, cooperation	4	1	2	2	0	0	M
		Standard cut-off time for release of the transport order (TO)	2	0	4	3	0	0	A
		Special transports	2	1	4	1	1	0	A
		Minimum order quantity	2	6	1	0	0	0	O
		Information transmission between the supplier and OEM	6	0	2	1	0	0	M
		KANBAN call offs (JIT calls)	2	0	6	1	0	0	A
		Start-up and phase-out control	0	0	5	4	0	0	A
		The delivery of sub-suppliers to the supplier	4	3	0	2	0	0	M
		Maximum storage time	4	0	1	4	0	0	M
		Transportation time	4	0	3	2	0	0	M
		Production progress information	6	0	0	3	0	0	M
		Number of parts in package	4	3	2	0	0	0	M
		Easy handling packaging	0	7	0	2	0	0	O
		Stack ability of the package	2	5	0	2	0	0	O
		Traceability of the product	2	5	0	2	0	0	O
		Corrosion prevention and moisture control	4	1	0	4	0	0	M
		Security in goods transportation	2	3	0	4	0	0	I
		Risk and crisis management	0	2	0	7	0	0	I
		Logistics failures	2	1	2	4	0	0	I
		Digitalisation of the supply chain	0	0	3	6	0	0	I
		The LCD bag material	2	3	0	4	0	0	I
		Maximum handling weight of the box	3	0	0	5	1	0	I
		Pallet size	5	1	0	3	0	0	M
		Clean returnable packaging	0	6	0	2	1	0	O
		Intermediate layers or nesting elements	6	2	0	0	0	1	M

Table 6 The refined Kano model classification, total satisfaction index, and weights of CRs for DMCS product

Category		*CRs*	*Better*	*Worse*	*Weight of attribute*	*Total satisfaction index*	*Kano group*	*Refined Kano group*
Technical	Mechanical	Double side foam which is connect the LCD to backlight frame	0.56	–0.56	0.56	0	O	Low value-added
		Enough DAM space	0.78	–0.56	0.78	0.22	M	Critical
		Rigidity of backlight unit housing	0.25	–0.75	0.75	–0.50	A	Low attractive
		Optical alignment features definition	0.44	–0.56	0.56	–0.12	A	Low attractive
		De-coupling of backlight unit and panel	0	–0.89	0.89	–0.89	A	High attractive
		Sealant double side tape design	0.56	–0.56	0.56	0	O	Low value-added
		Propensity to leakage of foam tape	0.89	–0.44	0.89	0.45	M	Critical
		Dimension of the backlight frame	0.56	–0.44	0.56	0.12	M	Necessary
		GAP between rear glass and black housing	0	–0.89	0.89	–0.89	A	High attractive
		Formation air bubbles on LCD panel	1	–0.44	1	0.56	M	Necessary
		Alignment features on back housing of LCD to align centre frame	0.44	–0.56	0.56	–0.12	A	Low attractive
		Height difference between the display frame and bonding surface	0.56	–0.22	0.56	0.34	M	Necessary
		Parallelism of display polariser to support elements on the KIT	0.44	–0.22	0.44	0.22	I	Care-free
		Gap between backlight frame and LCD	0.22	–0.22	0.22	0	I	Care-free
		Light leakage due to mechanical lay out on the frame and back light	0.78	–0.22	0.78	0.56	M	Critical
		Thickness of the inner glass	0.13	–0.25	0.25	–0.12	I	Care-free
		Thickness of the polariser	0	–0.38	0.38	–0.38	I	Care-free
		Type of polariser	0.78	–0.44	0.78	0.34	M	Critical
		Backlight reflection sheet shape	0.78	–0.33	0.78	0.45	M	Critical
		Shield film shape	0.25	0	0.25	0.25	I	Care-free
		Flatness of backlight housing	0.56	–0.56	0.56	0	O	Low value-added

Table 6 The refined Kano model classification, total satisfaction index, and weights of CRs for DMCS product (continued)

Category		*CRs*	*Better*	*Worse*	*Weight of attribute*	*Total satisfaction index*	*Kano group*	*Refined Kano group*
Technical	Mechanical	Contamination of the display	1	–0.56	1	0.44	O	High value-added
		Thickness of TFT-/colour filter glass	0.33	–0.22	0.33	0.11	I	Care-free
		Foil banding material of the side of the display	0.67	–0.33	0.67	0.34	M	Critical
Technical	Electrical	Foil banding width	0.13	–0.13	0.13	0	I	Care-free
		Position of the LEDs	0.67	–0.22	0.67	0.45	M	Critical
		Thickness of the driver IC	0.22	–0.22	0.22	0	I	Care-free
		Softness of FPC material	0.33	–0.56	0.56	–0.23	A	High attractive
		Chip on glass (COG)/foil on glass (FOG) bonding-chip bonding with anisotropic conductive film (ACF)	0.11	–0.11	0.11	0	I	Care-free
		Resistance of the track material	0.33	–0.22	0.33	0.11	I	Care-free
		LED power consumption	0.22	–0.33	0.33	–0.11	I	Care-free
	Optical	Stability regarding the contrast at higher temperatures	0.44	–0.44	0.44	0	I	Care-free
		Thermal reliability	0.56	–0.22	0.56	0.34	I	Potential
		DARK DOT rate	0.33	–0.33	0.33	0	I	Care-free
		BU percentage	0.78	–0.67	0.78	0.11	O	High value-added
		Type of LED material	0.44	–0.33	0.44	0.11	I	Care-free
		Nit of brightness of screen	0.33	0.56	0.56	0.89	I	Potential
Quality	Definition of standard conditions	Digital PWM rate	0.56	–0.22	0.56	0.34	I	Potential
		Repeatability due to sensitivity of the display	0.67	–0.33	0.67	0.34	M	Critical
		Parameter settings of equipment (e.g., print screen of equipment GUI with settings)	0.33	–0.22	0.33	0.11	I	Care-free
		Touch Mura Evaluation	0.67	–0.67	0.67	0	O	Low value-added
		Respect to PRE	0.78	–0.33	0.78	0.45	M	Critical
		Stability of the MSA	0.38	–0.13	0.38	0.25	I	Care-free
		Register active display area measurement	0.44	–0.22	0.44	0.22	I	Care-free

Table 6 The refined Kano model classification, total satisfaction index, and weights of CRs for DMCS product (continued)

Category		*CRs*	*Better*	*Worse*	*Weight of attribute*	*Total satisfaction index*	*Kano group*	*Refined Kano group*
Quality	Measurements conditions	Water absorption rate	0.29	–0.29	0.29	0	I	Care-free
		Definition of the defects scale	0.78	–0.44	0.78	0.34	O	High value-added
		Difference between measurements LMK and TOPcon	0.44	–0.33	0.44	0.11	I	Care-free
		Reaching temperature for glass NTC during the measurement	0.67	–0.22	0.67	0.45	M	Critical
Quality	Measurements conditions	Measurement method regarding the part status (free or on the Jig)	0.44	–0.11	0.44	0.33	I	Care-free
		High temperature/high humidity storage condition	0.33	–0.22	0.33	0.11	I	Care-free
		Position of tracks on FPCs	0.67	–0.22	0.67	0.45	M	Critical
	Customer rejection rate	Sample size for measurement	0.56	–0.44	0.56	0.12	M	Necessary
		Material of the metal frame	0.89	–0.67	0.89	0.22	O	High value-added
	Cost	Consignment contract	0	–0.14	0.14	–0.14	I	Care-free
		Cost breakdown sheet (CBDS) for tooling	0.17	–0.33	0.33	–0.16	I	Care-free
		Packaging Cost	0.25	–0.50	0.50	–0.25	I	Care-free
		Equipment set up requirements	0.33	–0.33	0.33	0	I	Care-free
		Tool strategy	0.33	–0.67	0.67	–0.34	A	High attractive
		The optical measurement report	0.67	–0.33	0.67	0.34	M	Critical
		Timeline to sourcing decision	0.33	–0.22	0.33	0.11	I	Care-free
		The amount of volume scenario	0.67	–0.67	0.67	0	O	High value-added
		Availability of the whole component	0.13	–0.50	0.50	–0.37	I	Care-free
		Sampling Agreement	0.22	–0.11	0.22	0.11	I	Care-free
		Raw material definition	0.11	–0.22	0.22	–0.11	I	Care-free
		Target price	0.13	–0.25	0.25	–0.12	I	Care-free
Sustainability	Globalisation	Safe and sustainable transport systems	0.89	–1	1	–0.11	O	Low value-added
		Commitment to health and safety of employees	0.89	–0.78	0.89	0.11	O	High value-added

Table 6 The refined Kano model classification, total satisfaction index, and weights of CRs for DMCS product (continued)

Category		*CRs*	*Better*	*Worse*	*Weight of attribute*	*Total satisfaction index*	*Kano group*	*Refined Kano group*
Sustainability	Globalisation	Take responsibility of sustainability and create transparency	0.78	–0.67	0.78	0.11	O	High value-added
Sustainability	Pollution production	CO_2 emissions	0.67	–0.89	0.89	–0.22	O	Low value-added
		Product environmental performance footprint	0.78	–0.67	0.78	0.11	O	High value-added
		Potential toxicity to human	0.89	–0.78	0.89	0.11	O	High value-added
Sustainability	Pollution production	Climate pledge friendly products	0.56	–0.78	0.78	–0.22	O	Low value-added
		Quality of water discharges	0.78	–0.67	0.78	0.11	O	High value-added
Sustainability	Urbanisation and eco-design energy	Reduce operational water and energy consumption	0.67	–1	1	–0.33	O	Low value-added
		New sustainable materials implementation	0.56	–1	1	–0.44	O	Low value-added
		Reduce material through eco-design	0.56	–0.89	0.89	–0.33	O	Low value-added
		Water consumption	0.78	–0.89	0.89	–0.11	O	Low value-added
		Waste avoidance (zero waste to landfill)	0.56	–0.89	0.89	–0.33	O	Low value-added
		Strengthen the circular economy strategy	0.67	–0.67	0.67	0	O	High value-added
		The energy supply from renewable sources	0.56	–0.78	0.78	–0.22	O	Low value-added
	Health and safety	Amount of emission of hazardous material (RoHS compliance)	0.78	–0.78	0.78	0	O	High value-added
		Road safety	0.56	–0.56	0.56	0	O	Low value-added
		Accident rate per hours of the work	0.89	–0.67	0.89	0.22	O	High value-added
	Water	Water quality	0.89	–0.78	0.89	0.11	O	High value-added
		Water scarcity	0.78	–0.89	0.89	–0.11	O	Low value-added
Delivery		Order lead-time	0.78	–0.78	0.78	0	O	High value-added
		Better delivery flexibility	0.11	–1	1	–0.89	A	High attractive
		Communication, cooperation	0.56	–0.33	0.56	0.23	M	Necessary
		Standard cut-off time for release of the transport order (TO)	0.22	–0.44	0.44	–0.22	A	Low attractive

Table 6 The refined Kano model classification, total satisfaction index, and weights of CRs for DMCS product (continued)

Category	*CRs*	*Better*	*Worse*	*Weight of attribute*	*Total satisfaction index*	*Kano group*	*Refined Kano group*
Delivery	Special transports	0.38	–0.63	0.63	–0.25	A	High attractive
	Minimum order quantity	0.89	–0.78	0.89	0.11	O	High value-added
	Information transmission between the supplier and OEM	0.67	–0.22	0.67	0.45	M	Critical
	KANBAN call offs (JIT calls)	0.22	–0.67	0.67	–0.45	A	High Attractive
	Start-up and phase-out control	0	–0.56	0.56	–0.56	A	Low attractive
	The delivery of sub-suppliers to the supplier	0.78	–0.33	0.78	0.45	M	Critical
	Maximum storage time	0.44	–0.11	0.44	0.33	M	Necessary
	Transportation time	0.44	–0.33	0.44	0.11	M	Necessary
	Production progress information	0.67	0	0.67	0.67	M	Critical
	Number of parts in package	0.78	–0.56	0.78	0.22	M	Critical
	Easy handling packaging	0.78	–0.78	0.78	0	O	High value-added
	Stack ability of the package	0.78	–0.56	0.78	0.22	O	High value-added
	Traceability of the product	0.78	–0.56	0.78	0.22	O	High value-added
	Corrosion prevention and moisture control	0.56	–0.11	0.56	0.45	M	Necessary
	Security in goods transportation	0.56	–0.33	0.56	0.23	I	Care-free
	Risk and crisis management	0.22	–0.22	0.22	0	I	Care-free
	Logistics failures	0.33	–0.33	0.33	0	I	Care-free
	Digitalisation of the supply chain	0	–0.33	0.33	–0.33	I	Care-free
	The LCD bag material	0.56	–0.33	0.56	0.23	I	Care-free
	Maximum handling weight of the box	0.38	0	0.38	0.38	I	Care-free
	Pallet size	0.67	–0.11	0.67	0.56	M	Critical
	Clean returnable packaging	0.75	–0.75	0.75	0	O	High value-added
	Intermediate layers or nesting elements	1	–0.25	1	0.75	M	Critical

The difference between better and worse values is known as the total satisfaction index. The CRs can be ranked based on the calculated values of the total satisfaction index. Negative values of the total satisfaction index indicate that the non-fulfilment of a certain requirement causes dissatisfaction and positive values indicate that the fulfilment of a particular requirement causes satisfaction. In addition, higher values have more influence on the satisfaction rate. After calculating the weight and satisfaction index of the items, the average importance of the sub-criteria was obtained. Then, the refined Kano model classification was determined based on the average weight and classification of the simple Kano model.

Also, the average weight of the main categories of CRs and their classification is in the Table 7.

Table 7 Classification of the main categories in the refined Kano model of case study

	Category	*Weight*	*Kano classification*	*Refined Kano classification*
Technical	Mechanical	0.623	M	Critical
	Electrical	0.378	I	Care-free
	Optical	0.518	I	Care-free
Quality	Definition of standard conditions	0.547	I	Care-free
	Measurements conditions	0.517	I	Care-free
	Customer rejection rate	0.725	M or O	High value-added or necessary
	Cost	0.403	I	Care-free
Sustainability	Globalisation	0.89	O	Low value-added
	Pollution production	0.824	O	High value-added
	Urbanisation and eco-design energy	0.874	O	Low value-added
	Health and safety	0.743	O	High value-added
	Water	0.89	O	High value-added
	Delivery	0.63	M	Critical

The reliability and validity for five categories of the product were fulfilled. In terms of compatibility of the CRs in the five main categories, the CRs were verified correspondingly. The negative questions of the Kano questionnaire were not only negated by negative prefixes but also the questions understood in a negatively comprehensible. The Kano classification is then given for each category as shown in Table 5 and subsequently for each CR. In Table 6, the CRs classified by the refined Kano model according to the classification shown in Table 2. According to the refined Kano model, high value-added attributes cause a high level of customer satisfaction and thus reduce defective products and increase production efficiency. Among the sub-criteria, 20 CRs follow this feature. The 15 items of CRs are low value-added attributes. Although this feature does not play a significant role in satisfying customer demands, still the absence of it causes dissatisfaction, so it should be considered in the product. The high attractive attributes include seven items. This feature is the best tool to attract customers to improve customer satisfaction. Therefore, it recommends fulfilling that kind of CRs. The Indifferent attribute is divided into two, which are significantly classified as potential. The potential attributes' CRs become an attractive quality attribute, and suppliers should consider the Potential needs of the product to attract the customer. In this study, three CRs are in this category. The care-free features are scattered into four categories except for sustainability. Meeting the care-free requirements in the DMCS requires remarkable costs. Therefore, it is better not to apply these features to the product or simplify or superficially apply them. Even in some performance needs of the DMCS, care-free features can make improvements at a high cost which in the absence of these features does not disrupt the product's performance.

Almost in every category, there are must-be attributes divided into two dimensions. Critical quality is the basis for the manufacturer to meet customer expectations and these CRs are significant. In the five categories of the CRs, some critical attributes need to consider in the product to satisfy the consumer. Despite critical features, there are Necessary items in each category except for sustainability. The necessary items must provide from the customer's point of view. If we do not satisfy these features, the level of BU drops which means customer dissatisfaction. Table 7 shows the main dimensions of CRs, mechanical, and delivery in the critical category; electrical, optical, definition of standard conditions, measurements conditions, and cost are in the care-free category. Customer rejection rate, pollution production, health and safety, and water are classified in the high value-added category. On the other hand, the items of globalisation and urbanisation and eco-design energy are in the low value-added group.

Table 8 Coding of OPTICAL requirements

Requirement name	*Code*	*Item ranking*
Stability regarding the contrast at higher temperatures	C1	2
Thermal reliability	C2	1
DARK DOT rate	C3	5
BU percentage	C4	4
Type of LED material	C5	3
Nit of brightness of screen	C6	6

4.3 SWARA approach results

Then, the SWARA approach is discussed to weight the sub-criteria for each main criteria separately, and the results of this approach are presented in the following tables. For example, the calculation of OPTICAL sub-criteria weight is shown in Table 8. The OPTICAL sub-criteria consist of six items and, first, provided to the experts. They were asked to arrange the criteria according to their importance. Table 8 shows the coding of the requirements and the rankings of the sub-criteria based on the experts' opinions.

Afterward, it is time to calculate the S_j, k_j, and criteria's importance weight, respectively (Table 9).

Table 10 shows the weights of all criteria related to CRs considering the SWARA approach.

4.4 Discussion and managerial implications

The outcome of this paper is headlined for an automotive company to improve the attributes of the display DMCS based on sustainable requirements acquired by final customers and OEM companies. Also, the CRs with high importance weight for an automotive product can be outlined as a benchmark to improve for other products or services in the future. The study results for managers of the OEM Company will offer a model to recognise and rank the CRs and gives an insight for an efficient management competence to identify the customers' concerns regarding the product.

Table 9 Weighting of OPTICAL requirements

Requirement name	*Code*	S_j	k_j	$q_j = \frac{q_{j-1}}{k_j}$	$w_j = \frac{q_j}{\sum q_j}$
Stability regarding the contrast at higher temperatures	C1	0.1	1.1	0.909	0.203
Thermal reliability	C2	1	1	1	0.224
DARK DOT rate	C3	0.168	1.168	0.575	0.129
BU percentage	C4	0.179	1.179	0.672	0.150
Type of LED material	C5	0.148	1.148	0.792	0.177
Nit of brightness of screen	C6	0.102	1.102	0.522	0.117

The proposed method easily can be developed in practice concerning MCDM tools. The executive managers can take proper strategies to apply the Kano model and MCDM tools to obtain the relative weight of the CRs. The proposed method can help the OEMs to receive semi-products from the suppliers according to the emphasised customer parameters to deliver better service or products to the customer.

Current research shows two approaches of Kano and SWARA to address a real problem involving the CRs to recognise and evaluate their significant parameters to improve the products.

There are some reasons why the SWARA methods have been selected. First, because of the large number of criteria, the SWARA method is simpler to compute the data compared the other tools like AHP. Even though other methods like ANP are based on pairwise comparison and is difficult to get a high consistency rate and the process of calculation is time-consuming. Also, the SWARA method is a policy-based tool that is applied in various areas and a vital tool to evaluate the importance weight of criteria depending on their priority. Meanwhile, the Kano model supports another idea to classify and rank the CRs based on Kano theory which is different from MCDM methods.

The calculation details of the criteria weights obtained based on the Kano model are encountered in Table 6, while the importance weights of CRs based on the SWARA method are shown in Table 10. In competitive market manufacturing, the product which is not aligned with customer preference might be a tremendously huge cost for the company therefore; it makes sense to follow customer desires during the time. The result shown in each category of the CRs has different values in the Kano model and the SWARA method. It means the methods have different variables. For instance, the highest weight obtained from the refined Kano model for the 'technical' category belongs to the 'sealant double side tape design' is 0.56 in the 'low value-added' group whereas, the highest rate for the 'technical' category belongs to 'de-coupling of backlight unit and panel', 'propensity to leakage of foam tape', and 'GAP between rear glass and black housing' has a value of 0.89.

Here, what has been done in this article is that the weights of the sub-criteria are obtained from the comparison between the sub-criteria within a cluster of the category, so the sub-criteria of one class are compared with each other and not with other sub-criteria in another category. For example, the 'better delivery flexibility' from the 'delivery' cannot be compared with the 'contamination of the display' from the 'technical' because they are not of the same type, and also the experts which evaluate them are different in the two categories, however, the value of both items is 1.

5 Conclusions

Generally, this paper provides a scientific and engineered framework for features that may help manufacturing companies re-evaluate their services and reach efficient and new technological features in the automotive area.

This paper aimed to apply the refined Kano approach and SWARA to categorise and prioritise CRs. First, 112 CRs of the DMCS display were identified in five different categories technical, cost, delivery, sustainability, and quality. Then, CRs were categorised using the refined Kano model. In the last step, the SWARA was used to obtain importance weights. According to the results from the Kano model, the mechanical and delivery are in the critical group. Therefore, suppliers should pay more attention to these requirements to customers who do not feel these features are not considered (these requirements are critical from the customers' point of view, and if not met their expectations may lead to losing the market).

Electrical, optical, definition of standard conditions, measurement conditions, and cost are in the carefree category. The supplier can spend the budget and time on other needs if necessary. The customer's rejection rate, Pollution production, Health and Safety, and Water are in high value-added classification. Not only do they increase satisfaction but also, increase profitability and competitiveness of the organisation as it requires efforts to improve these requirements, and the emphasis of the customers on them. In the end, it has a direct effect on customer satisfaction. Therefore, the supplier must improve these needs that are the most significant CRs in the point of view of OEM, which ultimately reduces the defects and increases the BU, or at least decreases the deviation range. On the other hand, globalisation, urbanisation, and eco-design energy should be considered by the supplier, although it does not have a significant impact on customer satisfaction to prevent dissatisfaction and produce a consistent product.

Table 10 Weights of CRs considering the SWARA approach

Category		*CRs*	*Weight*	*Item ranking*
Technical	Mechanical	Double side foam which is connect the LCD to backlight frame	0.0567	9
		Enough DAM space	0.0630	7
		Rigidity of backlight unit housing	0.0088	20
		Optical alignment features definition	0.0635	6
		De-coupling of backlight unit and panel	0.0440	13
		Sealant double side tape design	0.0675	1
		Propensity to leakage of foam tape	0.0194	17
		Dimension of the backlight frame	0.0380	14
		GAP between rear glass and black housing	0.0666	4
		Formation air bubbles on LCD panel	0.0671	2
		Alignment features on back housing of LCD to align centre frame	0.0110	18
		Height difference between the display frame and bonding surface	0.0068	21
		Parallelism of display polariser to support elements on the KIT	0.0666	4
		Gap between backlight frame and LCD	0.0338	15
		Light leakage due to mechanical lay out on the frame and back light	0.0556	10
		Thickness of the inner glass	0.0099	19
		Thickness of the polariser	0.0293	16
		Type of polariser	0.0637	5
		Backlight reflection sheet shape	0.0551	11
		Shield film shape	0.0667	3
		Flatness of Backlight Housing	0.0456	12
		Contamination of the display	0.0025	22
		Thickness of TFT-/colour filter glass	0.0590	8
	Electrical	Foil banding material of the side of the display	0.1810	1
		Foil banding width	0.1315	6
		Position of the LEDs	0.1468	3
		Thickness of the driver IC	0.1440	4

Table 10 Weights of CRs considering the SWARA approach (continued)

Category		*CRs*	*Weight*	*Item ranking*
Technical	Electrical	Softness of FPC material	0.0760	7
		Chip on glass (COG)/foil on glass (FOG) bonding-chip bonding with anisotropic conductive film (ACF)	0.0332	8
		Resistance of the track material	0.1507	2
		LED power consumption	0.1368	5
	Optical	Stability regarding the contrast at higher temperatures	0.203	2
		Thermal reliability	0.224	1
		DARK DOT rate	0.129	5
		BU percentage	0.150	4
		Type of LED material	0.177	3
		Nit of brightness of screen	0.117	6
Quality	Definition of standard conditions	Digital PWM rate	0.0893	5
		Repeatability due to sensitivity of the display	0.0172	7
		Parameter settings of equipment (e.g., print screen of equipment GUI with settings)	0.2038	3
		Touch Mura evaluation	0.2585	2
		Respect to PRE	0.3063	1
		Stability of the MSA	0.0289	6
		Register active display area measurement	0.0960	4
	Measurements conditions	Water absorption rate	0.0387	4
		Definition of the defects scale	0.2896	2
		Difference between measurements LMK and TOPcon	0.2784	3
		Reaching temperature for glass NTC during the measurement	0.0133	7
		Measurement method regarding the part status (free or on the jig)	0.0339	6
		High temperature/high humidity storage condition	0.0386	5
		Position of tracks on FPCs	0.3075	1
	Customer rejection rate	Sample size for measurement	0.49	2
		Material of the metal frame	0.51	1
Quality	Cost	Consignment contract	0.0401	9

Table 10 Weights of CRs considering the SWARA approach (continued)

Category		*CRs*	*Weight*	*Item ranking*
Quality	Cost	Cost breakdown sheet (CBDS) for tooling	0.3365	1
		Packaging cost	0.0504	8
		Equipment set up requirements	0.0546	5
		Tool strategy	0.0576	4
		The optical measurement report	0.0259	10
		Timeline to sourcing decision	0.0526	6
		The amount of volume scenario	0.0510	7
		Availability of the whole component	0.0184	11
		Sampling agreement	0.0155	12
		Raw material definition	0.2261	2
		Target price	0.0712	3
Sustainability	Globalisation	Safe and sustainable transport systems	0.5286	1
		Commitment to health and safety of employees	0.3504	2
		Take responsibility of sustainability and create transparency	0.1210	3
	Pollution production	CO_2 emissions	0.2218	3
		Product environmental performance footprint	0.0753	5
		Potential toxicity to human	0.2334	2
		Climate pledge friendly products	0.2064	4
		Quality of water discharges	0.2631	1
	Urbanisation and eco-design energy	Reduce operational water and energy consumption	0.0287	7
		New sustainable materials implementation	0.0324	5
		Reduce material through eco-design	0.2196	3
		Water consumption	0.2506	1
		Waste avoidance (zero waste to landfill)	0.2341	2
		Strengthen the circular economy strategy	0.0308	6
		The energy supply from renewable sources	0.2038	4
	Health and safety	Amount of emission of hazardous material (RoHS compliance)	0.4419	2
		Road safety	0.0717	3
		Accident rate per hours of the work	0.4864	1

Table 10 Weights of CRs considering the SWARA approach (continued)

Category		*CRs*	*Weight*	*Item ranking*
Sustainability	Water	Water quality	0.1200	2
		Water scarcity	0.8800	1
Delivery		Order lead-time	0.0864	2
		Better delivery flexibility	0.0649	9
		Communication, cooperation	0.0103	22
		Standard cut-off time for release of the transport order (TO)	0.0132	19
		Special transports	0.0089	26
		Minimum order quantity	0.0652	8
		Information transmission between the supplier and OEM	0.0095	23
		KANBAN call offs (JIT calls)	0.0735	6
		Start-up and phase-out control	0.0132	19
		The delivery of sub-suppliers to the supplier	0.0142	18
		Maximum storage time	0.0778	3
		Transportation time	0.0764	5
		Production progress information	0.0123	20
		Number of parts in package	0.0665	7
		Easy handling packaging	0.0208	15
		Stack ability of the package	0.0236	12
		Traceability of the product	0.0170	17
		Corrosion prevention and moisture control	0.0189	16
		Security in goods transportation	0.0092	25
		Risk and crisis management	0.0094	24
		Logistics failures	0.0245	11
		Digitalisation of the supply chain	0.0217	14
		The LCD bag material	0.0909	1
		Maximum handling weight of the box	0.0606	10
		Pallet size	0.0772	4
		Clean returnable packaging	0.0226	13
		Intermediate layers or nesting elements	0.0113	21

As can be seen, the needs of pollution production, health and safety, and water are among the sustainability needs and are in the high value-added group. It shows that in addition to the economic and profit, the company must pay attention to the sustainable development category in terms of people's familiarity with sustainability concepts and green products. Today, everyone is aware of the importance of social, humanitarian, and environmental goals. All worldwide industries, namely the automotive industry must maintain sustainable customers and attract new customers to create sustainable development. A company can create value when the management method includes various characteristics to integrate the economic, environmental, and social dimensions. Sustainability is the performance of the enterprise in all aspects of the company's sustainability drivers that go beyond the traditional organisational boundaries and from the upstream performance of the value chain (suppliers) to the downstream (customers).

Although we considered and ranked 112 CRs in different aspects, this study suffered from some limitations. There maybe have not been identified and included all the CRs. Second, the research is compiling the ideas of a different range of experts with different skills who are not professionals in other fields, making the studies separate. The third limitation is related to the content of the questionnaire which should be more generic to the final customer than the experts in the case the final customer sometimes does not feel invisible criteria that are significant to the experts.

This paper provides a scientific and engineered framework for features that may help manufacturing organisations re-evaluate their services and achieve efficient features in the automotive field. For future research, it is recommended to use other MCDM tools and compare their results with SWARA for big data. On the other hand, the combination of MCDM methods and refined Kano model can help to improve the results, due to the managerial and mathematical aspects of the methods. For instance, in the service area due to uncertainty, it is possible to integrate the model with fuzzy theory. In addition, this method can be applied as a programming framework to use in other areas, including the various products, healthcare systems, education, and financial systems to identify significant criteria and classify and weigh these criteria to generalise and apply them as an organised method in different countries. Meanwhile, environmental concerns have become one of the main concerns in many countries today, so there is a need to highlight these requirements.

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References

Akmal, S., Hashim, N., Hambali, R.H. and Sihombing, H.I. (2020) 'Kano method for diagnosing attribute of product requirement to enhance customer satisfaction', *International Journal of Advanced Science and Technology*, Vol. 29, No. 9s, pp.6160–6170.

Al Rabaiei, K., Alnajjar, F. and Ahmad, A. (2021) 'Kano model integration with data mining to predict customer satisfaction', *Big Data and Cognitive Computing*, Vol. 5, No. 4, p.66.

Alinezhad, A. and Khalili, J. (2019) 'SWARA method', in *New Methods and Applications in Multiple Attribute Decision Making (MADM)*, pp.99–102, Springer, Cham.

Amin, A., Anwar, S., Adnan, A., Nawaz, M., Alawfi, K., Hussain, A. and Huang, K. (2017) 'Customer churn prediction in the telecommunication sector using a rough set approach', *Neurocomputing*, Vol. 237, pp.242–254.

Avikal, S., Singh, R. and Rashmi, R. (2020) 'QFD and fuzzy Kano model based approach for classification of aesthetic attributes of SUV car profile', *Journal of Intelligent Manufacturing*, Vol. 31, No. 2, pp.271–284.

Berger, C., Blauth, R. and Boger, D. (1993) *Kano's Methods for Understanding Customer-Defined Quality*.

Bhardwaj, J., Yadav, A., Chauhan, M.S. and Chauhan, A.S. (2021) 'Kano model analysis for enhancing customer satisfaction of an automotive product for Indian market', *Materials Today: Proceedings*, Vol. 46, pp.10996–11001.

Chen, J. and Chang, Y.P. (2018) 'Analytical vehicle KANO model development', in *ASME International Mechanical Engineering Congress and Exposition*, American Society of Mechanical Engineers, November, Vol. 52187, p.V013T05A061.

Chen, K.J., Yeh, T.M., Pai, F.Y. and Chen, D.F. (2018) 'Integrating refined kano model and QFD for service quality improvement in healthy fast-food chain restaurants', *International Journal of Environmental Research and Public Health*, Vol. 15, No. 7, p.1310.

Chen, L.F. (2012) 'A novel approach to regression analysis for the classification of quality attributes in the Kano model: an empirical test in the food and beverage industry', *Omega*, Vol. 40, No. 5, pp.651–659.

Chen, L.S., Liu, C.H., Hsu, C.C. and Lin, C.S. (2010) 'C-Kano model: a novel approach for discovering attractive quality elements', *Total Quality Management*, Vol. 21, No. 11, pp.1189–1214.

Chen, W.K., Chang, J.R., Chen, L.S. and Hsu, R.Y. (2022) 'Using refined Kano model and decision trees to discover learners' needs for teaching videos', *Multimedia Tools and Applications*, Vol. 81, No. 6, pp.8317–8347.

Cui, Y., Liu, W., Rani, P. and Alrasheedi, M. (2021) 'Internet of things (IoT) adoption barriers for the circular economy using Pythagorean fuzzy SWARA-CoCoSo decision-making approach in the manufacturing sector', *Technological Forecasting and Social Change*, Vol. 171, p.120951.

Erdem, B. and Gundogdu, I. (2018) 'Kumiss treatment in the context of health tourism: a research in Kyrgyzstan', *International Journal of Medical Research & Health Sciences*, Vol. 7, No. 11, pp.135–155.

Go, M. and Kim, I. (2018) 'In-flight NCCI management by combining the Kano model with the service blueprint: a comparison of frequent and infrequent flyers', *Tourism Management*, Vol. 69, pp.471–486.

Južnik Rotar, L. and Kozar, M. (2017) 'The use of the Kano model to enhance customer satisfaction', *Organizacija*, Vol. 50, No. 4, pp.339–351.

Kano, N. (1984) 'Attractive quality and must-be quality', *Hinshitsu* (*Quality, The Journal of Japanese Society for Quality Control)*, Vol. 14, pp.39–48.

Keršuliene, V., Zavadskas, E.K. and Turskis, Z. (2010) 'Selection of rational dispute resolution method by applying new step-wise weight assessment ratio analysis (SWARA)', *Journal of Business Economics and Management*, Vol. 11, No. 2, pp.243–258.

Lin, Y., Cheng, H.P., Tseng, M.L. and Tsai, J.C. (2010) 'Using QFD and ANP to analyze the environmental production requirements in linguistic preferences', *Expert Systems with Applications*, Vol. 37, No. 3, pp.2186–2196.

Lo, C.H. (2021) 'Application of refined Kano's model to shoe production and consumer satisfaction assessment', *Sustainability*, Vol. 13, No. 5, p.2484.

Matzler, K. and Hinterhuber, H.H. (1998) 'How to make product development projects more successful by integrating Kano's model of customer satisfaction into quality function deployment', *Technovation*, Vol. 18, No. 1, pp.25–38.

Mikulić, J. and Prebežac, D. (2011) 'A critical review of techniques for classifying quality attributes in the Kano model', *Managing Service Quality: An International Journal*.

Montenegro, J.F., Contreras, P.A. and Sáenz, F. (2021) Hybridization of the Kano model and business model canvas: aeronautical and metalworking industry in Bogota, Colombia. *Heliyon*, Vol. 7, No. 10, p.e08097.

Normando, S., Bertomoro, F. and Bonetti, O. (2022) 'Investigating the effects of matching to caretakers' preference on satisfaction in different types of adopted dogs using the Kano model alongside with more traditional methods', *Journal of Veterinary Behavior*, Vol. 51, pp.1–7.

Rezaei, J. (2015) Best-worst multi-criteria decision-making method', *Omega*, Vol. 53, pp.49–57.

Rotscholl, I. and Krüger, U. (2021) 'Short distance uniformity and BlackMURA measurements', *Journal of the Society for Information Display*, Vol. 29, No. 5, pp.370–381.

Shahin, A. and Shahiverdi, S.M. (2015) 'Estimating customer lifetime value for new product development based on the Kano model with a case study in automobile industry', *Benchmarking: An International Journal*.

Sharif Ullah, A.M.M. and Tamaki, J.I. (2011) 'Analysis of Kano-model-based customer needs for product development', *Systems Engineering*, Vol. 14, No. 2, pp.154–172.

Shen, Y., Kokkranikal, J., Christensen, C.P. and Morrison, A.M. (2021) 'Perceived importance of and satisfaction with marina attributes in sailing tourism experiences: a Kano model approach', *Journal of Outdoor Recreation and Tourism*, Vol. 35, p.100402.

Sun, K.A. and Kim, D.Y. (2013) 'Does customer satisfaction increase firm performance? An application of American customer satisfaction index (ACSI)', *International Journal of Hospitality Management*, Vol. 35, pp.68–77.

Timko, M. (1993) 'An experiment in continuous analysis', *Center for Quality of Management Journal*, Vol. 2, No. 4, pp.17–20.

Witell, L., Löfgren, M. and Dahlgaard, J.J. (2013) 'Theory of attractive quality and the Kano methodology – the past, the present, and the future', *Total Quality Management & Business Excellence*, Vol. 24, Nos. 11–12, pp.1241–1252.

Xu, Q., Jiao, R.J., Yang, X., Helander, M., Khalid, H.M. and Opperud, A. (2009) 'An analytical Kano model for customer need analysis', *Design Studies*, Vol. 30, No. 1, pp.87–110.

Yang, C.C. (2005) 'The refined Kano's model and its application', *Total Quality Management & Business Excellence*, Vol. 16, No. 10, pp.1127–1137.

Yeboah, M.A., Ansong, M.O., Appau-Yeboah, F., Antwi, H.A. and Yiranbon, E. (2014) 'Empirical validation of patient's expectation and perception of service quality in Ghanaian hospitals: an integrated model approach', *American International Journal of Social Science*, Vol. 3, No. 3.

Yin, S., Cai, X., Wang, Z., Zhang, Y., Luo, S. and Ma, J. (2022) 'Impact of gamification elements on user satisfaction in health and fitness applications: a comprehensive approach based on the Kano model', *Computers in Human Behavior*, Vol. 128, p.107106.