https://dx.doi.org/10.1016/j.techfore.2021.121464

Requirement-driven Evolution and Strategy-enabled Service Design for New Customized Quick-Response Product Order Fulfillment Process

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Abstract

Under the new digital transformation era, technologies such as the Cyber-physical system (CPS), the Internet of things (IoT) and Artificial Intelligence (AI) are increasingly mature, making it possible to transform from traditional factories to smart factories. During the transformation, building a communication channel between customer requirements and production capacity in the product manufacturing stage to realize the customized order service with low volume and high-mix production is critical. This study attempts to propose a novel requirement-driven and strategy-based model to derive the solution design of bringing the fertilization for the quick response order placement and production configuration service through three phases, that is, (1) requirement-based service diagnosis, (2) design strategy generation, and (3) service system conceptualization and evaluation. In the first phase, a statistical kano analysis method was proposed to identify, collect, and mining customer requirements considering industry contexts. In the second phase, TRIZ evolution trends were modified to adapt to the smart factory and the strategy generation procedures for designing digital transformation based on key enterprise processes were established accordingly. Finally, a novel service development maturity model was constructed to evaluate ideas of functions of new digital systems, which are inspired by design strategy considering future scenarios. A comprehensive case study of an empirical case with the design of the "Customized Product Order Fulfillment System" for the laptop production process is conducted to demonstrate this approach. The proposed novel requirement-driven and strategy-based model is expected to provide valuable insights for suggestions on technological trends and forecasting, future diverse and innovative applications in customized order fulfilment scenarios. In addition, with full consideration of social and technological factors, the model serves as a tool to guide practitioners in designing a customized order fulfilment system.

Keyword: *customized order fulfillment, customer requirements, require-driven and strategy-enabled design, Kano model, TRIZ evolution trend*

1 INTRODUCTION

The advanced technologies, such as the Internet of Things (IoT), machine learning, deep learning, and advanced cyber-physical systems (CPS), trigger a new digital transformation era and improve more flexibility in smart factories (Brettel et al., 2014; Kagermann et al., 2013). The smart factories with a CPS-based production line allow specific and dynamic requirements to be met and customized products to be produced. The new way of production makes manufacturing companies confront an environment with new opportunities and threats (Kagermann et al., 2013, Menon et al., 2020). Quickly responding to the new environment and distributing its design and production resources to meet customer requirements (CRs) is a critical issue for a company (Porter, 2014, Menon et al., 2020).

Personalized customization is a significant symbol in the smart manufacturing transformation process. Its essence focuses on directly converting customer demands into a production schedule based on an internet platform and intelligent plant. It enables the user-centric customized design and on-order production, which can satisfy the diverse market demands and solve the contradiction between stranded inventory and shorting capacity manufacturing to realize the coordination of supply and marketing dynamically. In the smart factories' revolution process, enterprises' attention has transferred from product or service quality into the customers' value. It brings the analysis and exploration of customer demands and correspondingly becomes the core issue to promote its evolution process.

In this industrial revolution environment, the new manufacturing transformation of mass customization for high-complexity and low-volume production is moving forward. Today, companies and their production systems face challenging issues including a complexity derived from a high variation of products (Synnes, 2016; Zawadzki & Żywicki, 2016). These high-complexity/ low-volume environments show a very challenging situation for production companies. Demonstrating the inherent unsustainability in the business model aspect and some uncertain effects on company performance, the traps of digitalization paradox in smart manufacturing applications development are commonly regarded to be caused by the excessive attention on technical possibilities rather than customer requirements (Albana et al., 2018,); the frequent change of dynamic user requirements due to the insufficient satisfaction on quick response to user requirements influenced of fashion trend and social media (Gajewska & Zimon, 2018; Min et al., 2018); and the lag between the changes of user requirements and the raising customized solutions (Lee et al.,2019b; Synnes, 2016). Thusly, several research questions still remain: (1) How to acquire high variety of clients' requirements and then balance the requirements with the affordance of the digital manufacturing world, smart factory should be a new answer with new concepts of configurable/ mass customized order fulfillment process with product configuration systems (Lee et al., 2019b). (2) How a company responds in the new environment and (3) how their resources are to be distributed to optimize production and product transactions within their capability. The key to success is meeting various dynamic CRs effectively and reducing the time of the customized products to market. To address these issues, companies need a new way to directly collect dynamic CRs of the front-side of order placement, such as a customized product ordering system. Therefore, developing the right ordering and product configuration service, which involves functions for shaping and modifying products, is extremely important.

It is expected that a product configuration system could benefit companies by transforming customer voice into configurations. However, existing configuration systems are not likely to adapt well to meet the dynamic CRs. Currently, a typical strategy of customization named make-to-order (MTO) is providing selections of subassembly to customers to configure the products themselves and then place their orders (Baykasoğlu et al., 2019). MTO is a business production strategy allowing consumers to purchase products that are customized to their specifications. An MTO manufacturer starts to work on an order only after it has been placed by the customer. Consequently, the main driver in MTO operations is the new transformation about customer orders (Albana et al., 2018). In view of the various products and changing demand, companies adopt MTO and quick response manufacturing (QRM) strategies to be able to respond quickly to user demand through the quick design and production of products.

To satisfy the individual client, it is necessary to measure and capture his/her implicit requirements of complex product features. Accordingly, the Kano model, which can significantly facilitate the recognition of marketing and product design needs, is adopted in this study in the early design stage of an effective quick response ordering system. The Kano model suggests that products and service features have biased influences on customer satisfaction (CS) (Llinares & Page, 2011). Specifically, some features of the product/service cause satisfaction, while others cause dissatisfaction. Therefore, comprehending the client's expectations helps the producers focus on the correct features. In general, this approach contributes to comprehensive resources management, with which the enterprise's resources can be efficiently arranged to best fulfill the clients' demand, especially for online e-commerce services (Gajewska & Zimon, 2018). Even though the Kano model has been successfully applied in some technical disciplines and tangible product design (Lee et al., 2019a; Lee et al.,2020; Wu et al., 2020), its potential has not been fully recognized in the area of customized B to B e-commerce under smart manufacturing (Lee et al., 2019a; Lee et al., 2019c). Kano model has the prospect to facilitate the development process of a smart system during the intelligent manufacturing process under the new digital transformation era of smart manufacturing.

The Kano model is a requirement-oriented method that deals with the requirement side and the problem side. Kano can conduct statistics and analysis by its user requirement indicators about product preference, determine its Kano model requirement attributes, and calculate each indicator's satisfaction coefficient and dissatisfaction coefficient. Thusly these requirement attributes could be used in designing product characteristics-related systems such as order fulfillment systems (Lee et al., 2019b; Lee et al., 2019c). Meanwhile, TRIZ evolution trends, which have the essential features of time, space, and interface, could be used as a methodology for inspiring and deriving solutions based on extensive knowledge. Thus, the proper integration and application of the two have a complementary effect. This research conducts research based on this integrated philosophy (Shahin et al., 2017; Hartono et al., 2019).

Considering the advantages of the Kano model, this research aims to explore how to use it to understand CRs of product characteristics clearly and thoroughly. Meanwhile, an empirical case with the laptop production process is demonstrated in this research. Based on the TRIZ evolution trends, the Kano results can be employed into the proposition of design strategies which are extended into the conception of system functions. The remainder of this study is structured as follows: Section 2 presents the research literature on Kano model and its application in product and service design fields. In addition, it shows the theory of TRIZ evolution trends is applied in the non-technology domain. In Section 3, the Kano-based survey method is introduced, including the subjects, the data collection process, and analysis procedures. Then, the TRIZ evolution trends are modified and its specific process is illustrated in this section. In Section 4, results about CR on laptop product design and overall conceptual framework based on Kano-TRIZ are revealed. Finally, implications and contributions are summarized in Section 5.

2 LITERATURE REVIEW

2.1 A glance of the Kano model

Kano (1984) suggested quality attribute performance is non-linearly and dynamically correlated with overall satisfaction. Quality attributes can be classified into six categories, i.e., One-dimensional (O), Attractive (A), Must-be (M), Indifferent (I), Reverse (R), Questionable (Q) (Berger, 1993). The category of a quality attribute depends on the CS level and CRs fulfillment levels, as shown in Figure 1, where the x coordinate is the product attribute performance or the degree of requirement fulfillment (from absolute unfulfilled to absolute fulfilled) and the y coordinate is the level of (dis)satisfaction (Chai et al., 2015). For example, the CS linearly increases with the performance of One-dimensional quality attribute. It is worth noting that, for the attractive attribute, even if its performance cannot meet CRs, the overall satisfaction would be positive. By contrast, the must-be attribute would induce a high level of dissatisfaction if its performance cannot meet CRs. Kano model includes three procedures:1) Kano investigation, 2) Kano evaluation, and 3) Kano categorization. In Kano investigation, each CR is examined with a pair of questions, including functional form and dysfunctional form to obtain feedback from both positive and negative aspects. In Kano evaluation, a 5 × 5 dimensions matrix is generated, as shown in Table 1. Then, each product attribute is classified into a specific category in Kano categorization following Table 1. Each product attribute is investigated from two perspectives- meeting CR, or not meeting CR. In this way, the categorization of the investigated requirements of each respondent is defined. The views of respondents may vary as attractive to as must-be. In such cases, the averaged result is considered.

The CR can be displayed in the form of curves in the (un)fulfillment/ (dis)satisfaction coordinate system. Nevertheless, from a practical point of view, a better way should be the use of the satisfaction index (SI) vs. dissatisfaction index (DI), which can be calculated as formulas (1) and (2) (illustrated in Figure 2). A scatter plot that uses the DI as the horizontal axis and the SI as the vertical axis can be established to determine CR classification. Kano model as a means which implores the relationship between the CRs and the satisfaction becomes the breakthrough point to resolve this predicament. The Kano analysis results can provide the right advice on designing the default option in the configuration system.

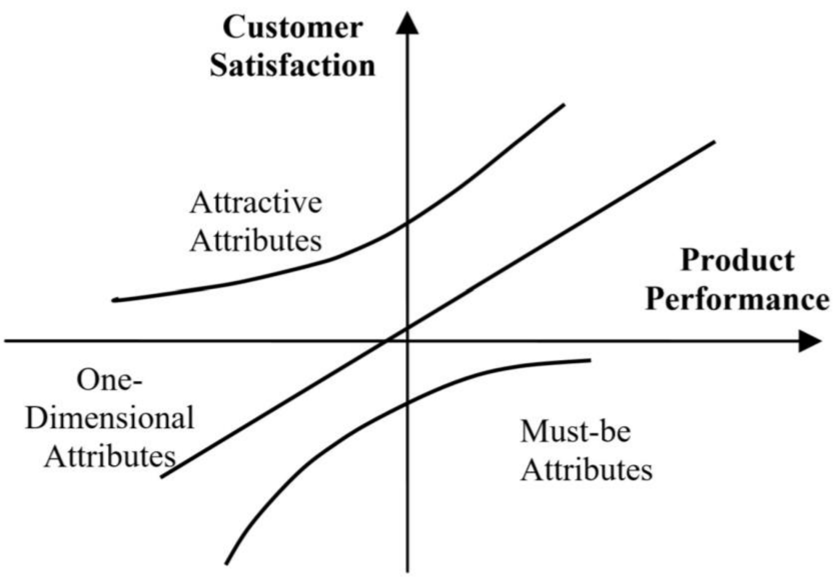

Figure 1 Kano model (adopted form Kano et al., 1984)

Table 1 Two-dimensional attribute classification

		Provide				
		A. Highest satisfaction	B. High satisfaction	C. Satisfaction zero	D. Low satisfaction	E. Lowest satisfaction
Do not provide	A. Highest satisfaction	Question	Attractive	Attractive	Attractive	One-dimensional
	B. High satisfaction	Reverse	Indifferent	Indifferent	Indifferent	Must-be
	C. Satisfaction zero	Reverse	Indifferent	Indifferent	Indifferent	Must-be
	D. Low satisfaction	Reverse	Indifferent	Indifferent	Indifferent	Must-be
	E. Lowest satisfaction	Reverse	Reverse	Reverse	Reverse	Question

$$* SI_i = \frac{A_i+O_i}{A_i+O_i+M_i+I_i} \qquad * DI_i = \frac{M_i+O_i}{A_i+O_i+M_i+I_i}$$

Figure 2 Calculation formula of the SI and DI from Kano model

2.2 Kano for service quality and service design in smart factory

Kano model is a suitable and practical model to capture CRs and the corresponding satisfaction level (Wang & Ji, 2010; He, et al., 2017). Many Kano-based works have been conducted in identifying CS and CRs in product design fields. More and more qualitative and quantitative Kano-based approaches abound in the literature in recent years. The research attention ranges from product design to service design and the combination of them. For example, Ji et al. (2014) adopted the Kano model for identifying CS at different CR fulfillment levels to enhance product design. Violante and Vezzetti (2017) proposed a novel assessment matrix that identified the relationships and classifications requirements between different Kano qualitative and quantitative approaches to assist in selecting the most suitable methodology which responses better in customer-driven product and service design. Ma (2019) presented a Kano-based engineering and operation framework for driving services in the automobile industry. Liu (2012) presented an integration method of Kano model with QFD which provides a method for choosing the most proper modules in the product development process. Sohn et al. (2017) applied Kano model to the triadic relationship in logistics service provision. By applying Kano model, Chen et al. (2011) investigated the categorization of home delivery quality elements derived from the service convenience model and their impact on CS. Lin et al. (2010) proposed a refined Kano-based "quality attributes–satisfaction" model integrating a moderated regression approach with data collected from an online tax declaration service to improve the product quality (Lin, Yang, Chan, & Sheu, 2010). Yang (2005) developed a refined Kano model in which the I-S model was integrated with the "importance" concept on quality decision-making. Wang (2013) combines several methods, including the fuzzy analytical hierarchy process (AHP), fuzzy Kano model with zero-one integer programming (ZOIP), to analyze customers' decision-making process in configuring products.

As a mature method to measure the users' potential requirements and satisfaction, the Kano model has been applied in many fields, such as healthcare, tourism, product design industry, etc.. Faced with the rising healthcare costs and fierce industrial competition, some researchers utilized Kano model to assist the healthcare service suppliers in focusing on the enhancement of patient satisfaction for managing expenditure and improving service efficiency (Hejaili et al., 2009; Chang & Yang, 2010; El-Hashmi & Gnieber, 2013; Sulisworo, 2000; Materla & Antony, 2019; Howsawi et al., 2020; Johnson & Johnson, 2021; Barrios-Ipenza et al., 2021). In the past few years, a lot of studies could provide deeper sights into the tourism industry to probe into the relationship between service quality and tourist satisfaction to better meet customer expectations (Kuo et al.,2016; Cheng & Chen, 2018; Velikova et al., 2017; Pai et al., 2018; Lin et al., 2018; Gregory et al., 2015; Karakuş & Çoban, 2018; Pandey & Sahu, 2020; Sadeghi & Dadgar, 2019; Shen et al., 2021; de Albuquerque et al., 2021). Since Kano is good at transforming the voice of the customer into a series of product development, it always provides a function for acquiring customer preference for potential customer attributes in the product design domain (Wu & Cheng, 2018; Tama & Hardiningtyas, 2015; Yadav et al., 2017; Xiang & Da-peng, 2019; Avikal & Rashmi, 2020; Wu, 2021).

However, the Kano model was initially adopted to explore the diverse and flexible demands in the smart factory under industry 4.0. Qu et al. (2019) proposed an integrated method including fuzzy Kano to capture the preferential SMSs-R and the framework of SMSs-Rs, which leads to a better understanding and precise requirements of the smart manufacturing systems (SMS). Kumar & Routroy (2015) presented an application of the Kano model for achieving manufacturer satisfaction to assist a supplier in achieving Preferred Supplier Status (PSS) to cultivate a long-term relationship with the supplier. Lee et al. (2019) applied Kano to develop a product configuration system to provide digital “Make-to-order” (MTO) service to transform the voice of customers to engineers in the face of the new manufacturing transformation.

In conclusion, only a few Kano-related studies explored dynamic CR in the revolutionary context of Industry 4.0. Relatively little research initiated the studies for the CR analysis of high-complexity products under Industry 4.0 at present (Lee et al., 2019b; Li, et al., 2017; Wang et al., 2017; Lee et al., 2019c). Hence, this study attempts to bridge the research gap by analyzing CR based on the Kano model.

2.3 TRIZ evolution trend-based service design

TRIZ, a practical knowledge-based toolkit, focuses on solving conflict demands and generating creative solutions (Savranksy, 2000). Fey and Rivin (2005) defined TRIZ as a methodology for effectively developing new technology systems and a set of principles that describe how technologies and systems evolve. The premise of TRIZ is that the development and evolution of technology is not a random process, but predictable and subject to certain laws. TRIZ trends analysis was incipiently devoted to recognizing the status quo of technologies development and finding the future evolution directions in industrial fields. Bogatyrev & Bogatyreva (2009) provided ten innovative evolution trends for strategic design to predict future markets in the technology and biology domain. Vidal et al. (2015) utilized Fuzzy Cognitive Maps (FCMs) to link the TRIZ evolution trends and the eco-design for ceramic industry products. Combining the text mining method on patents of magnetic random access memory (MRAM) systems and the underlying principles of TRIZ evolutionary trends, Wang et al. (2010) presented that MRAM concludes ten significant technology trends. Some researchers adopted the TRIZ evolution trends to acquire good patents (Verhaegen et al., 2009; Park et al., 2013; Yoon & Kim, 2011; Park et al., 2012).

The evolution trends and laws not only exist in industrial technology but also in other domains. Mann and Domb (1999) modified the TRIZ trends by collecting more examples and the essential feature of the service and put forward three categories of time, space and interface, to apply them to non-technical fields. Chiang et al. (2013) summarized 18 evolution trends from 32 non-technical trends for the online bookstores to improve the E-commerce service quality. Huang (2017) revised it through interviews with practical experts and creatively proposed 20 evolution trends of the tourism service industry. Lee et al. (2021) applied the TRIZ evolution trends in the public service innovation to propose a Green Chain Smart Recycling and Processing System (GC-SRPS) for enhancing waste management service quality. Pezzotta et al. (2011) put forwards a method to use the Laws of Technical Systems Evolution (LEST) and TRIZ evolution trends to describe the most valuable enhancement breakthrough points that could be made for given Product-Service Systems (PSS).

The TRIZ theory has been widely applied in technology and other fields. However, few researchers have applied it in intelligent factories. This study will fill this gap. The development trend of market and technology does not happen randomly and is promoted according to the evolution pattern. Researchers and development personals can quickly find the core technology in line with these evolution patterns.

3 A Novel Kano-TRIZ Service Design Method

This paper proposes a novel service design method based on Kano model and TRIZ evolution trends. This method titled the “RDS” model (which combines the initial letters of each stage, Figure 3) gives explicit guidelines and a systematic design approach toward achieving requirement-based service innovation. The research framework includes three phases, namely, (1) Requirement-based Service Diagnosis, (2) Design Strategy Generation, and (3) Service System Conceptualization and Evaluation. The entire process considers (1) industry context, (2) customer requirements, (3) key enterprise process, (4) new digital systems, and (5) future scenarios. In the first phase, customer requirements considering industry contexts were collected, identified, and analysed using kano requirement analysis. The second phase consisted of the strategy generation procedures for designing digital transformation based on key enterprise processes by TRIZ evolution trends. Finally, ideas of functions of new digital systems inspired by design strategy considering future scenarios were evaluated based on the new service development maturity model in the third phase. In the following section, the three phases are described in detail.

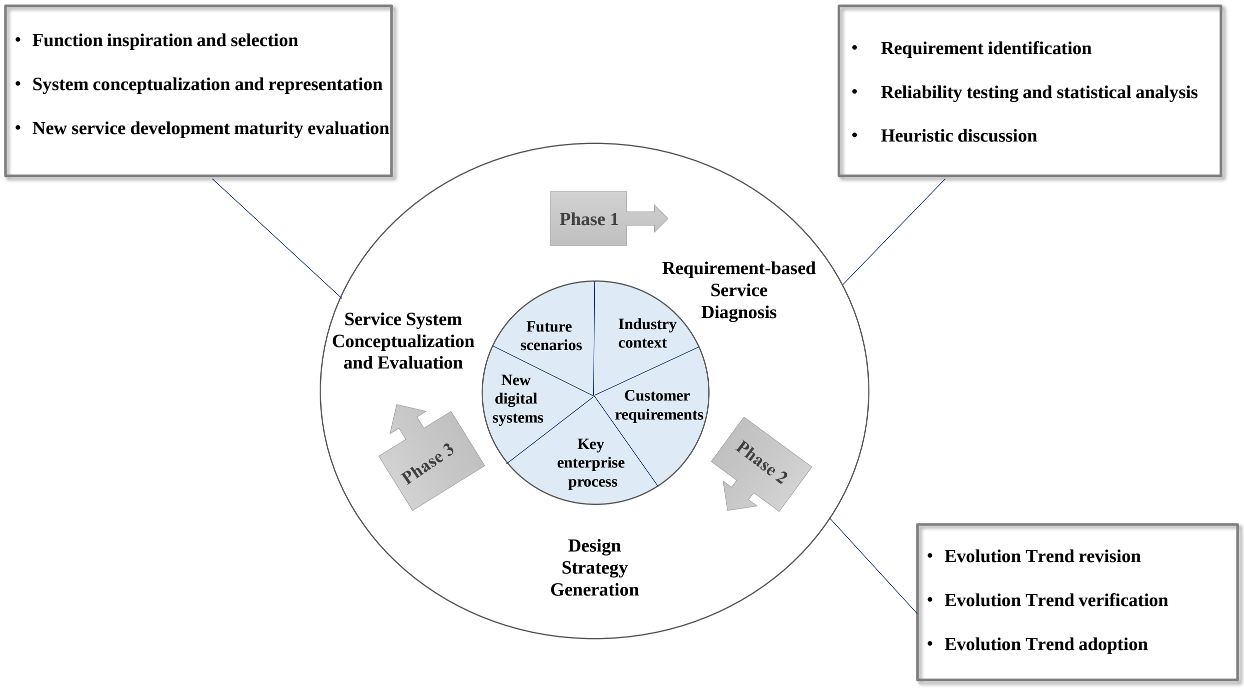

Figure 3: Research framework of the system conceptualization based on Kano-TRIZ design strategy

Phase1：Requirement-based Service Diagnosis

Considering the characteristics of vagueness, incompleteness and time-varying, the ontology model or product design hierarchy need to be constructed for better realizing product configuration before designing a product ordering recommendation system (Chen et al., 2013; Ayundhita et al., 2019; Lee et al., 2020). Due to the fuzziness of CR on electronic products characteristics such as laptops (Esaki, 2013), some requirement knowledge elicitation methods such as interviews, questionnaires, experiments, are taken to achieve matching between customer requirement ontology and product family case ontology (Esaki 2013, Lee et al., 2020). Kano model is one of the questionnaire-based theories for this. Thus, it was adopted for obtaining the product characteristics family which are customer required. After we identify these CRs, we attempt to use these requirement-based product characteristics for designing an expected recommendation system in a smart manufacturing context to enhance the ordering decision-making process considering the fuzziness of electronic products

(Ayundhita et al., 2019).

In terms of the above concerns, the customer knowledge under the background of smart manufacturing is elicited by conducting a Kano survey and analysis in the first phase. The analytics of CR is based on the Kano questionnaire survey (as shown in the Appendix 1). The steps are discussed as follows, including requirement identification, reliability testing and statistical analysis, and heuristic analysis. The CRs in this study refer to the customer preference on products purchasing process, specifically for laptop products in this paper. Hence, Kano questionnaire in this paper takes the product parameters of the laptop as CR.

(1) Requirement identification

This section mainly identifies the requirement and screens the subjects of the questionnaire survey. The survey was carried out among laptop customers. An online survey was conducted to collect data from those who have experience in buying laptops. The survey consists of three demographic questions and eight paired questions related to CR. The demographic questions include gender age and the primary usage of laptops. The remaining eight pairs of questions are corresponding to the eight CRs of laptops. The requirement survey is devoted to asking about customer desires and purchasing motives in the exploratory phase. In this study, we adopt registering the primary product usage to identify the requirements. In addition, the basic information of the recruited Kano survey respondents is also presented in this part.

(2) Reliability testing and statistical analysis

Data collection covering the design and distribution process of Kano questionnaire is conducted in this step. The Kano model was used to understand CR rather than select them. The typical CR, which can reflect the product characteristic, was selected. The preselection allows avoiding overlong questionnaires, which are normally caused by the paired Kano questions, and thusly reduces the risk of a low return rate. With the collected questionnaire, we carried out a reliability investigation and tested positive and negative questions individually. The leading indicator of reliability adopted is Cronbach Alpha. Meanwhile, we conducted the reliability test on the condition of the scenario of excluding the question (variable/item). SPSS was used to conduct the reliability analysis for all the positive and negative questions.

(3) Heuristic discussion

The CR characteristic analysis using Kano model is performed in this step. As before, the Kano survey assists in classifying CRs into six Kano categories (Kano et al., 1984). The sum of all the requirements enables the calculation of two separate indicators: SI and DI. Besides, the statistical analysis is conducted in the SPSS statistical software package with a confidence level set to 0.05. First, descriptive statistics and reliability as a measure of internal consistency were calculated. Second, to analyze relationships between the variables tested, two sets of Pearson-product moment correlations were calculated. Finally, to observe the discrepancy of requirement classification among different users' groups, target group analysis integrating SI, DI, and the identification information of respondents was carried out using the radar chart method. In addition, to test the CR difference in the target groups, the analysis of variance (ANOVA) was conducted on positive and negative questions across gender and age.

Phase 2: Design Strategy Generation

Based on the service failure points from the customer's knowledge, the main task in this phase is to conduct the design strategies with the modified TRIZ evolution trends. Trend revision, verification, and adoption are contained in this phase. TRIZ theory is an approach toolkit that covers all aspects of understanding and solving problems. It always has been used in the industrial field to grab the evolution rules.

(1) Evolution Trend revision

This step focuses on modifying the industrial TRIZ evolution trends to adapt to the smart manufacturing scene. In this study, qualitative research was used to investigate the development rules of intelligent manufacturing from TRIZ evolution. Firstly, the trend of the manufacturing industry was found by literature review and observation. The technical 37 TRIZ evolution trends proposed by Mann (2004) were considered to depict the industrial characteristics (see Table 2). Based on the 37 TRIZ trends, we invited three smart manufacturing experts to view their opinions about intelligent manufacturing's evolution trends. Finally, the result of brainstorming generates the revision of TRIZ evolution trends in the smart manufacturing industry.

Table 2: The 37 evolution trends in technical fields based on TRIZ theory

The 37 evolution trends		
1.Action Coordination	2.Rhythm Coordination	3.Non-linearities
4.Mono-Bi-Poly Sim	5.Mono-Bi-Poly VAR	6.Macro to Nano
7.Smart materials	8.Space segmentation	9.Surface segmentation
10.Object Segmentation	11.Macro to Nano	12.Webs and Fibers
13.Decreasing Density	14.Increasing Asymmetry	15.Boundary breakdown
16.Geometric Evolution Line	17.Geometric Evolution Vol	18.Nesting Down
19.Dynamization	20.Mono-Bi-Poly Sim	21.Mono-Bi-Poly VAR
22.Mono-Bi-Poly Diff	23.Nesting UP	24.Reduced damping
25.Sense Interaction	26.Color Interaction	27.Increasing Transparency
28.Customer Purchase	29.Market Evolution	30.Design Point
31.Boundary breakdown	32.Degrees of Freedom	33.Trimming
34.Controllability	35.Decreasing human involvement	36.Design Methodology
37.Reduce Energy Conv		

(2) Evolution Trend verification

To verify the adaption of TRIZ evolution trends, a reliable experiment was conducted in this step. Reliability analysis was performed by filling out a form to test the participating field experts' degree of mutual agreement on the selection of the TRIZ evolution trends. The mutual agreement degree is calculated by Formula (1), and the reliability is determined by Formula (2). If the mutual agreement degree is more significant than 0.70, the reliability is acceptable (Chen, et al., 2015; Weber, 1990).

$$\text{Degree of mutual agreement} = \frac{2\times\text{number of items completely agreed by two partied}}{\text{number agreed by researcher}+\text{number agreed by domain experts}} \qquad \text{Formula (1)}$$

$$\text{Reliability} = \frac{n\times\text{Degree of average mutual agreement}}{1+[(n-1)\times\text{Degree of average mutual agreement}]} \qquad \text{Formula (2)}$$

[n= Number of experts]

(3) Evolution Trend adoption

In this step, the task is to generate innovative service design strategies by applying the above trends. Throughout the acquisition for development rule of intelligent manufacturing, design strategies for customized service can be extracted out by incorporating the Kano results. The strategies will be mapped in the construction of the new system.

Phase 3: Service System Conceptualization and Evaluation

In this phase, the system structure is conceptualized and visualized according to the proposed design strategies. The process contains function creation, structure conceptualization and representation, and new service development maturity evaluation. The role and the relationship among each function are unfolded in the form of a system structure figure.

(1) Function inspiration and selection

In this step, the primary mission is to create the system functions given the design strategies based on TRIZ modified evolution trends. The novel service design strategies can be extended in the service demands, which transform into system design requirements. It can be divided into diverse system modules and finish the creation of the intelligent function.

(2) System conceptualization and representation

In this step, the work concentrates on completing the data flow and connecting the system functions. Data plays a significant role in the system running and runs through the whole system. It is a valuable tool to connect each module and give a hand in accomplishing the system structure, which presents the relationship of all functions, databases, and data portfolios.

The customized service system considering the customer's position and industrial context is conceptualized in this step. Meanwhile, the subsystems and the detailed design were also well-visualized in this stage.

(3) New service development maturity evaluation

To evaluate the reasonableness feasibility of the new service system, the new service development maturity (NSDM) model by Jin et al (2014) is adopted. To ensure the accuracy of evaluation, five experts with rich theoretical and practical experience in the manufacturing domain are invited to join the panel discussion and evaluation. We can evaluate their previous service quality with the NSDM model. After that, the comparison of the maturity of the current and new service processes was represented by a radar chart. The maturity assessment is conducted using twelve dimensions based on the NSDM model, inclusive of **strategy goals, strategy specifications, resource distribution, systematic procedure, formal paperwork, responsibility assignment, organization culture, process, service technology, customer role, involvement stages, and involvement method**. The radar charts of the previous and expected service system were depicted based on the assessment attributes with five levels: 0-none, 1-basic level, 2-transparent level, 3-aware level, 4-autonomous level, and 5-integrated level.

4 Case Study: Customized Product Order Fulfillment System Design

A comprehensive case with the new service system design for better quick response for the order placement of the laptop production process is illustrated for verifying the proposed design method in this section. The RDS design phases are analyzed and implemented phase-by-phase as follows.

4.1 Requirement-based service diagnosis

4.1.1 Requirement identification

A. Online survey

The survey was carried out among laptop customers. An online survey was conducted to collect data from those who have experience in buying laptops. The survey consists of three demographic questions and eight paired questions related to CR. The demographic questions include gender, age, and the primary usage of laptops. To construct the selection pool for primary laptop parameters, reference data is obtained from UserBenchmark (http://www.userbenchmark.com/), which is a platform that tests and evaluates thousands of PC and laptop components with millions of benchmarks and votes. The remaining eight pairs of questions are corresponding to the eight CRs of laptops. One hundred twenty-three participants were recruited for this evaluation, and 120 valid questionnaires were finally obtained and analyzed in this study. The obtained data are sufficient to illustrate the Kano model-based CR analysis. All the following statistical processes take the sample size into account, whether in the situation of the confidence level, the p-value level, or other suitable metrics. According to the gender, the 120 respondents consist of 48 males and 72 females. The respondents with an average of 27.5±8.7 years old were divided into four groups based on their age, including 16-25, 26-35, 36-45, 46, and above.

B. Analysis of the basic information of the respondents

A total of 120 respondents participated in the investigation. The sample consists of customers from four age ranges:16-25, 26-35, 36-45, 46 and above. The respondents cover male and female users. Table 3 shows the number of respondents from the gender perspective.

Table 3: The relationship between the gender of respondents and the usage

	A (Basic Office Work)	**B (Design Work)**	**C (Gaming)**	**D (Professional)**	**E (others)**	**Total**
Female	45 (62.50%)	11 (15.28%)	3 (4.17%)	11 (15.28%)	2 (2.78%)	72
Male	27 (56.25%)	9 (18.75%)	5 (10.42%)	7 (14.58%)	0 (0.00%)	48

Note: The values in parentheses in the table are all line percentages.

As shown in Table 3, there are 48 males (40%) and 72 females (60%). It is not difficult to find out that both male and female users, the main CRs for purchasing the laptop is “Basic Office Work”. The requirements of females and males for “Basic Office Work” was 62.50% and 56.25%, respectively. While for “Gaming”, males show a higher value (10.42%) than that of females (4.17%). Then, we analyze the relationship between the age of respondents and the usage in Table 4.

Table 4: The relationship between the age of respondents and the usage

	A Basic Office Work	**B Design Work**	**C Gaming**	**D Professional**	**E Others**	**Total**
B (16-25)	40 (57.14%)	15 (21.43%)	2 (2.86%)	12 (17.14%)	1 (1.43%)	70 (58.33%)
C (26-35)	12 (50.00%)	5 (20.83%)	4 (16.67%)	3 (12.50%)	0 (0.00)	24 (20%)
D (36-45)	17 (73.91%)	0 (0.00%)	2 (8.70%)	3 (13.04%)	1 (4.35%)	23 (19.1%)
E (46and above)	3 (100.00)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	3 (2.5%)
Total	72	20	8	18	2	120

Note: The values in parentheses in the table are all line percentages.

Table 4 shows that 58.33% of respondents fall into the group of 16-25. The percentages in the interval of the 26-35 and the 36-45 were 20% and 19.17%, respectively. Only 2.50% of the respondents are aged over 46. By collecting data from users ranging from 16-years old to over 46-year old, the survey is expected to provide objective and comprehensive data for this analysis. It can be found that Basic office work is still the primary usage among all the age groups users. Besides, after the Basic office work, it is the Design work and Professional work such as programming are popular among teenagers or juniors whose age is between 16 and 35. This phenomenon is in line with the fact that more teenagers are currently engaged in professional work, such as designing or programming. In a word, the age factor owns a particular influence on the primary usage of laptops.

4.1.2 Reliability testing and statistical analysis

This section mainly operates statistical analysis in three aspects: reliability testing, frequency data and other basic indicators. Before analysis, two tasks are performed: first, convert letters to numbers. In this study, option A meant the highest satisfaction and was set as “1”; option E indicated the lowest satisfaction and was converted to “5”. Second, generally, most of the positively formulated responses showed within the range of satisfaction and most of the negatively formulated responses showed within the rage of dissatisfaction.

A. Reliability testing

With the collected questionnaire, we carried out a reliability investigation and tested positive and negative questions individually. The leading indicator of reliability adopted is Cronbach Alpha. Meanwhile, we conducted the reliability test on the condition of the scenario of excluding the question (variable/item). SPSS was used to conduct a reliability analysis for all the positive and negative questions.

Table 5 and Table 6 show the results of the reliability test. As shown in Table 5, with positively formulated questions, the value of Cronbach’s alpha is 0.594. It is only slightly higher than the suggested value of 0.5. Since questions are broader, it is considered to be significant to a certain degree. To ensure the rigor of statistical research, we used iterative elimination to check the internal consistency of the used scale. The results are listed in Table 6.

Table 5: Positive Reliability Statistics

Cronbach’s Alpha	**Cronbach’s Alpha Based on Standardized Items**	**N of Items**
0.594	0.592	8

Table 6: Positive items overall statistics

		Scale mean if item deleted	Scale Variance if item deleted	Corrected item-Total correlation	Cronbach's Alpha if item deleted
Positive	Biz	11.283	9.270	0.196	0.575
	Multimedia	11.583	8.560	0.262	0.560
	Computation	11.483	8.716	0.225	0.571
	Storage	11.233	8.046	0.258	0.567
	Display	11.483	7.916	0.366	0.527
	Audio	11.467	7.482	0.464	0.494
	Battery life	11.750	8.804	0.275	0.556
	Cooling system	11.475	8.466	0.325	0.542

The information shown in Table 6 refers to the Cronbach's alpha coefficient value after the topic is removed from the questionnaire. It can be clearly seen that the value in this column is lower than 0.594, which is the value before the deletion. In almost all cases, removing a positive question would lead to a reduction in the whole consistency. Therefore, it is unreasonable to delete any positive items from the questionnaire. The group of negatively formulated questions reached a higher value of the Cronbach's alpha, i.e., 0.856, by using the same process, which is shown in Table 7. Table 8 shows the results of the reliability test, which is calculated after the scenario of removing individual variables. The data in the last column of Table 8 are all lower than 0.856. In other words, deleting negative questions of any requirement will result in a decline in overall consistency. In summary, since the value of Cronbach's alpha did not increase, the scenario of removing individual variables did not increase the survey reliability and more analysis should be conducted with the original group of items.

Table 7: Negative Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	No. of Items
0.856	0.857	8

Table 8: Negative items overall statistics

		Scale mean if item deleted	Scale Variance if item deleted	Corrected item-Total correlation	Cronbach's Alpha if item deleted
Negative	Biz	28.892	20.263	0.606	0.816
	Multimedia	29.083	21.876	0.510	0.826
	Computation	29.383	21.036	0.573	0.819
	Storage	28.908	21.350	0.609	0.815
	Display	29.058	21.772	0.580	0.819
	Audio	29.275	21.966	0.545	0.822
	Battery life	28.850	20.194	0.682	0.806
	Cooling system	29.242	20.833	0.631	0.812

B. Analysis of the data frequencies

An overview of all five levels of the investigated requirements is provided in Table 9. and the related statistical analysis is unfolded below.

(1) From the analysis of Table 9, the highest level of satisfaction will be met by meeting the CR7 (Battery life) and CR2 (Multimedia). From a realistic view, for most users, battery life and multimedia are CR that they always use in their daily life. Therefore, these two requirements rank among the critical ones from the perspective of users, and a conclusion could be achieved. Thus, they can affect the whole level of users' satisfaction significantly.

(2) Nevertheless, how will it be discontent if we do not fulfill some of the following eight requirements? In the case of the CR1, the number of users who will be upset gets the highest again in the CR1 (Biz), CR4 (Storage), and CR7 (Battery life). Previous results have partially confirmed this. Results pointed out the critical status of the primary office work in the user experience and its influence on the overall satisfaction of users.

(3) At the same time, if the laptop performances badly in CR8 (Cooling system), CR5 (Display), and CR6 (Audio), a few users feel dissatisfied but barely acceptable.

(4) It is worth noting that in the case of the CR7 (Battery life), this attribute is significant to those belonging to a relatively large group of respondents: 89 respondents (in fulfilling this requirement) and 77 respondents (in its unfulfillment). Therefore, it can be estimated that the degree of user satisfaction is proportional to the satisfaction degree of Battery life.

Table 9: The frequencies data for all eight pairs of investigated requirements

		A	B	C	D	E	SUM
Positive	Biz	33	77	9	1	0	120
	Multimedia	79	19	22	0	0	120
	Computation	68	29	23	0	0	120
	Storage	56	29	31	3	1	120
	Display	68	33	17	2	0	120
	Audio	71	23	24	2	0	120
	Battery life	89	21	9	1	0	120
	Cooling system	62	40	18	0	0	120
Negative	Biz	0	13	13	13	81	120
	Multimedia	0	5	27	32	56	120
	Computation	0	8	42	29	41	120
	Storage	0	6	15	32	67	120
	Display	0	5	19	45	51	120
	Audio	0	4	34	44	38	120
	Battery life	1	9	9	24	77	120
	Cooling system	1	7	25	45	42	120

4.1.3 Heuristic discussion

The works related to Kano theory are carried out in this part: requirements classification, requirement analysis based on the user's personal basic information, and discussion of Kano results. We treated these groups as "CR," including CR1-business (Biz); CR2-Multimedia; CR3-Computation; CR4-Storage; CR5-Display; CR6-Audio; CR7-Battery life; CR8-Cooling. Kano approach requires each requirement to be classified according to the answers of both positive and negative questions. Before answering the questions, the subjects were given a brief introduction about the research objective and the eight investigated requirements to reduce the risk of misleading responses. Then, respondents reported their satisfaction levels with a 5-degree scale, ranging from "Wow!! This attribute is awesome! I like it", to "This attribute is a must. It should always come along with the product", "I don't care about this attribute", "This attribute is not good. But I can still accept it", and up to "No, I don't like this attribute at all". The revised evaluation sheet was then used to evaluate answers (Lee et al., 2011).

A. Requirement classification

The Kano classification results of the eight requirements for 120 respondents are separately quantified in Table 10. The SI and DI of each requirement are calculated according to the aforementioned formula. The DI is the horizontal axis and the SI is vertical. A scatter plot of eight requirements is drawn in this two- dimensional map of the axis, which in turn yields a classification of the eight requirements. The CR is shown in the form of SI/DI plot in Figure 4.

The eight requirements are classified in Figure 4 and the results are generally consistent with the previous analysis, which verifies the correctness of the above results. The analysis of the category results in Figure 4 shows that CR2, CR3, CR5, CR6, and CR8 are in the Attractive dimension, where the ratio between potential satisfaction (in case of requirement fulfillment) and potential dissatisfaction (in case of requirement unfulfillment) is positive. Based on the results, CR1 (Biz) and CR4 (Storage) are classified into the Must-be Quality dimension. Meanwhile, CR7 (Battery life) is in a One-dimensional dimension.

Table 10: The calculation results of SI and DI index

	A	O	I	M	R	Q	Total	Kc	*SI	*DI
Biz	13	20	26	**61**	0	0	120	M	0.275	0.675
Multimedia	35	**44**	29	12	0	0	120	O	0.658	0.467
Computation	**41**	27	38	14	0	0	120	A	0.567	0.342
Storage	25	31	28	35	0	1	120	M	0.471	0.555
Display	**40**	28	29	21	0	2	120	A	0.576	0.415
Audio	**45**	26	37	12	0	0	120	A	0.592	0.317
Battery life	27	**62**	15	15	1	0	120	O	0.748	0.647
Cooling system	38	23	**39**	19	0	1	120	I	0.513	0.353

The SI/DI index can be used to determine the degree of the functional impact. SI index can be interpreted as an increased satisfaction coefficient. DI index means that if a certain functional attribute was provided, user satisfaction would increase. DI index can be called the dissatisfaction coefficient after elimination. It means that if a certain functional attribute is not provided, user satisfaction will decrease. It is worth noting that the DI index represents a negative relationship. The larger the DI value, the greater the impact on user dissatisfaction, and the greater the impact of reduced satisfaction. For example, according to the results in this research, “Battery life” is a one-dimensional (expected) functional attribute of laptop computers by consumers, and it is the first feature that manufacturers should consider as an enhanced feature. In addition, Multimedia, Computation, Display, Audio, and Cooling are attractive functions that can make consumers excited. There is a direct correspondence between consumer requirements and Kano model attributes (Figure 5). In this study, the mapping figure obtained by the SI/ DI index is shown in Figure 4.

According to the mode, the resulting category can be determined. Almost all the requirements belong to category A (attractive). However, more than half of the subjects considered the requirements CR7 (Battery life) as One-dimensional. Therefore, it is probably the battery fields through which the higher configuration can improve the potential satisfaction of users. The results also show that the CR8 (Cooling system) can be seen as a relatively indifferent requirement. This means that satisfying this requirement by better configuration can hardly enhance the satisfaction or dissatisfaction of the users. The CR1 (Biz) can be seen as the requirement thoroughly, whose unfulfillment leads to a high proportion of users' dissatisfaction. It reveals that basic office function to users is a critical factor in the perceived quality of the product.

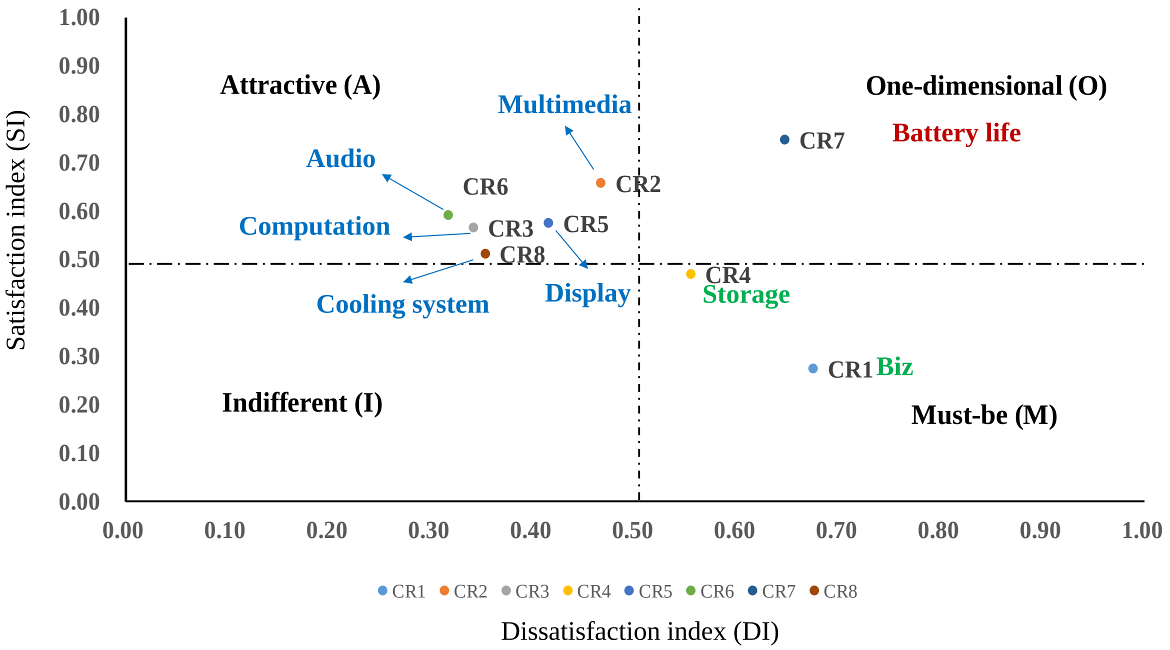

Figure 4: The results of CR categorization based on the Kano Model

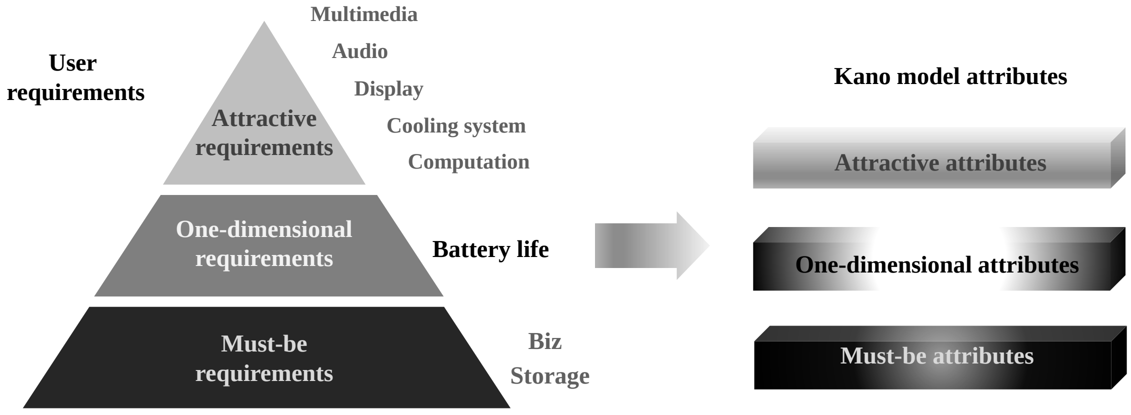

Figure 5: Correspondence between user requirements and Kano model attributes

B. Requirement analysis based on the user's personal basic information

For all groups of respondents, the previous results present an overall categorization of their requirements. It can also be obtained based on the demographic variables of the respondents, namely, gender and age, stratifying the data. First, an ANOVA was conducted on the positive and negative questions across gender. The significant difference of the mean response in the positive question of "display" has been found between male and female, with $F_{(1, 119)} = 4.17$, $p = 0.04 < 0.05$.

Figure 6 shows the SI and DI ratio towards the perception of the eight requirements in the males and females. Based on Kano methodology, these radar charts below can be explained according to the following criteria. The higher the dominance of SI over DI, the more attractive the requirement is. The reverse is also true that if DI dominates over SI, the requirement is most inclined to be a must-be. Hence, Figure 6 generates the following findings.

Male users consider display mostly an Indifferent attribute, while for female users, it is mostly an Attractive attribute. It is ordinary because women usually take the laptop as a video player and the Display function is a critical requirement for them. The relative values for the display are shown in Table 11.

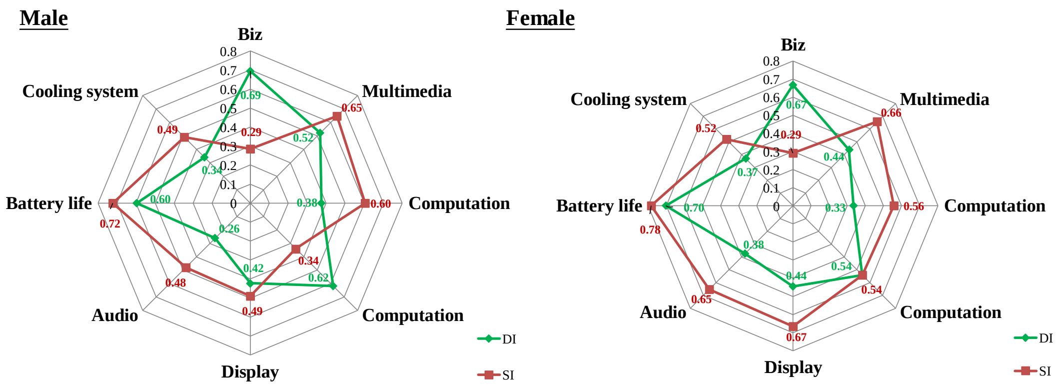

Figure 6: Satisfaction index (SI) and Dissatisfaction index (DI) in seven requirements relative to gender; Male (**left**); Female (**right**)

Table 11: The value of satisfaction index (SI) and Dissatisfaction index (DI) about CR5 (Display) based on gender

	gender	SI	DI	Categorization of Requirements
CR5(Display)	Male	0.46	0.46	Indifferent
	Female	0.64	0.64	Attractive

The analysis for Figure 7 is as follows:

(1) For CR2 (multimedia), the significant difference of the mean response in the positive question of it has been found between group “16-25” and group “26 - 35”, with $F_{(1, 94)} = 4.55$, $p = 0.036 < 0.05$. we can find that this requirement for young people in group “16-25” is attractive, but for group “26 - 35”, it changes into the Must-be. In this case, one could suppose that less experienced users have relatively low requirements on multimedia.

(2) CR3 (computation) is another interesting requirement, the significant difference of the mean response in the positive question of it has been found between group “16-25” and group “36 - 45”, with $F_{(1, 94)} = 5.89$, $p = 0.017 < 0.05$. It shifts from Indifferent to Must-be. In a way, it is natural because group “36 - 45” usually devote to intensive and immense computational work and the computation capacity is critical for them. The relative values for the above two requirements are shown in Table 12.

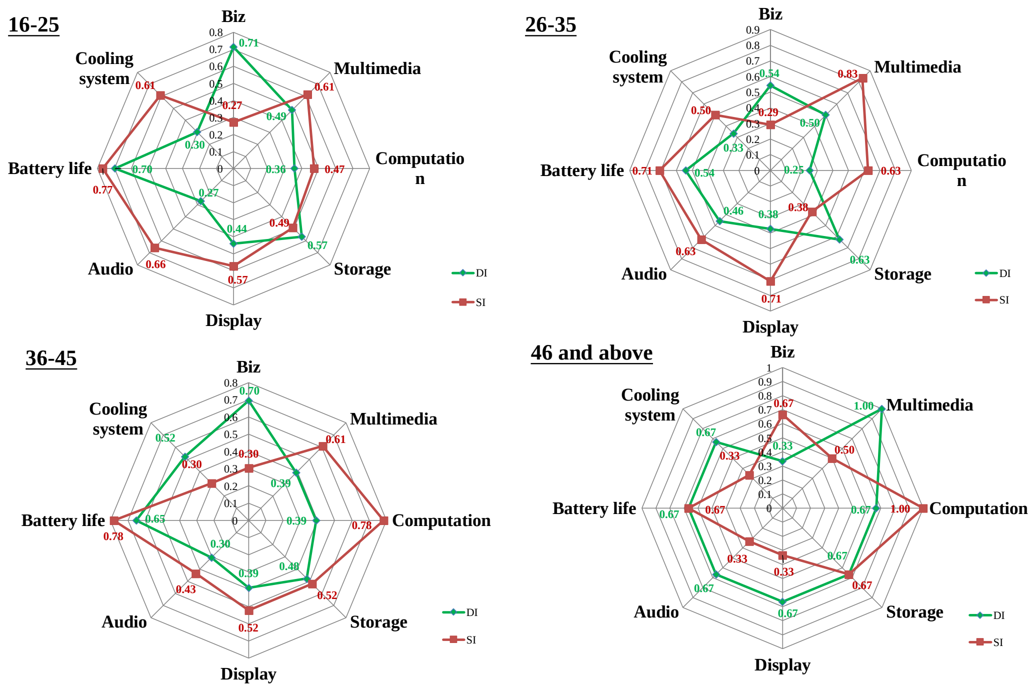

Figure 7: Satisfaction index (SI) and Dissatisfaction index (DI) in seven requirements relative to age

Table 12: The value of satisfaction index (SI) and Dissatisfaction index (DI)about CR2 and CR3 based on age

	age	SI	DI	Categorization of Requirements
CR2(Multimedia)	16~25	0.61	0.49	Attractive
	26~35	0.50	0.83	Must-be
CR3(Computation)	16~25	0.36	0.47	Indifferent
	36~45	0.39	0.78	Must-be

C. Discussion of Kano results

The analyzed results of the laptop CRs are summarized as the following Table 13. The table presents the overall influence of the identified attributes in the laptop case on the CS. The results of the other statistical and target group analysis are also shown in the table.

It needs to be mentioned that these results are only illustrative. The size of the sample is just 120 respondents and this stratification makes it even smaller. In spite of this defection, the presented results can be regarded as an appropriate demonstration of a broader and in-depth analysis of requirements. If the previous process goes with big data from the broader users, enterprises can explore richer potential requirement information. The above Kano results combining revision TRIZ evolution trends can help the company to configure a product that can make the customer obtain the maximum satisfaction of the users under limited conditions and realize quick customization.

Table 13: The overall results of the Kano model

CR	CR name	If fulfilled	If unfilled	Other findings
CR1	Biz	It has the lowest influence on satisfaction.	Most respondents indicated that they were dissatisfied or very dissatisfied.	Most stable requirement
CR2	Multimedia	A lot of respondents indicated that they were satisfied or very satisfied.	It is dominated by a middle level of dissatisfaction.	High potential requirement
CR3	Computation	It is dominated by a middle level of satisfaction.	It is dominated by a lower level of satisfaction.	Attractive requirement
CR4	Storage	It is dominated by a lower level of satisfaction.	It has a high influence on dissatisfaction.	Least stable requirement and it has a wide distinction on the users' gender
CR5	Display	It is dominated by a middle level of satisfaction.	It is dominated by a middle level of dissatisfaction.	It has wide distinction on the users' gender.
CR6	Audio	Many respondents indicated that they were satisfied or very satisfied.	It has the lowest influence on dissatisfaction.	Attractive requirement.
CR7	Battery life	Most respondents indicated that they were satisfied or very satisfied.	Many respondents indicated that they were dissatisfied or very dissatisfied.	Most linear, most potential requirement.
CR8	Cooling system	It is dominated by a slightly lower level of satisfaction.	It is dominated by a slightly lower level of satisfaction.	Relative indifferent requirement and it has wide distinction on the users' age.

4.2 Design strategies generation

4.2.1 Evolution trend revision

Through combing historical and literature materials, we found 37 industrial evolution trends. Experts and practitioners revised them and sorted out 20 evolution lines that conform to the intelligent manufacturing field's background and situation (see Table 14). The detailed interpretation of 20 specific evolution processes is shown in Appendix 2.

Table 14: The modified TRIZ evolution trends for the manufacturing domain

Original 37 evolution TRIZ trends	**Revision 20 evolution TRIZ trends with empirical interview**	**Specific explanation of evolution process in manufacturing domain**
1.Action Coordination	Services Flexibility (#1)	Sale-To-Order (STO)→Assemble-To-Order (ATO)→Make-To-Order (MTO)→Engineer-To-Order (ETO)
2.Rhythm Coordination	Service Efficiency (#2)	Cumbersome and unitary work→Sectional optimization of a single chain→Global resource optimization
3.Non-linearities	Adaptability to the external environment (#3)	Forced response to circumstances→ Proactively address environmental changes
4.Mono-Bi-Poly Sim.	-	-
5.Mono-Bi-Poly VAR.	-	-
6.Macro to Nano	Attitude towards user feedback (#4)	Handle customers' complain passively→Actively acquire user's requirement→Service communication channel based on the feedback system
7.Smart materials	-	-
8.Space segmentation	-	-
9.Surface segmentation	-	-
10.Object Segmentation	Customization degree (#5)	Mass customization→Tailor-made product for a target users' groups →Personalized precise customization (S1)
11.Macro to Nano	-	-
12.Webs and Fibers	-	-
13.Decreasing Density	-	-
14.Increasing Asymmetry	Increasing service interface (#6)	Participation at the end of the service process→Participation in the whole service process using the user interface
15.Boundary breakdown	User to interact with manufacturing (#7)	Passively accept users' requirements→Actively propose the needs→ Self-participate in the process of developing, designing, and manufacturing activities (S2)
16.Geometric Evolution Line	Increase market publicity (#8)	Physical factory→Two publicity methods→Three publicity methods →Multiple publicity methods
17.Geometric Evolution Vol	-	-
18.Nesting Down	-	-
19.Dynamization	Resilience of order processing system (#9)	Mechanical mass production→Flexible manufacturing based on order→Make-to-order customization production
20.Mono-Bi-Poly Sim	Increase sales of additional products or	Additional service/product provision→Multi-domain operating development→Comprehensive development

	services in tourism (#10)	
21.Mono-Bi-Poly VAR	-	-
22.Mono-Bi-Poly Diff	Cross-domain product or service portfolio (#11)	Incidental products or services in the main business→Package of products or services in the relevant domain→Integration of cross-domain products or services
23.Nesting UP	Consumer demand level (# 12)	Rigid requirement-Flexible requirement (S3)
24.Reduced damping	Virtualize consumption process (#13)	Offline purchase channels→E-commerce platform→Accurate response model
25.Sense Interaction	Product perception (#14)	Product attribute performance→Elementary sensorial reflection→Advanced psychological reflection
26.Color Interaction	Add featuring services (#15)	Elementary service recommendation to enhance obvious satisfaction →Advanced service recommendation to enhance potential-satisfaction→Customized service recommendation to enhance comfortable-experience
27.Increasing Transparency	Service process transparency (#16)	Convert→Sectional transparent→Wide-open
28.Customer Purchase	-	-
29.Market Evolution	Customer expectation (#17)	Expectation achievement basically→Expectation contentment furthest→Expectations satisfied exceedingly
30.Design Point	-	-
31.Boundary breakdown	-	-
32.Degrees of Freedom	-	-
33.Trimming	-	-
34.Controllability	Controllability (#18)	Periodic monitoring→Total quality control→Real-time total quality management for industrial chain
35.Decreasing human involvement	Decreasing human involvement (#19)	Human resource-oriented participation→Partial machine participation→Automation operation driven by data flow
36.Design Methodology	-	-
37.Reduce Energy Conv	Cost reduction (#20)	Fund control→Spend management→Cost optimization control→Optimal distribution of existing resources

4.2.2 Evolution Trend verification

Reliability analysis is performed by inviting experts and practitioners to fill the investigation form. As shown in Table 15, the degree of agreement between the practitioners and each expert was 1, 0.94%, and 0.89%. Simultaneously, the reliability index was 0.981, both greater than 0.70, indicating that the reliability was acceptable.

Table 15: Reliability experiment for modified TRIZ evolution trends

Modified TRIZ evolution trends		Agreement/disagreement of three domain experts level			
		1	**2**	**3**	**Degree of the domain experts agreement level**
#1	Services Flexibility	○	○		66.7%
#2	Service Efficiency	○	○	○	100%
#3	Adaptability to the external environment	○	○		66.7%
#4	Attitude towards user feedback	○	○	○	100%
#5	Customization degree	○	○	○	100%
#6	Increasing service interface	○	○	○	100%
#7	User to interact with manufacturing	○	○	○	100%
#8	Increase market publicity	○	○	○	100%
#9	Resilience of order processing system	○	○	○	100%
#10	Increase sales of additional products or services in tourism	○	○	○	100%
#11	Cross-domain product or service portfolio	○	○	○	100%
#12	Consumer demand level	○	○	○	100%
#13	Virtualize consumption process	○	○	○	100%
#14	Product perception	○		○	66.7%
#15	Add featuring services	○	○	○	100%
#16	Service process transparency	○	○	○	100%
#17	Customer expectation	○	○	○	100%
#18	Controllability	○	○	○	100%
#19	Decreasing human involvement				
#20	Cost reduction				
Total		18	17	16	
Degree of agreement with the researcher		1	0.94%	0.89%	
Reliability			0.981		

○Indicates agreement; blank indicates disagreement.

4.2.3 Evolution trend adoption

Based on the 20 evolution trends and case companies' ideas in order processing, this article innovatively put forward the future application prospects. At the same time, it takes the product configuration process of notebook computers as an example in view of the customization degree (# 5), the user to interact with manufacturing (#7), and the consumer demand level (#12) innovation principles of three high explanatory notes.

Strategy 1: Precise diffraction strategy

Figure 8: The modified evolution trends for customization degree

Every company exists for that it satisfies the particular needs of customers. For traditional enterprises, market research is an essential method to obtain customer needs. The usual practice is to define a certain range of target users rather than each user. Therefore, it is difficult for enterprises to meet each specific demand when defining and designing products. The Internet platform represented by e-commerce enables enterprises to break out of the narrow competitive space. Through big data analysis, enterprises can choose customers more actively, identify customer needs more effectively, and develop products and services that meet the needs of target customers more pertinently, as shown in Figure 8.

S1 (Precision diffraction strategy): By capturing necessary user information and historical customized order information from the front end of the product configuration system, the Kano model is used to quantitatively analyze and calculate product performance and preferences for the target groups. It can obtain the diverse requirements of product attributes for different consumer groups and the analysis results can be used in the service design of the recommended default configuration project in the system, which can help companies change the passive marketing method to active and accurately grasp user preferences to provide more customized products and service.

Strategy 2: Regenerative chain strategy

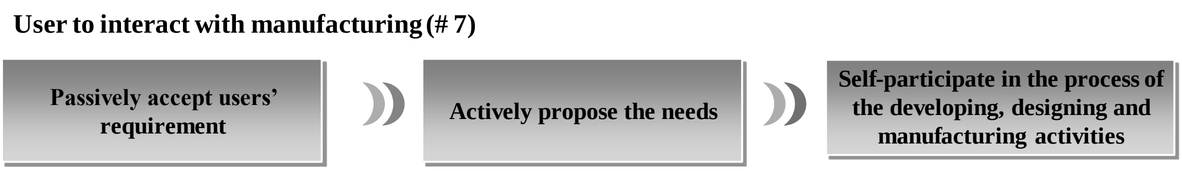

Figure 9: The modified evolution trends for users to interact with manufacturing

Some companies develop social customer relationship management based on emerging internet technologies such as the Internet of Things, big data, cloud platforms, and other means. By establishing user databases, they conduct big data portraits of user consumption behaviors, changing passively satisfying user needs into interactive active interaction. Through the continuous development of intelligent manufacturing systems, user needs can be wholly retained and analyzed. Customer preferences will be integrated as a reference factor in the product development and manufacturing process to maximize users' satisfaction and improve customer satisfaction. The evolution process is shown in Figure 9.

S2 (Regenerative chain strategy): Admittedly, there is always a particular information gap between the service demander and the service provider. In certain situations, there may be some conflict between customer requirements and engineering characteristics. Combining the Kano model and other models in the system design can work in the connection function, build a bridge between producers and consumers, reduce the communication time costs, and increase resource utilization efficiency. Kano analysis results show that disparate product features have significantly different attractiveness for users. If the relationship between the CSs are qualified into the different mathematical models and is employed into the algorithm design process of the configuration system, the company's resources will be transferred to more attractive products attributes. The feedback service mainly focuses on triggering out a CS-measure questionnaire into the customer's mailbox after purchasing and having experience with the products. The technical developer will use the results to fertilize the database of parts optimization options. The feedback loop can remedy the gap between the two terminals of the service and help enterprises seize preemptive opportunities to maximize customer satisfaction.

Strategy 3: Flexible accommodation strategy

Figure 10: The modified evolution trends for customer demand level

As seen in Figure 10, under the new consumption pattern, consumers' demand has also changed, from the rigid need based on function and price into the elastic demand that takes quality, experience, value proposition, and other factors into consideration. The first is the emergence of well-chosen, users prefer to boutiques. Secondly, customers' behaviors have begun to be rational and mature. They hope to pursue superior products at a reasonable price. Under the "new consumption," the selection has gradually become the mainstream demand from the traditional subdivision need, and the user demand is also increasingly diversified and differentiated. S3 (Flexible accommodation Strategy): The elasticity of consumer demand urges companies to enhance order processing flexibility. To meet the diverse and complex needs of users, the product order fulfillment system provides scientific and efficient adjustment services based on the customer profile, including the expected budget and other special requests to enrich the marketing model. According to the Kano model category, the adjustment priority for the default configuration projects was determined to improve the flexibility and initiative of service, with the orientation of rapid response to demands' changes.

C. Analysis of other basic indicators

After analyzing the frequencies, it is possible to calculate the primary indicators of the position and variability of potential satisfaction. The results are shown based on the positively and negatively formulated questions (as shown in Table 16).

(1) As confirmed with the beforementioned results of frequencies, meeting the CR7 (Battery life) and CR2 (Multimedia) can achieve the highest potential satisfaction. As meanwhile, these two requirements rank are one of the relatively stable positive elements affecting satisfaction.

(2) In the positive direction, conversely, meeting CR1 (Biz) brings the lowest satisfaction. At the same time, this requirement is the most stable positive element.

(3) The CR4 (Storage) requirement ranks among the least stable positive elements (that is, the answers of respondents differed significantly). The highest level of variability in Table 9, Standard Deviation (St Dev) and Confidence Intervals (CI for mean), confirmed this point.

(4) In the negative direction, the highest potential dissatisfaction can be realized by dissatisfying the CR7 (Battery life).

(5) The CR1 (Biz) requirement ranks are one of the least stable harmful elements, and at

the same time, meeting this requirement induces higher potential dissatisfaction.

In summary, two interesting points can be found. First, if satisfying the CR1 (Biz), it will not bring too much satisfaction, while, if not, it will do bring great dissatisfaction. Second, when CR7 (Battery life) is satisfied, it will bring greater satisfaction, while, when it does not be satisfied, it will bring great dissatisfaction.

Table 16: Basic characteristics of CRs (un)fulfillment

		N	Mean	StDev	95% CI for mean	
Positive	Biz	120	1.8250	0.6146	1.7150	1.9350
	Multimedia	120	1.5250	0.7849	1.3846	1.6654
	Computation	120	1.6250	0.7859	1.4844	1.7656
	Storage	120	1.8750	0.9623	1.7028	2.0472
	Display	120	1.6250	0.8472	1.4734	1.7766
	Audio	120	1.6417	0.8544	1.4888	1.7945
	Battery life	120	1.3583	0.6806	1.2366	1.4801
	Cooling system	120	1.6333	0.7295	1.5028	1.7639
Negative	Biz	120	4.3500	1.0460	4.1628	4.5372
	Multimedia	120	4.1583	0.9128	3.9950	4.3217
	Computation	120	3.8583	0.9686	3.6850	4.0316
	Storage	120	4.3333	0.8788	4.1761	4.4906
	Display	120	4.1833	0.8464	4.0319	4.3348
	Audio	120	3.9667	0.8557	3.8136	4.1198
	Battery life	120	4.3917	0.9686	4.2184	4.5650
	Cooling system	120	4.0000	0.9309	3.8334	4.1666

4.3 Service system conceptualization and evaluation

4.3.1 Function inspiration and selection

Throughout the above three design strategies, we can design a Customized Product Order Fulfillment System to assist in the response for future and expected flexible manufacturing scenarios. The Customized Product Order Fulfillment System contains four functions: Recommending service (F1), Adjustment service (F2), Order service (F3), and Feedback service (F4).

S1 (Precise diffraction strategy) extends into the F1. Throughout the Kano-based market survey, it can acquire the target users' groups' preferences which can be employed to recommend the default order project using portrait technology. Specifically, combining the users' necessary information with the historical order message, cloud computing technology collects the requirement preference tendency of the customized configuration project for different users' groups, such as office staff, professional game players. The analysis results can be utilized in the back-end setting of the default configuration scheme. It means that when customers input basic identity information at the user interface to allow character portrait, the system automatically provides the recommended laptop configuration project based on historical big data.

S3 (Flexible accommodation strategy) is mapped into the F2 and F3. By collecting the clients' specific ordering demands by the interface for clients to generate a digital solution, the default project can be adjusted dynamically to feat the diverse needs and facilitate order processing flexibility. In other words, the adjustment priority could be confirmed by the sensibility of Kano categories, which leads to polishing the original recommended configuration results with maximizing the impact of customers' satisfaction. Product order fulfillment system allows users to own additional adjustment services to meet diverse and complex demands, such as laptop expected budgets and other specific requirements to flourish the flexibility and validity of the order processing. With the quick response to order modification and optimization, the system can place an order of the final customized project.

S2 (Regenerative chain strategy) leads to the F4. After the delivery of products, the system triggers a feedback questionnaire to measure the service/ product quality. The results can be utilized in the optimization for the Customer profile DB and the Engineering characteristic DB. It always exists some contradictions between the customer requirements and technical characteristics, which underlines the communication chain between the supply and demand sides to bridge the information gap. The mathematical relationship between the CR and CS based on the results of Kano categories can be mapped in the algorithm design of the product order fulfillment system to enhance enterprises' optimized resource allocation. In addition, at the end of service delivery, the analysis results of the users' feedback questionnaires give the support for technicians to update the selection pool of laptop components, pursuing sustainable development.

4.3.2 System conceptualization and representation

Under Industry 4.0, service suppliers are driven to meet the diverse and dynamic customers' demands in a short time. Therefore, this study focuses on proposing a design mechanism for developing a customized order fulfillment system, which can assist in handling users' requirements by offering the customized configuration project. Moreover, a case study is conducted to represent how to employ the product configuration system in the order placement process for small and medium-sized enterprises in the laptop industry. It takes the Kano survey results from the market and the customized demand from the customers' interface as the input while generating the final product portfolio as output. The final configuration project has been revised and adjusted by the customer profiles and the special requirement to select the most matched components from the selection pool of primary functional engineering characteristics, such as central processing unit (CPU), graphics processing unit (GPU), random-access memory (RAM), hard disk drive (HDD), solid-state drive (SSD), display, speaker, battery, and fan. Then, the system should place the final confirmed order and trigger the feedback questionnaires of service/product satisfaction. The feedback results help the technical department to sustainably update the information of different user groups and historical configuration records, which gather the potential knowledge assets for the organization to pursue the new edges for development. By providing "Recommendation Service", "Adjustment Service", "Ordering Service", and "Response Service", the system can process a large amount of information between the front and back end departments with higher efficiency and obviously reduce the configuration mistakes from the marketing department. Furthermore, it economizes on manpower spent in the traditional manual activities and improve the accuracy of response to users' requirement for the long-term development of the enterprise. In the operation of the system, data connect various modules and complete the system structure, which means data could shows the relationship between all functions and databases. The framework of the data flow path for the "**Customized Product Order Fulfillment System"** is shown in the Figure 11.

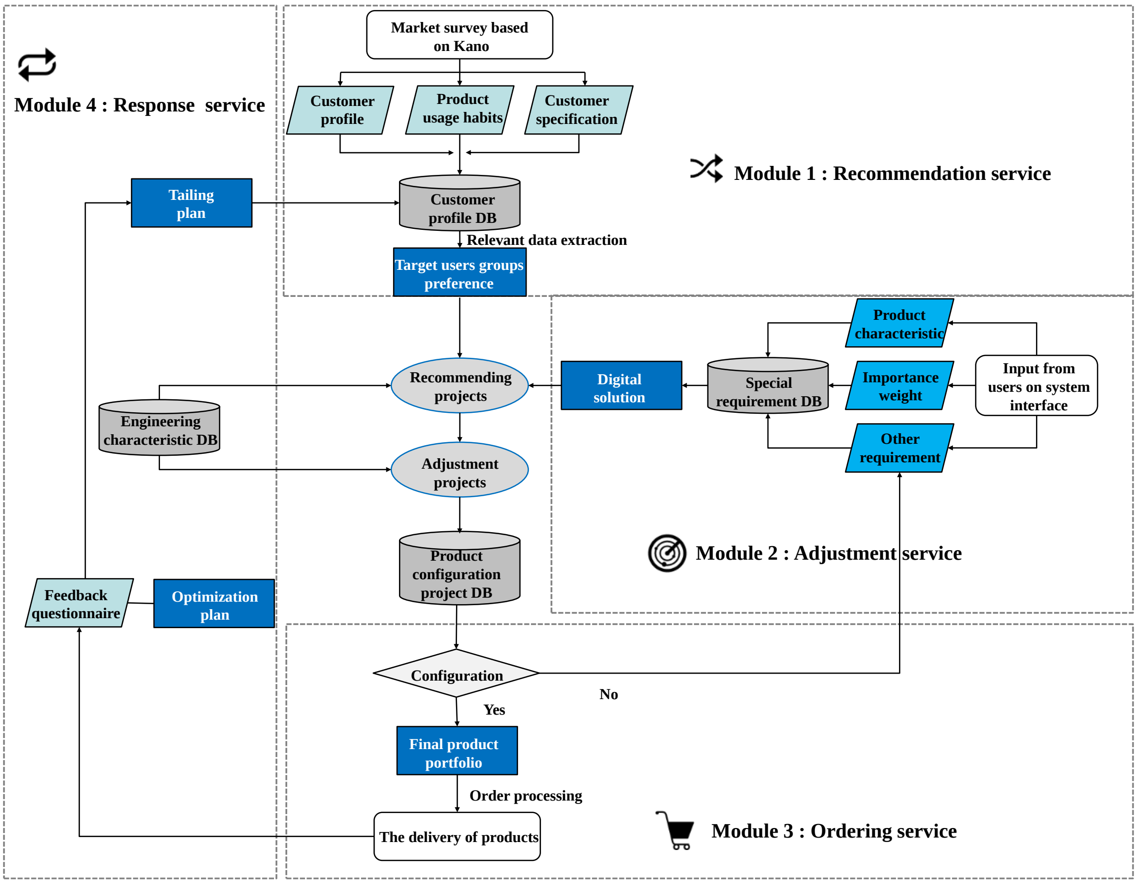

Figure 11: The overall conceptual framework based on Kano-TRIZ service design method

Combining the customer preference based on Kano model with the TRIZ evolution trends, customized service with the system structure is constructed. We summarized a coherence figure from phase 1 to phase 3 in Figure 12.

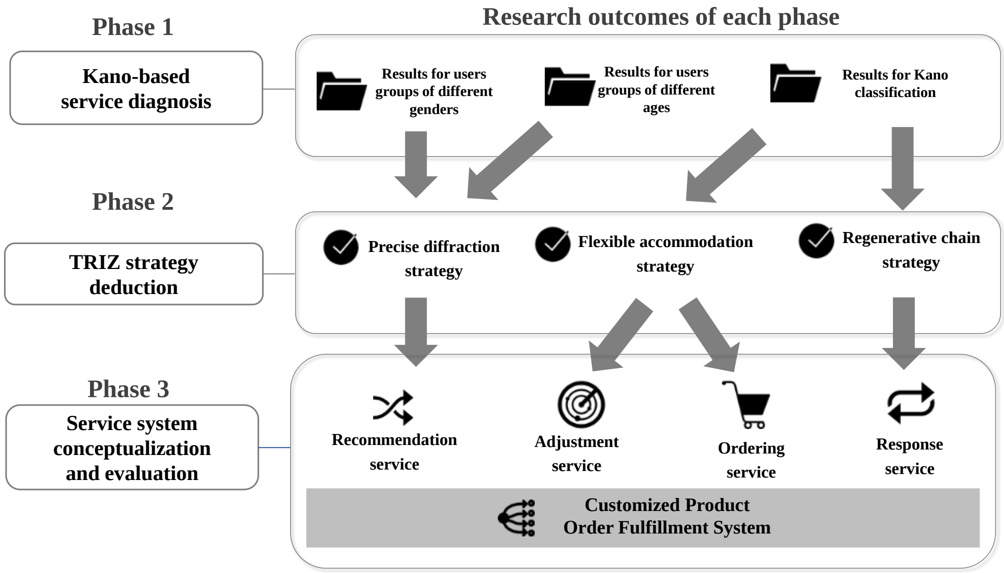

Figure 12: Coherence and results of phases in this case.

4.3.3. New service development maturity evaluation

After the expert panel discussion from five experts, a radar chart based on the NSDM model is shown in Figure 12. By contrasting comparing previous and new services reported, that the system quality and the degree of digitization are enriched in each dimension of the new system conception. The most extraordinary transformation is about the attribute of seen in “strategy goals” (from 1.4 to 4.2), in which the organization strategy and organization could be transformed by the new digital order fulfillment system. In the new and expected scenario, the IT infrastructure in the whole supply chain allows plug-and-play inter-organization communication enabling interoperability and intralogistics based on the designed **Customized Product Order Fulfillment System**. The service technology level is also improved from 1.8 to 4.4, which transformed from a human-dependent digitalization plan in the management side to a well-established digital development at different across horizontals and verticals departments based on the new digital planning recommendation mechanisms.

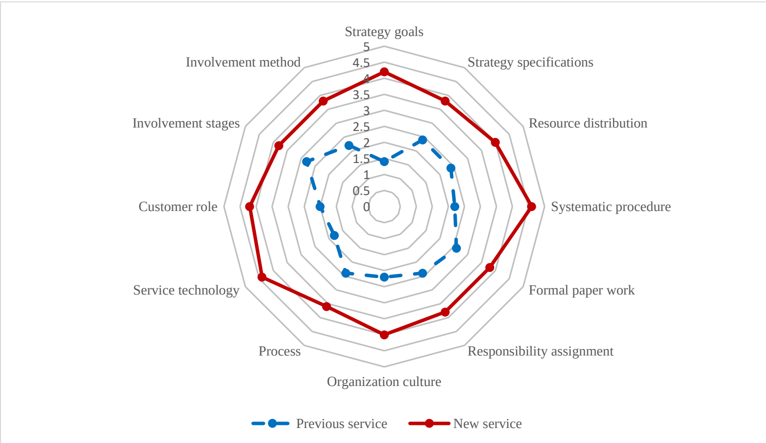

Figure 13: The comparison radar chart of the previous and new service capability

5 CONCLUSIONS

Motivated by the new manufacturing transformation of mass customization for high-complexity and low-volume production, and the three research questions listed in Section 1, this study aims to propose a novel requirement-driven and strategy-enabled “RDS” design approach, which integrates the Kano model and TRIZ evolution trend theory to achieve customized quick-response product order fulfillment system. The research framework includes (1) requirement-based service diagnosis, (2) design strategy generation, and (3) service system conceptualization and evaluation. With this novel and integrated approach, this research presents the utilization of the Kano model to better capture and understand the CR of laptop users. It brings the fertilization for the quick response order placement and production configuration service.

The main contributions of the proposed approach can be concluded into five points:

(1) Expand the utility of customer requirements on system design as kernel indicators. The CRs of a laptop are analyzed from several aspects, including the differences in gender and age. The results provide references for developing customized laptops and confirm the potential of Kano-based CR analysis. In addition, the result can also be used in the optimization purchasing plan from the systematical automatic recommendation according to the basic identification information, appeal usage, and the classification results of the target group.

(2) Enable customer survey data-driven identification of system design requirements for product attributes, rather than relying on engineers' experience. The study demonstrates an approach to figure out the important product attributes via Kano-based classification of CRs. The approach can provide better advice on the design of the default option in the configuration system. The adjustive priority sequence for the configuration project in the system can also be determined based on the CR Kano category results.

(3) Apply a strategic design evaluation approach in the smart factory era. The design strategies from revision TRIZ evolution trends build a bridge between the Kano model and the module design of the Customized Product Order Fulfillment System. The TRIZ strategies expanded the TRIZ evolution trends' application for service system design in the smart manufacturing domain. The Kano-TRIZ service design method rich the potential space for the Kano tools and may inspire other researchers to explore the application of Kano model in the system design.

(4) Obtain a requirements-driven and evolution strategy-based service design method under industry 4.0. By adopting the proposed method, the advantage of credibility of realizing service system innovation from knowledge-oriented TRIZ evolution trends, and the advantage of validity of transforming the voice of the customer into engineering design characteristics from customer-oriented Kano could be both acquired.

(5) A general strategic Kano-TRIZ design framework was proposed in this study. It is

general and can be extended to other fields. It flourishes the literature of the Kano model's application in the area of new customized C to B e-commerce under smart manufacturing and can enlighten the future work to focus on the further diverse and innovative application for better quick response for the order placement of the laptop production process.

Based on these contributions, future research directions lie in two aspects. On the one hand, the proposed approach could be adopted by industry practitioners to develop new product order fulfillment systems with different products. A diverse products and multi-sourced concept requirement evaluation manner con be achieved by online purchasing behavioral data and product testing and reviewing data. On the other hand, besides the quick response capability of quick identifying and responding in the laptop's order fulfillment process, advanced intelligent capabilities such as adaptability of other product fulfillment process should be explored in the future. These two research directions can further enhance the customized and quick response capability of handing a specific customized ordering scenario with product order fulfillment system.

Acknowledgement

This research was partially supported by the Xi'an Jiaotong University [grant number: 7121192301] and National Natural Science Foundation of China [grant number 72174168]. We appreciate the support from the Human factor and design lab of MAE at Nanyang Technological University. With NTU's help, the system demo video could be watched to understand our purpose about this. (https://www.youtube.com/watch?v=H9S25m64IDM).

Appendix

Appendix1: The Survey for the Users of Personal Laptop

Section 1: Basic identify information on respondents

Gender: A. Male B. Female

Age: A. 16 and below B. 16-25 C. 26-35 D. 36-45 E. 46 and above

Major usage for the laptop produts:

A. Basic Office Work (MS PPT, MS Word, MS Excel)
B. Design Work (2D/3D Design, Animation, Rendering)
C. Gaming
D. Professional (Computation, Programming)
E. Others

Section 2: questionnaire based on Kano model

The purpose of the follewing question is to measure your satisfation degree with the fulfillment or the unfullfillment for the eight characteristics when you are purchasing a laptop product. The options for all the questions are the same which are explained by notes below. Please read the notes before accomplishing the questionnaire.

1-1	If a laptop product performs well in basic office work and surfing such as *MS Word, MS Excel, MS PPT, email, web surfing, video playing*, how do you feel?	1 2 3 4 5
1-2	If a laptop product performs poor in basic office work and surfing, how do you feel?	1 2 3 4 5
2-1	If a laptop product performs well in graphic processing such as *2D/3D design, video editing*, *gaming, rendering,* how do you feel? .	1 2 3 4 5
2-2	If a laptop product performs poor in graphic processing, how do you feel?	1 2 3 4 5
3-1	If a laptop product performs well in Computation such as *data analysis, database, programming, algorithm,* , how do you feel?	1 2 3 4 5
3-2	If a laptop product performs poor in Computation, how do you feel?	1 2 3 4 5
4-1	If a laptop product owns a very large Storage space (> 4TB), how do you feel?	1 2 3 4 5
4-2	If a laptop product owns a very small Storage space (< 128GB), how do you feel?	1 2 3 4 5
5-1	If a laptop product performs well in Display screen, how do you feel?	1 2 3 4 5
5-2	If a laptop product performs poor in Display screen, how do you feel?	1 2 3 4 5
6-1	If a laptop product performs well in Audio system, how do you feel?	1 2 3 4 5
6-2	If a laptop product performs poor in Audio system, how do you feel?	1 2 3 4 5

7-1	If a laptop product owns very long Battery life (> 8 hrs), how do you feel?	1 2 3 4 5
7-2	If a laptop product owns very short Battery life (< 1 hrs), how do you feel?	1 2 3 4 5
8-1	If a laptop product performs well in Cooling system, how do you feel?	1 2 3 4 5
8-2	If a laptop product performs poor in Cooling system, how do you feel?	1 2 3 4 5

Note: 1 = I delight with it in that way; 2 = It satisfied with it that way; 3 = I am neutral; 4 = I can bear with it that way; 5 = I frustrate with it that way.

Appendix2: TRIZ Evlution Trend for Smart Factory

NO.	Revision evolution TRIZ trends with empirical interview	Specific explanation of evolution process in manufacturing domain
1	Services Flexibility (#1)	Sale-To-Order (STO)→Assemble-To-Order (ATO)→Make-To-Order (MTO)→Engineer-To-Order (ETO)
	Detailed interpretation: Intelligent manufacturing improved the flexibility of the design and sales process in manufacturing, shifting the process from a large-volume order-based sales mode to a small-volume order-based design mode.	
2	Service Efficiency (#2)	Cumbersome and unitary work→Sectional optimization of a single chain→Globality working circle optimization
	Detailed interpretation: The manufacturing system evolves from the optimization of a single link to the development of the overall system，realizing the efficient integration of various resources and elements.	
3	Adaptability to the external environment (#3)	Forced response to circumstances→ Proactively address environmental changes
	Detailed interpretation: Traditional factories are poorly aware of and are greatly affected by external environmental changes. Due to the optimization of its' manufacturing mode, smart factories have strong environmental robustness and responsiveness.	
4	Attitude towards user feedback (#4)	Handle customer's complain in a passive way→Actively acquire user's requirement→Service communication channel based on feedback system
	Detailed interpretation: The handling of problems reported by users gradually changed from manual handling to evaluation and optimization of service quality through user survey. Nowadays, the closed-loop of intelligent services is realized through the construction of the Internet platform.	
5	Customization degree (#5)	Mass customization → Tailor-made product for a target users' groups → Personalized precise customization (S1)
	Detailed interpretation: Every companies exist for that it satisfies certain vital needs of customers. For traditional enterprises, market research is an important means to obtain customer needs. The usual practice is to define a certain range of target users, rather than each user. Therefore, it is difficult for enterprises to meet each specific demand when defining and designing products. The Internet platform represented by e-commerce enables enterprises to break out of the narrow competitive space. Through big data analysis, enterprises can choose customers more actively, identify customer needs more effectively, and develop products and services that meet the needs of target customers more pertinently.	

6	Increasing service interface (#6)	Participation at the end of the service process→Participation in the whole service process using the user interface
	Detailed interpretation: Industry 4.0 brings great freedom and flexibility to the production, during this process, users change from partial participation to full participation. Users not only appear at both ends of the production process, but can also participate in production extensively and in real-time.	
7	User to interact with manufacturing (#7)	Passively accept users' requirement→Actively propose the needs→Self-participate in the process of the developing, designing and manufacturing activities (S2)
	Detailed interpretation: Some companies develop social customer relationship management based on the emerging internet technologies such as the 15Internet of Things, big data, cloud platforms and other means. By establishing user databases, they conduct big data portraits of user consumption behaviors, changing passively satisfying user needs into interactive active interaction. At present, through the continuous development of intelligent manufacturing systems, user needs can be completely retained and analyzed. Customers preferences will be integrated as a reference factor in the product development and manufacturing process, so as to maximize the satisfaction of users and improve customer satisfaction.	
8	Increase market publicity (#8)	Physical factory→Two publicity methods→Three publicity methods→Multiple publicity methods
	Detailed interpretation: With the widespread application of the Internet and social media, the marketing of traditional manufacturing industry has begun to expand from the print media to the electronic network media for cross-border marketing.	
9	Resilience of order processing system (#9)	Mechanical mass production→Flexible manufacturing based on order→Make-to-order customization production
	Detailed interpretation: The evolution of the manufacturing order system has changed from the initial rigid mass order production to flexible production based on user orders. Nowadays, it is more inclined to service-oriented manufacturing, that is, personalized customized order production.	
10	Increase sales of additional products or services in tourism (#10)	Additional service/product provision→Multi-domain operating development→All-sided development
	Detailed interpretation: With the increasing competitiveness in manufacturing industry, companies develop related businesses from other perspectives except developing products and services closely related to its business. Nowadays, more emphasis is placed on the comprehensive closed-loop integrated development from pre-sales to after-sales.	
11	Cross-domain product or service portfolio (#11)	Incidental products or services in the main business→Package of products or services in the relevant domain→Integration of cross-domain products or services
	Detailed interpretation: Nowadays, manufacturing enterprises have begun to expand its business to other fields and explore businesses that may emerge in other field from all perspective to seize opportunities for future development.	
12	Consumer demand level (# 12)	Rigid requirement-Flexible need (S3)
	Detailed interpretation: Under the new pattern of consumption, the demand of consumers has also changed, from the rigid demand based on function and price into the flexible demand that takes quality, experience, value proposition and other factors into consideration. The first is the emergence of well-chosen, users prefer to boutiques. Secondly, customers' behaviors have begun to be rational and mature. They hope to pursue superior products at a reasonable price. Under the "new consumption", the selection has gradually become the mainstream demand from the traditional subdivision need, and the user demand is also increasingly diversified and differentiated.	

13	Virtualize consumption process (#13)	Offline purchase channels→Ecommerce platform→Accurate response model
	Detailed interpretation: The consumption process of industrial manufacturing gradually evolve from physical channels to direct selling platform. Accompanied by the development of MTO operating model, it has gradually transformed into a precision marketing and user demand quick response model.	
14	Product perception (#14)	Product appearance attributes perception→Fundamental sensorial perception→Superior psychological experience
	Detailed interpretation: The product sensory test includes not only consumer's sensory perception for the product attributes but the elementary senses. Now, the products sensory is also involved in advanced psychological activities, including consumers' emotions, memory, association, thinking and so on.	
15	Add featuring services (#15)	Elementary service recommendation to enhance obvious satisfaction→Advanced service recommendation to enhance potential-satisfaction→Customized service recommendation to enhance comfortable-experience
	Detailed interpretation: The exploration of manufacturing industry to improve customer satisfaction only involves some low-cost service recommendations, and then it turns to standard service recommendations for specific groups. Nowadays, enterprises pay more attention to users' experience for products or services.	
16	Service process transparency (#16)	Convert→Sectional transparent→Wide-open
	Detailed interpretation: The application of the Internet platform makes information more transparent and openly, promoting information sharing in various consumer service fields including industrial manufacturing and processing fields.	
17	Customer expectation (#17)	Expectation achievement basically → Expectation contentment furthest → Expectations satisfied exceedingly
	Detailed interpretation: During the process of industrial product development and manufacturing, customer expectation is much more emphasized, from meeting it to exceeding it and give customers pleasant experience services.	
18	Controllability (#18)	Periodic monitoring→Total quality control→Real-time total quality management for industrial chain
	Detailed interpretation: Smart factories are committed to the subsequent service quality improvement work that occurs in the later stages of the purchase behavior, and builds a closed-loop enabling system for automatic data flow.	
19	Decreasing human involvement (#19)	Human resource-oriented participation → Partial machine participation → Automation operation driven by data flow
	Detailed interpretation: Intelligent manufacturing has evolved into the automation of data flow. In the horizontal, vertical, and product life cycle data integration process of enterprises, data interconnection, intercommunication, and interoperability can be realized without human intervention.	
20	Cost reduction (#20)	Fund control → Spend management → Cost optimization control → Optimal distribution of existing resources
	Detailed interpretation: Manufacturing industry shift from cost control to the optimal configuration of various subsystems, enabling them to cooperate and to deliver the highest quality products at a lower cost.	

Reference

Albana, A.S.; Frein, Y.; Hammami, R. (2018). Effect of a lead time-dependent cost on lead time quotation, pricing, and capacity decisions in a stochastic make-to-order system with endogenous demand. International Journal of Production Economics, 203, 83-95.

Avikal, S., Singh, R., & Rashmi, R. (2020). QFD and Fuzzy Kano model based approach for classification of aesthetic attributes of SUV car profile. Journal of Intelligent Manufacturing, 31(2), 271-284.

Ayundhita, M. S., Baizal, Z. K. A., & Sibaroni, Y. (2019, March). Ontology-based conversational recommender system for recommending laptop. In Journal of Physics: Conference Series (Vol. 1192, No. 1, p. 012020). IOP Publishing.

Barrios-Ipenza, F., Calvo-Mora, A., Criado-García, F., & Curioso, W. H. (2021). Quality Evaluation of Health Services Using the Kano Model in Two Hospitals in Peru. International Journal of Environmental Research and Public Health, 18(11), 6159.

Baykasoğlu, A.; Subulan, K.; Güçdemir, H.; Dudaklı, N.; Eren Akyol, D. (2019). Revenue management for make-to-order manufacturing systems with a real-life application. The Engineering Economist, 1-39.

Berger, C.; Blauth, R.; Boger, D. Kanos methods for understanding customer-defind quality, 1993.

Bogatyrev, N. R., & Bogatyreva, O. A. (2009, March). TRIZ evolution trends in biological and technological design strategies. In Proceedings of the 19th CIRP Design Conference–Competitive Design. Cranfield University Press.

Brettel, M.; Friederichsen, N.; Keller, M.; Rosenberg, M. (2014). How virtualization, decentralization and network building change the manufacturing landscape: An Industry 4.0 Perspective. International Journal of Mechanical, Industrial Science Engineering, 8, 37-44.

Chai, C., Bao, D., Sun, L., & Cao, Y. (2015). The relative effects of different dimensions of traditional cultural elements on customer product satisfaction. International Journal of Industrial Ergonomics, 48, 77-88.

Chang, D. S., & Yang, S. L. (2010, June). Combining Kano model and service blueprint for adult day care service—A case study in Taiwan. In 2010 7th International Conference on Service Systems and Service Management (pp. 1-5). IEEE.

Chen, C. K., Shie, A. J., Wang, K. M., & Yu, C. H. (2015). An ageing-in-place service innovation model by using TRIZ methodology. Human Factors and Ergonomics in Manufacturing & Service Industries, 25, 166-182.

Chen, J., Cheng, Y., & Nie, D. (2013, May). Product configuration method based on ontology mapping. In 2013 IEEE 4th International Conference on Software Engineering and Service Science (pp. 97-101). IEEE.

Chen, M. C., Chang, K. C., Hsu, C. L., & Yang, I. C. (2011). Understanding the relationship between service convenience and customer satisfaction in home delivery by Kano model. Asia Pacific Journal of Marketing and Logistics.

Cheng, C. C., & Chen, C. T. (2018). Creating excellent and competitive motels services. International Journal of Contemporary Hospitality Management.

Chiang, T. L., Yi, C. Y., & Chang, C. M. (2013, July). An empirical study of applying Kano model and TRIZ business evolution trends to improve E-commerce service quality. In Proceedings of

2013 IEEE International Conference on Service Operations and Logistics, and Informatics (pp. 340-344). IEEE.

de Albuquerque, A. P. G., de Melo, F. J. C., & de Medeiros, D. D. (2021). Airline quality assessment towards strategic tourism management improvements. Tourism Review.

El-Hashmi, K. N., & Gnieber, O. K. (2013). Kano's model for clinical laboratory. International Journal of Industrial and Manufacturing Engineering, 7(10), 1994-1998.

Esaki, K. (2013). Verification of quality requirement method based on the SQuaRE System Quality Model.

Fey, V., & Rivin, E. (2005). Innovation on demand: new product development using TRIZ. Cambridge University Press.

Gajewska, T., & Zimon, D. (2018). Study of the logistics factors that Influence the development of e-commerce services in the customer's opinion. Archives of Transport, 45.

Gregory, A. M., Parsa, H. G., Nusair, K., Kwun, D. J., & Putrevu, S. (2015). Examining the effects of vacation ownership product attributes on customer satisfaction: An investigation of product purchase and use. International Journal of Contemporary Hospitality Management.

Hartono, M., Setijadi, S., & Norwandi, L. (2019). A conceptual integrative model of Kansei Engineering, Kano and TRIZ towards sustainability in services. Journal of Advanced Research in Dynamical and Control Systems, 11(5), 385-390.

He, L., Song, W., Wu, Z., Xu, Z., Zheng, M., & Ming, X. (2017). Quantification and integration of an improved Kano model into QFD based on multi-population adaptive genetic algorithm. Computers & Industrial Engineering, 183-194.

Hejaili, F. F., Assad, L., Shaheen, F. A., Moussa, D. H., Karkar, A., AlRukhaimi, M., ... & Al-Sayyari, A. A. (2009). Culture-related service expectations: a comparative study using the Kano model. Quality Management in Healthcare, 18(1), 48-58.

Howsawi, A. A., Althageel, M. F., Mohaideen, N. K., Khan, M. S., Alzahrani, A. S., Alkhadir, M. A. & Hawsawi, R. A. (2020). Application of the Kano model to determine quality attributes of patient's care at the primary healthcare centers of the Ministry of Health in Saudi Arabia, 2019. Journal of Family & Community Medicine, 27(3), 178.

Huang, H.C., & Shih, H.Y., Chen, Y. & Hsu, S.C. (2017). The dilemma and solution of Taiwan's tourist industry on Chinese tourists: Application of TRIZ method to tourist industrial innovation. Industry and Management Review, 19(4), 34-35 (In Chinese).

Ji, P., Jin, J., Wang, T., & Chen, Y. (2014). Quantification and integration of Kano's model into QFD for optimising product design. International Journal of Production Research, 52(21).

Jin, D., Chai, K. H., & Tan, K. C. (2014). New service development maturity model. Managing Service Quality: An International Journal. 24(1), 86-116.

Johnson, P., & Johnson, J. (2021). Kano and other quality improvement models to enhance patient satisfaction in healthcare settings. Journal of Family and Community Medicine, 28(2), 139-139.

Kagermann, H.; Helbig, J.; Hellinger, A.; Wahlster, W. (2013). Recommendations for implementing the strategic initiative INDUSTRIE 4.0: Securing the future of German manufacturing industry; final report of the Industrie 4.0 Working Group; Forschungsunion.

Kano, N., Seraku, N., Takahashi, F. and Tsuji, S. (1984). Attractive quality and must-be quality, Hinshitsu, The Journal of the Japanese Society for Quality Control, April, 39-48.

Karakuş, Y., & Çoban, S. (2018). Evaluation Of Stakeholders' Expectations Towards Congress Tourism By Kano Model: Case Of Nevşehir. Anais Brasileiros de Estudos Turísticos-ABET, 8-20.

Kumar, C. S., & Routroy, S. (2015). Demystifying manufacturer satisfaction through Kano model. Materials Today: Proceedings, 2(4-5), 1585-1594.

Kuo, C. M., Chen, H. T., & Boger, E. (2016). Implementing city hotel service quality enhancements: Integration of Kano and QFD analytical models. Journal of Hospitality Marketing & Management, 25(6), 748-770.

Lee, C. H., Chen, C. H., & Lee, Y. C. (2020). Customer requirement-driven design method and computer-aided design system for supporting service innovation conceptualization handling. Advanced Engineering Informatics, 45, 101117.

Lee, C. H., Chen, C. H., & Trappey, A. J. (2019a). A structural service innovation approach for designing smart product service systems: Case study of smart beauty service. Advanced Engineering Informatics, 40, 154-167.

Lee, C. H., Chen, C. H., Lin, C., Li, F., & Zhao, X. (2019b). Developing a Quick Response Product Configuration System under Industry 4.0 Based on Customer Requirement Modelling and Optimization Method. Applied Sciences, 9(23), 5004.

Lee, C. H., Li, F., Chen, C. H., Lin. C. A Kano-Based Quick-Response Product Configuration System Under Industry 4.0, Proceedings of 26th ISPE International Conference on Transdisciplinary Engineering (TE 2019), Tokyo, Japan, 2019c, 63-71.

Lee, C. H., Li, L., & Zhong, P. (2021, September). TRIZ Evolution Trend-Based Public Service Innovation for Enhancing Social Participation of Life Garbage Classification. In International TRIZ Future Conference (pp. 57-73). Springer, Cham.

Li, F., Lee, C. H., Xu, G., Chen, C. H., & Khoo, L. P. (2017). A QFD-enabled conceptualization for reducing alarm fatigue in vessel traffic service centre. Proceedings of 24th ISPE International Conference on Transdisciplinary Engineering (TE 2017), Singapore, Singapore, 2017, 821-828.

Lin, C. F., Fu, C. S., & Li, C. C. (2018). Integrating means-end chains and the Kano model to understand tourists' cognitive structure toward leisure and recreational resources of suburban-mountains. Asia Pacific Journal of Tourism Research, 23(2), 183-199.

Lin, S. P., Yang, C. L., Chan, Y. H., & Sheu, C. (2010). Refining Kano's quality attributes–satisfaction' model: A moderated regression approach. International Journal of Production Economics, 126(2), 255-263.

Liu, H. (2012). Research on Module Selection Method Based on the Integration of Kano Module with QFD Method. Journal of Service Science and Management, 5(2), 206-211.

Llinares, C., & Page, A. F. (2011). Kano's model in Kansei Engineering to evaluate subjective real estate consumer preferences. International Journal of Industrial Ergonomics, 41(3), 233-246.

Ma, M. Y., Chen, C. W., & Chang, Y. M. (2019). Using Kano model to differentiate between future vehicle-driving services. International journal of industrial ergonomics, 69, 142-152.

Materla, T., Cudney, E. A., & Antony, J. (2019). The application of Kano model in the healthcare industry: a systematic literature review. Total Quality Management & Business Excellence, 30(5-6), 660-681.

Menon, K., Kärkkäinen, H., & Wuest, T. (2020). Industrial internet platform provider and end-user perceptions of platform openness impacts. Industry and Innovation, 27(4), 363-389.

Min, H., Yun, J., & Geum, Y. (2018). Analyzing dynamic change in customer requirements: An approach using review-based Kano analysis. Sustainability, 10(3), 746.

Pai, F. Y., Yeh, T. M., & Tang, C. Y. (2018). Classifying restaurant service quality attributes by using Kano model and IPA approach. Total Quality Management & Business Excellence, 29(3-4), 301-328.

Pai, F. Y., Yeh, T. M., & Tang, C. Y. (2018). Classifying restaurant service quality attributes by using Kano model and IPA approach. Total Quality Management & Business Excellence, 29(3-4), 301-328.

Pandey, A., & Sahu, R. (2020). Mapping heritage tourism service quality using the Kano model: a case study of Indian tourism. International Journal of Services and Operations Management, 37(2), 264-283.

Park, H., Ree, J. J., & Kim, K. (2012, June). An SAO-based approach to patent evaluation using TRIZ evolution trends. In 2012 IEEE International Conference on Management of Innovation & Technology (ICMIT) (pp. 594-598). IEEE.

Park, H., Ree, J. J., & Kim, K. (2013). Identification of promising patents for technology transfers using TRIZ evolution trends. Expert systems with applications, 40(2), 736-743.

Pezzotta, G., Regazzoni, D., Cavalieri, S., & Rizzi, C. (2011). Enhancement in industrial PSS design based on TRIZ: a case study. In Functional Thinking for Value Creation (pp. 225-230). Springer, Berlin, Heidelberg.

Porter, M.E.; Heppelmann, J.E. (2014). How smart, connected products are transforming competition. Harvard Business Review, 92, 64-88.

Qu, Y., Xinguo, M., Qiu, S., Liu, Z., Zhang, X., & Hou, Z. (2019). Integrating fuzzy Kano model and fuzzy analytic hierarchy process to evaluate requirements of smart manufacturing systems. Concurrent Engineering, 27(3), 201-212.

Sadeghi, A., Dehghani, M. A., & Dadgar, M. (2019). Ranking of the Factors Affecting Urban Tourism Satisfaction Using Kano Model, Case Study: Shiraz City. urban tourism, 6(3), 139-151.

Savransky, S. D. (2000). Engineering of creativity: Introduction to TRIZ methodology of inventive problem solving. CRC press.

Shahin, A., Abedi, S., Ranjbar, M. J., & Kamali, A. (2017). TRIZ and the Kano model: proposing an integrated approach for improving product quality according to customer needs. International Journal of Productivity and Quality Management, 20(3), 392-404.

Shen, Y., Kokkranikal, J., Christensen, C. P., & 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, 35, 100402.

Sohn, J. I., Woo, S. H., & Kim, T. W. (2017). Assessment of logistics service quality using the Kano model in a logistics-triadic relationship. International Journal of Logistics Management, 28(2), 680-698.

Sulisworo, D. (2000). Integrating Kano's model and SERVQUAL to improve healthcare service quality. Global Public Health.

Synnes, E.L. (2016). Welo, T. Bridging the Gap between High and Low-volume Production through Enhancement of Integrative Capabilities. Procedia Manufacturing 2016, 5, 26-40.

Tama, I. P., Azlia, W., & Hardiningtyas, D. (2015). Development of customer oriented product design using Kansei engineering and Kano model: Case study of ceramic souvenir. Procedia Manufacturing, 4, 328-335.

Velikova, N., Slevitch, L., & Mathe-Soulek, K. (2017). Application of Kano model to identification of wine festival satisfaction drivers. International Journal of Contemporary Hospitality Management.

Verhaegen, P. A., D'hondt, J., Vertommen, J., Dewulf, S., & Duflou, J. R. (2009). Relating properties and functions from patents to TRIZ trends. CIRP Journal of Manufacturing Science and Technology, 1(3), 126-130.

Vidal, R., Salmeron, J. L., Mena, A., & Chulvi, V. (2015). Fuzzy Cognitive Map-based selection of TRIZ (Theory of Inventive Problem Solving) trends for eco-innovation of ceramic industry products. Journal of Cleaner Production, 107, 202-214.

Violante, M. G., & Vezzetti, E. (2017). Kano qualitative vs quantitative approaches: An assessment framework for products attributes analysis. Computers in Industry, 86, 15-25.

Wang, C. H. (2013). Incorporating customer satisfaction into the decision-making process of product configuration: a fuzzy Kano perspective. International Journal of Production Research, 51(22), 6651-6662.

Wang, M. Y., Chang, D. S., & Kao, C. H. (2010). Identifying technology trends for R&D planning using TRIZ and text mining. R&d Management, 40(5), 491-509.

Wang, T., & Ji, P. (2010). Understanding customer needs through quantitative analysis of Kano's model. International Journal of Quality & Reliability Management, 27(2), 173-184.

Wang, Y. H., Lee, C. H., & Trappey, A. J. (2017). Modularized design-oriented systematic inventive thinking approach supporting collaborative service innovations. Advanced Engineering Informatics, 33, 300-313.

Wang, Y., Lee, C., & Trappey, A. J. C (2017). Modularized design-oriented systematic inventive thinking approach supporting collaborative service innovations. 33(aug.), 300-313.

Weber, R. P. (1990). Basic content analysis. London: Sage.

Wu, X., Hong, Z., Li, Y., Zhou, F., Niu, Y., & Xue, C. (2020). A function combined baby stroller design method developed by fusing Kano, QFD and FAST methodologies. International Journal of Industrial Ergonomics, 75, 102867.

Wu, Y. (2021). Product Appearance Design Based on Consumers' Kansei Image and Fuzzy Kano Model Satisfaction Evaluation-Case Study of Air Purifier.

Wu, Y., & Cheng, J. (2018). Continuous fuzzy kano model and fuzzy AHP model for aesthetic product design: case study of an electric scooter. Mathematical Problems in Engineering, 2018.

Xiang, C. H. E. N., & Da-peng, Q. I. U. (2019). Research of Product Design Based on Fuzzy-Kano Model and TOPSIS. Journal of Graphics, 40(2), 315.

Yadav, H. C., Jain, R., Singh, A. R., & Mishra, P. K. (2017). Kano integrated robust design approach for aesthetical product design: a case study of a car profile. Journal of Intelligent Manufacturing, 28(7), 1709-1727.

Yang, C. (2005). The refined Kano's model and its application. Total Quality Management & Business Excellence, 16(10), 1127-1137.

Yoon, J., & Kim, K. (2011). An automated method for identifying TRIZ evolution trends from patents. Expert Systems with Applications, 38(12), 15540-15548.

Zawadzki, P.; Żywicki, K. (2016). Smart product design and production control for effective mass customization in the Industry 4.0 concept. Management and Production Engineering Review, 7, 105-112.

Zheng, P.; Liu, Y.; Tao, F.; Wang, Z.; Chen, C. H. (2019). Smart Product-Service Systems Solution Design via Hybrid Crowd Sensing Approach. IEEE ACCESS, 2019, 7, 128463-128473.