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Kano-Based Design for B-to-B Customized Product Configuration Service

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Abstract. With the arrival of industry 4.0, it is 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, realizing the customized order service with low volume and high-mix production are critical. To achieve this potential, this study aims to understand the requirements of customers through the Kano model, which can classify the product attributes into one-dimensional, attractive, must-be, indifferent, reverse, and questionable requirements. Then, a design strategy for a conceptualization of the "Quick customized order configuration system" was proposed based on the Kano analysis results. Thus, an empirical case study of this product configuration system is illustrated as verification in this work.

Keywords. Customer requirement analysis; Kano model; Design strategy; Industry 4.0.

Introduction

Industry 4.0 revolution was triggered by advanced technologies, such as the Internet of Things (IoT), machine learning, deep learning, and advanced cyber-physical systems (CPS) to enhance smart factories [1-4]. The key to the success of smart factories is meeting various and dynamic CRs effectively and reducing the time of the customized products to market [5]. In other words, it is significant to make the engineering characteristics (ECs) to be more suitable with the customer requirement (CRs) in the customized order placement process. The product configuration system is based on the make-to-order (MTO) tactics, which utilizes the CRs as the input and configures recommended order plans based on predefined ECs. How companies respond to the transformation dilemma and how they allocate resources to optimize production and product trading within their capabilities are critical problems. Companies gather dynamic user requirements directly and make informed decisions in a short time [6]. To address this issue, companies need a new way to directly collect dynamic CRs of the front-side of order placement, such as a customized product ordering system. To satisfy the individual client, it is necessary to measure and capture his/her requirements of product features. Accordingly, the Kano model, which can significantly facilitate the recognition of marketing and product design needs, is adopted in this study. The Kano model suggests that products and service features have biased influences on customer

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satisfaction (CS) [7, 8]. Specifically, some features of the product/service cause satisfaction, while others cause dissatisfaction. Therefore, comprehending the client's expectations makes 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 [9-11]. Even though the Kano model has been successfully applied in some technical disciplines and tangible product design [8, 9], its potential has not been fully recognized in the area of customized B to B e-commerce under smart manufacturing [7, 12].

Considering the advantages of the Kano model, this research aims to explore how to use it to understand CRs clearly and thoroughly. Meanwhile, an empirical case with the laptop production process is demonstrated in this research.

1. Literature review

Kano suggested quality attribute performance is non-linearly and dynamically correlated with overall satisfaction. Owing to the varying relationship, quality attributes can be classified into six categories, i.e. One-dimensional (O), Attractive (A), Must-be (M), Indifferent (I), Reverse (R), Questionable (Q) [13]. The category of a quality attribute depends on the CS level and CRs fulfillment levels. Kano model has 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. Each product attribute is investigated from two perspectives- meeting CR or non-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. Kano analysis provides suitable and practical results to capture customer requirements by assessing their satisfaction. Abundant refined Kano qualitative and quantitative approaches abound in the literature. However, there has far been relatively little research into the customized order fulfillment and product configuration area under the background of smart manufacturing [10, 14]. The engineering practice about the acquisition of customer knowledge, the analysis of data, and the representation of information, which is related to customized order configuration and new product development, is still at the primary stage in developing the industry 4.0 driven and new product configuration system, not to mention a lack of literature on this subject [15-17].

2. Method

This study applys a novel service design method based on Kano model which includes three phases. First, customer requirements were collected and analysed using kano model, the second phase is the strategy generation procedures for designing based on requirement analysis, finally, the study generates ideas of functions of new digital systems inspired by design strategy. The analytics of CR is based on the Kano questionnaire survey. The CRs in this study refer to the customer preference during the

product purchasing process, specifically for laptop products in this paper. Subjects and data collections are described below.

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 positive and negative 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. 123 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. The 120 respondents consist of 48 males and 72 females, with an average of 27.5 ± 8.7 years old. The respondents were divided into four groups based on their age, including 16-25, 26-35, 36-45, 46 and above. Requirements of laptop attributes were divided into eight groups. Then, we treated these groups as "CR", including CR1-Robust business capabilities (Biz); CR2- Comprehensive multimedia support (Multimedia); CR3-Powerful computing performance (Computation); CR4-Reliable data storage (Storage); CR5-Vivid display quality (Display); CR6-Exceptional audio quality (Audio); CR7-long-lasting battery life (Battery life); and CR8-Advanced cooling system (Cooling system).

The statistical analysis is conducted in the SPSS statistical software package with the confidence level set to 0.05.

3. Results and Strategic Kano-based System Design

3.1. Kano analysis results

The 120 questionnaires' results of the eight requirements are separately summarized in Table 1. The Better index and Worse index of each requirement are calculated according to Kano's formula (as shown in Table 2). The Better index and the Worse index are presented in the second and third columns, respectively. Fig. 1 shows a scatter plot of eight requirements, which maps the quadrant to identify the influence of the requirements.

Table 1. Results of Requirements with Kano Attributes.

CRS	A	O	I	M	R	Q	Total
Biz	13	20	26	61	0	0	120
Multimedia	35	44	29	12	0	0	120
Computation	41	27	38	14	0	0	120
Storage	25	31	28	35	0	1	120
Display	40	28	29	21	0	2	120
Audio	45	26	37	12	0	0	120
Battery life	27	62	15	15	1	0	120
Cooling system	38	23	39	19	0	1	120

Better< 0.5; Worse>0.5. Quadrant 3 (Attractive): Better> 0.5; Worse<0.5.
Quadrant 4 (Indifferent): Better< 0.5; Worse<0.5.

The Better/Worse index can be used to determine the degree of the functional impact. The better index can be interpreted as an increased satisfaction coefficient. A better index means that if a certain functional attribute was provided, user satisfaction would increase. The worse 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 Worse index represents a negative relationship. The larger the Worse 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. In this study, the mapping figure obtained by the Better/ Worse index is shown in Fig. 2.

Table 2. Better index, Worse index, and quadrants

*Quadrant 1 (One-dimensional): Better> 0.5; Worse>0.5. Quadrant 2 (Must-be):

CRS	**Better index = (A+O/ (A+O+M+I))**	**Worse index = (O+M)/(A+O+M+I)**	**Quadrants***
Biz	0.275	0.675	2 (Must-be)
Multimedia	0.658	0.467	3 (Attractive)
Computation	0.567	0.342	3 (Attractive)
Storage	0.471	0.555	2 (Must-be)
Display	0.576	0.415	3 (Attractive)
Audio	0.592	0.317	3 (Attractive)
Battery life	0.748	0.647	1 (One-dimensional)
Cooling system	0.513	0.353	3 (Attractive)

As shown in figure 3, the "Satisfaction Sensitive Map" was used to sort out and prioritize the customer experience factors for improvement in order to prioritize the demand elements for improvement [18-19]. The factors selection line (a 1/4 arc with a radius of 0.707 passing through the point (0.5, 0.5)) is used to distinguish the improvement factors from other factors, and the Better index (BI) and Worse index (WI) values of each factor are utilized as its horizontal and vertical coordinates [19]. The size of the distance from the point on the right side of the element selection line to the line, or the sensitivity R ($R = \sqrt{BI^2 + WI^2} - 0.707$), is used to indicate the degree of improvement required for the factors. The degree of improvement is calculated by placing the improvement factors in descending order of sensitivity. The factors that require improvement are those that are located on the right side of the factor selection line. The more sensitive the customer experience is, the higher the factor's R value. The consumer experience is less sensitive to the factors on the left, thus they can be disregarded.

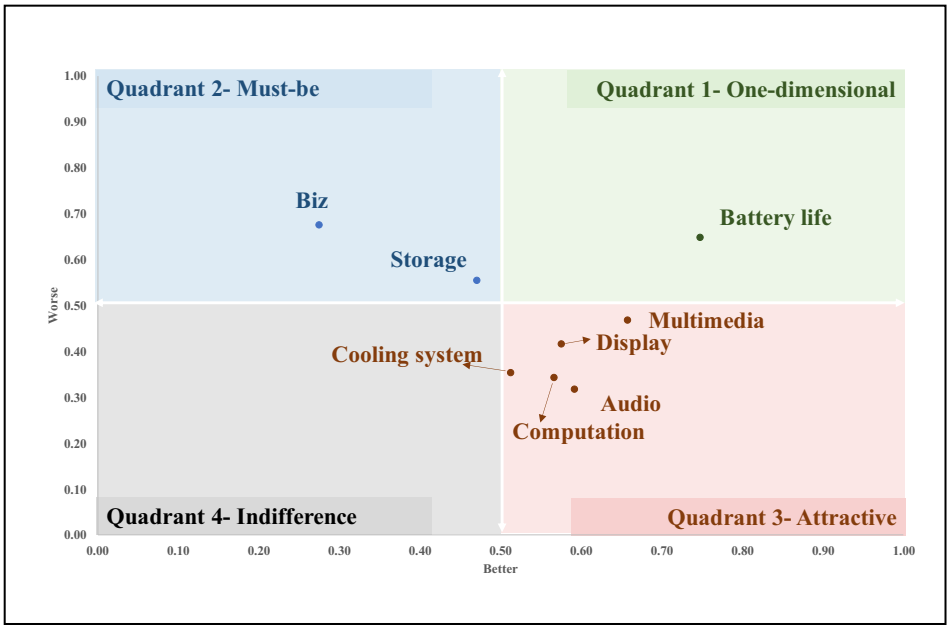

Figure 1. Scatter Diagram of Kano attributes.

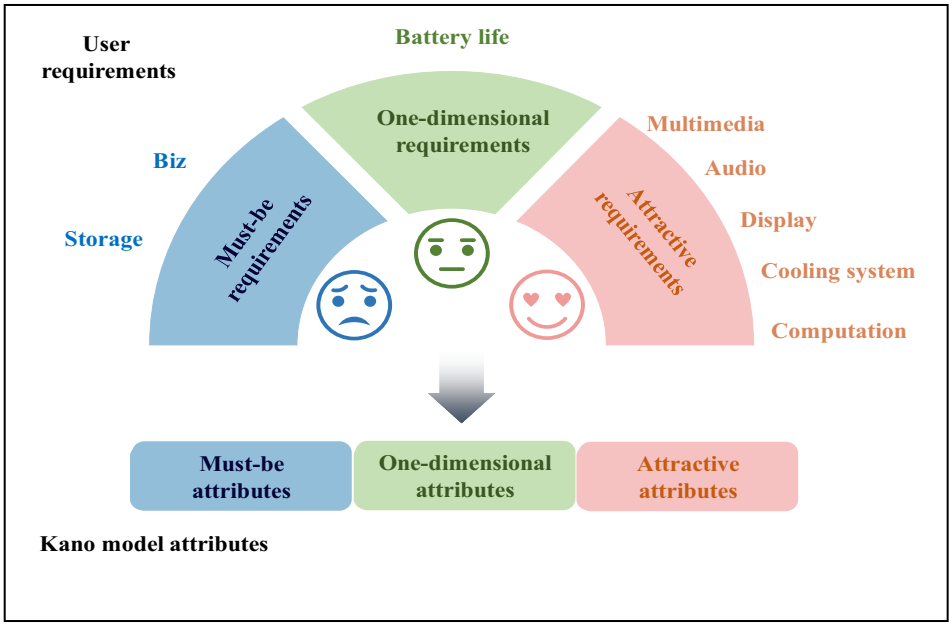

Figure 2. Correspondence between user requirements and Kano model attributes.

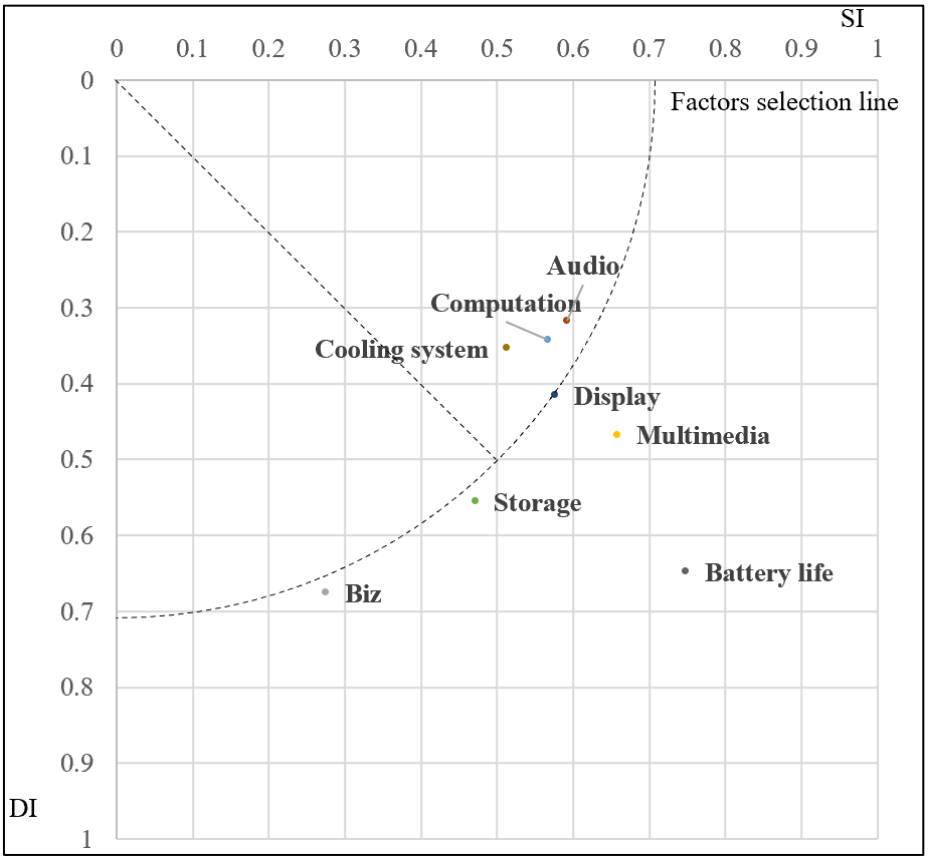

Figure 3. Satisfaction sensitive map.

3.2. Strategic Kano-based service system design

Company DT is a global and leading industrial automation manufacturer, offering business-to-business (B2B) products and solutions to serve global customers. It is also an automated manufacturing line for "small volume with high mix customization" as a smart manufacturer. Company A plays a loyal client and a central role as a business-to-business (B2B) information technology (IT) manufacturing company using DT's automated manufacturing line solution. Company A specializes in the flexible manufacturing of laptops based on DT's support. A retailer Company B is the potential customer of A, asking for laptops ordering based on diverse for customized manufacturing.

After understanding customers' requirements, we recommend enterprise A can have three design strategies, namely **"Building-a-bridge strategy", "Customized-customer-preference strategy" and "Flexible-and-quick-response strategy"**. This strategy responds to the quick recommendation service that the supply-side and demand-side research in commercial applications. There is an essential difference between "what you can give" and "what you want". The strategy devotes to building a bridge between the service demanders and the recommending configuration project from the service suppliers.

Building-a-bridge strategy: This strategy conducts users group division based on the customer profile, such as age and gender. The product attributes preferences analysis for the different groups according to the Kano model to dig out the general characteristic information about some purchasing groups, as shown in Fig. 4 and Fig. 5. The users' preference knowledge integrating the significant data cloud computing results for the historical customized order information can be employed in the design of default configuration project to offer more scientific and more suitable customized services.

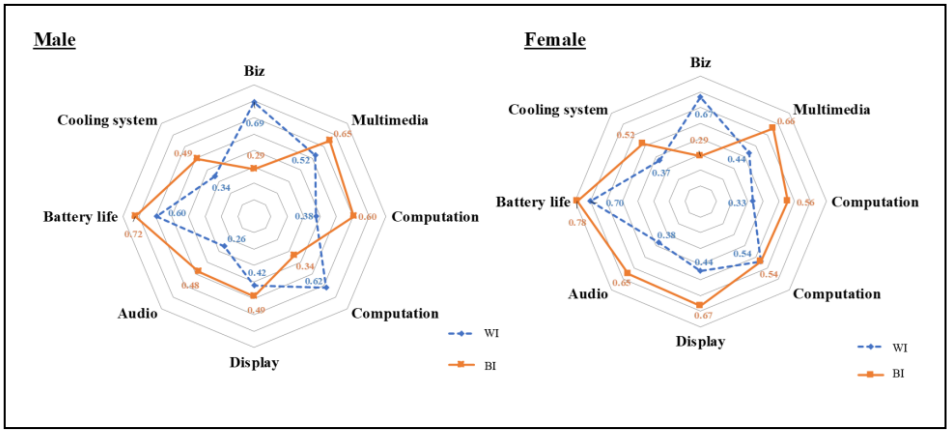

Figure 4. Gender-based Kano-Rader chat of laptop preference.

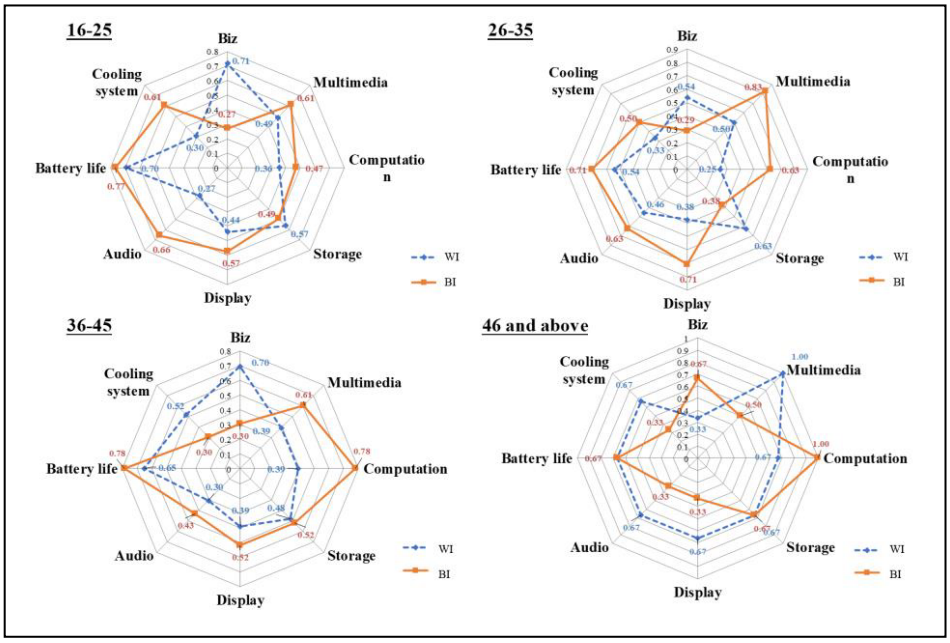

Figure 5. Age-based Kano-Rader chat of laptop preference.

Customized-customer-preference strategy: By capturing necessary user information and historical customized order information from the front end of the customer interaction interface, 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.

Flexible-and-quick-response strategy: The dynamic consumer demand urges companies to enhance order processing flexibility. To meet the diverse and complex needs of users, the product order fulfillment module should provide efficient product adjustment services based on the customer profile, including the expected budget and other special requests to enrich the flexible interaction with customers. 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.

Hence, these strategies could be inspired and transformed to conceptualize and design a service system titled **"Quick customized order configuration system"** after expert discussion.

The system will be a bridge between customers who place orders to the manufacturer with a flexible production line. It mainly provides functions with **(1) Customer preference and attributes selection module; (2) Optimizing and recommendation module; (3) Order decision-making module; (4) Order configuration and processing module (as depicted in Fig. 6).**

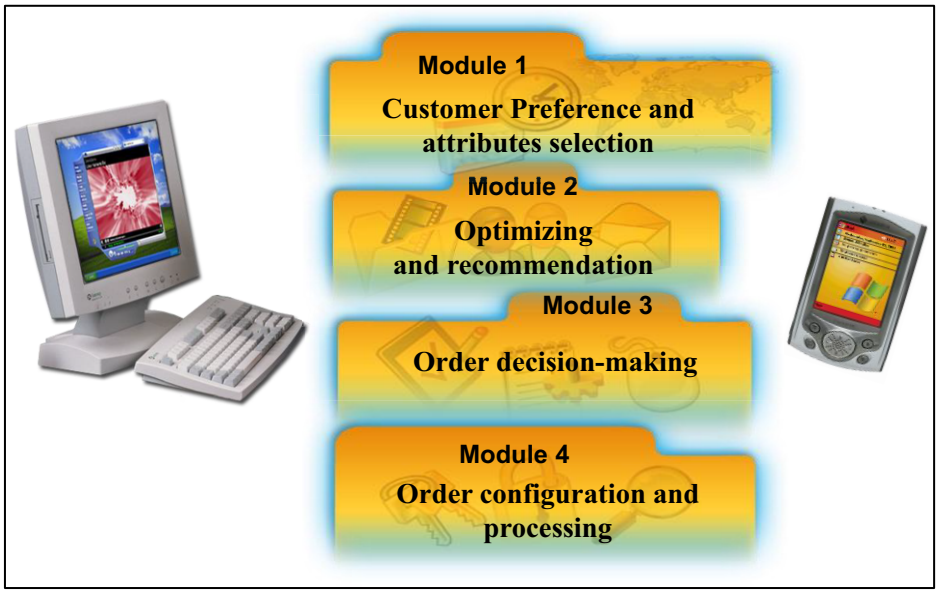

Figure 6. Quick customized order configuration system framework.

When accepting orders and processing orders, it can give customers space to flexibly choose product specification information as detailed as possible. Meanwhile, it

can help customers find their preferences easily and elicit requirements based on their age, gender, or using scenarios. Then, a following and drilled personal selection interface will be provided. In the expected model with the new service system, Company A could respond to a customer preference given by Company B. The customer preference could include the expected budget, Kano product attributes, ages, and genders. It could generate recommended laptop configuration results within budget immediately. After delivering the recommended results for the recommended product configuration for Company B, Company B could decide to place the final order for production. Finally, the order would be sent to Company A for manufacturing.

4. Conclusion

In conclusion, this study has the following contributions: First, the study demonstrates the classification of CRs using the Kano model. Based on the classification, such as attractive attributes, one-dimension, and must-be, the producers can figure out which attributes should be focused on first. Moreover, the results can generate some advice "Building- a -bridge strategy," "Customized-customer-preference," and "Flexible-and-quick-response" on the design of the default option in the configuration system. The CRs of the laptop are analyzed from several aspects, including the differences in gender and age. Kano results can inspire the design strategies which can be transformed into the relative detailed functions design of the quick response product configuration system according to the service concepts. Second, the proposed quick-response product configuration system builds a bridge between the engineering characteristics and the user's voice. The real production (to-be) scenarios among manufacturing solution suppliers, the manufacturing service providers and service demanders of SMEs are discussed with the empirical case of laptop product engineering. Therefore, a customer-centric, optimization-oriented quick-response configuration system is designed in a holistic and generalized way under the background of Industry 4.0. Third, as an explorative study, this study restricts its scope with a case of the laptop production process to illustrate the Kano potential in the system development process. Dynamic Kano results could be obtained iteratively by an online requirement acquirement system in the future to explore the industrial production context with more kinds of products. Meanwhile, it extends and evolves smart manufacturing approaches on **new product development** with **multidisciplinary design optimization, concurrent engineering and human-centered design** under Industry 4.0. It is hoped that this work provides valuable insights into the **engineering practice** and transdisciplinary theories in today's innovative connected environment. Additionally, as technology continues to advance, new features such as biometric authentication, AI-assisted computing, and 5G connectivity may become increasingly important for consumers. Therefore, further research is needed to understand how these emerging technologies will impact the demand for laptops.

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