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The Value and Realization Paths of Customer Participation in Mass Customization

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ABSTRACT

This paper examines the value and realization paths of customer participation in mass customization. From the perspective of production and operations management, it analyzes how customer participation balances individualized product demand and scale requirements through modular design, digital tools, and flexible production systems. The study shows that customer participation should be understood as 'value co-creation under constraints.' Customers participate in part of the production process within a standardized modular framework predefined by the firm. This participation helps firms reduce the cost of demand mismatch, activate momentum for product iteration, and build differentiated competitive advantages. Its realization depends on the coordination of modular production, digital technology, and differentiated supply chains. It also faces challenges such as conflict between customers' willingness and ability to participate and insufficient efficiency in enterprise value conversion. The paper ultimately emphasizes the need to optimize production system design and supply chain coordination in order to improve the efficiency of value conversion.

KEYWORDS

Mass customization; Customer participation; Modular production; Flexible production; Value co-creation

1. INTRODUCTION

With intensifying global competition and the deep penetration of digital technology, consumer markets are shifting from 'standardized supply' toward 'individualized demand.' On the one hand, emerging consumer groups are no longer satisfied with standardized products of a single type. They increasingly expect consumption to reflect their lifestyle attitudes and require products with personalized features. On the other hand, firms seek to break away from weak product competitiveness under standardized production and build differentiated competition through customized products. In actual production, customization is not a new concept. In traditional production, however, customization often meant higher production costs and greater production difficulty. As industrial production and market consumption continue to transform and upgrade, manufacturing that once sacrificed product diversity in pursuit of cost minimization and profit maximization must now respond to customers' new requirements for product innovation and meet firms' needs for customized production. With the popularization of Internet technology in particular, continuous upgrades in digital technology have raised the expectations of both firms and customers for personalization. The emergence of business models such as C2B platforms has created new modes of product transactions and imposed new requirements on customized products.

Mass customization emerged in response to this social environment. It refers to providing customized products for firms or target markets while maintaining the cost advantages of batch production,

thereby satisfying diverse enterprise needs [1]. This production mode has two advantages. First, it can meet changing market demand while preserving cost advantages through large-batch production. Second, it can satisfy a firm's need for product personalization through customized products and help the firm establish competitive advantage.

In traditional industrial production, the core goal of operations management is to achieve scaled production and reduce production costs by standardizing products. However, rising market demand for personalized products has made the disadvantages of traditional industrial production increasingly evident. First, the model of 'single-product design and small-batch production' cannot meet the needs of mass customization. It increases material loss and equipment use costs, creating a contradiction in production costs. Second, traditional production lines are highly rigid and usually operate through continuous and stable processes. Customized production, especially mass customized production, requires frequent adjustments to production plans, which makes its production cycle longer and its efficiency lower than standardized industrial production. Third, capacity planning is usually based on forecasts, and industrial production often precedes customer purchase. As a result, the production side struggles to respond to rapid changes in consumer demand, leading to wasted capacity and lost orders.

As consumption upgrading continues, consumers' disposable income has increased. This indicates that the consumer market has entered a development-oriented consumption stage. Customers have become less sensitive to product prices, no longer choosing products only on the basis of price, and are more willing to pay for high-quality products. At the same time, customer identity is changing. Customers have shifted from passive recipients to active participants. They can choose among rich product offerings and show stronger preferences for uniqueness and personalization. Under these conditions, firms that fail to satisfy customers' individual preferences will lose competitive advantage. Yet if firms merely satisfy customization demand, they may fall into the trap of diseconomies of scale.

Facing the contradiction between industrial production and individualized demand, mass customization uses cost advantages, differentiation advantages, and flexible production to combine the economies of scale in mass production with the economies of individuality in customized production, thereby achieving an effective balance between the two [2]. The core strategies of mass customized production are modularization, digitalization, and flexible production. These are not isolated elements, but an organic system that supports itself internally. Modularization provides the basic framework for mass customization. It decomposes products into standardized modules and customized modules, allowing firms to combine modules according to customer needs and meet customization requirements. For firms, modular design can effectively control production costs and improve production efficiency. Flexible production is the execution carrier of modular design. In mass production, it generally uses intelligent manufacturing technology so that production lines can quickly and dynamically switch product varieties, allocate materials, and schedule equipment. This mode improves flexibility and enables modular design to be implemented. In mass customized production, digitalization is usually applied to product design and modular division of labor.

In traditional production, customers are often located at the end of the production and sales chain. They only decide whether to buy the product and do not participate in product design or production. They are therefore 'passive recipients' of products. Under the mass manufacturing model, customer demand is reflected at all stages of manufacturing. First, during new product development, customers can express their opinions, participate deeply in research and development, and provide value creation for firms. Second, customers can participate in product design. As final users, they understand product needs more accurately and can help firms identify salient features of new products while integrating customer-side innovation ability and thinking. Finally, when products enter the market, customers can feed back their user experience and possible improvements to the firm. This forms a closed-loop process of value co-creation [3].

In mass customization, coordination between firms and customers is central. The main realization path relies on online customization through online platforms. Customers can express their needs on the customization platforms provided by firms and independently design innovative products that match their preferences. In intense market competition, the mass customization model can promptly incorporate customer feedback into the whole process of product design and production. This helps firms build differentiated advantages and improve competitiveness. In this process, the firm remains in a leading position and guides customers to participate in value co-creation.

2. CURRENT RESEARCH

Mass customization is a key direction for the transformation and upgrading of manufacturing under high-quality economic development. In recent years, it has attracted many scholars and industry practitioners to conduct in-depth research. Existing research on mass customization can be roughly divided into two areas: conceptual and theoretical research, and practical application research.

Davis first proposed the concept of mass customization in 1989, and Pine (1993) later formalized it. In China, Shao Xiaofeng et al. (2001) clearly defined mass customization as a model that reorganizes products and processes so that the customized part of production can be transformed into batch production, thereby meeting personalized demand with the cost and speed of economies of scale [4]. They argued that the core difference between this model and simple mass production lies in customer demand orientation. Other studies add that the essence of mass customization is to achieve a dynamic balance between local flexibility and overall consistency in the production process through emerging digital technologies. Its fundamental difference from scaled production lies in resolving the contradiction between personalization and scale (Shi Xuanya, 2025) [5]. Yu Dongling and Wu Nanxing (2004) divided mass customization into order-based sales, assembly, manufacturing, and design, noting significant differences in the scope of customer participation across different types [1].

From the perspective of practical application, Wu Yishuang et al. (2016) argued that mass customization is realized through the effects of virtual markets and data under current 'Internet Plus' technology. First, individualized demand is decomposed into homogeneous features. Second, standardized production meets homogeneous demand. Finally, standardized components are combined in personalized ways [6]. Some scholars, taking the furniture brand Shangpin Home Collection as an example, proposed a customization process in which customer participation is fully mobilized during design, information linkage between the firm and customers is strengthened when orders are placed, employee potential is stimulated in order splitting and production scheduling, and customer demand is deeply implemented. This ultimately satisfies individualized customization needs (Zhou Wenhui et al., 2018) [7]. Suzić et al. (2012), using a furniture manufacturing firm as a case, similarly proposed that group technology and production process analysis can support a transformation path toward mass customization [8]. In the context of fast-casual restaurants, Tang et al. (2025) found that mass customization improves consumers' utilitarian value, hedonic value, and uniqueness value, which significantly affects consumption evaluations and repurchase intention [9].

As mass customization has developed further, improving customization flexibility and building strong competitive advantage have become important research issues. This has made customer participation a necessary topic. Li Changjiang and Zeng Qi (2007) divided customer participation under mass customization into participation in sales, assembly, manufacturing, and design. They pointed out that the location of customer participation determines the depth of customization. The earlier customers participate, the higher the cost of customization, but the higher the degree of personalization [10]. Other scholars have constructed customer knowledge accumulation functions and rework design functions to calculate the optimal timing and communication frequency of customer participation. They proposed three participation modes: serial participation, in which customers intervene after development ends; parallel participation, in which customers intervene at

the early stage of development; and overlapping participation, in which customers intervene in stages during development [3].

3. THEORETICAL BASIS OF MASS CUSTOMIZATION AND CUSTOMER PARTICIPATION

Based on previous studies, this paper defines customer participation in mass customization as a value co-creation process in which customers, supported by the modular framework and digital tools provided by firms, actively intervene throughout the product life cycle, from research and development to diffusion, through demand expression, module selection, and collaborative design. In this process, individualized needs are transformed into concrete customization solutions. Its core logic is that customers participate deeply in product development and manufacturing. It must be emphasized, however, that customers do not create with complete freedom. They express their preferences within standardized modules preset by the firm. This arrangement both allows customers to participate and express their needs, thereby realizing product value, and enables firms to maintain scaled production.

Achieving good results in mass customization depends on deep customer participation. However, most customers do not spontaneously participate in this process. Firms must therefore consider how to effectively motivate customers to participate in customized production.

3.1. Lowering the Participation Threshold

The first obstacle to customer participation is cost, including time cost, operation cost, and cognitive cost. With the rapid development of digital technology, digital tools can effectively reduce these costs. Firms need to provide intuitive and easy-to-use participation methods and carriers, such as online configurators, augmented reality (AR), virtual reality (VR), and other virtual devices. These tools transform originally complex customization design into visual combinations of options, enabling customers to complete solution design even without relevant professional knowledge. In mass customization, products usually include standardized modules and customized modules. This structure narrows customers' decision scope and prevents them from abandoning participation because of choice overload or complex procedures.

3.2. Satisfying Psychological Needs

The primary goal of customer participation in mass customization is to satisfy psychological needs for participating in product design and realizing self-value. This requires attention to autonomy, competence, and belonging. During customization, firms should give customers appropriate control and allow them to adjust product appearance, parameters, and other elements within a reasonable range, thereby satisfying their need for self-expression. After customers complete their design, firms should improve the design, adjust production orders in a timely manner, modularize components, and promptly feed back the adjustment status to customers. This enables customers to gain a sense of achievement from value creation after customization is completed. Finally, to satisfy customers' sense of belonging and further meet their psychological needs, firms should build customer communities that allow them to feel recognition from similar groups.

3.3. Optimizing the Interaction Experience

The interaction experience significantly affects customers' participation behavior. In the specific process of participating in design, customers need to interact frequently with the firm and with other customers. This process may create psychological pressure and affect the probability of later participation. Firms can therefore promote self-service tools, such as mobile configuration interfaces,

to reduce the psychological pressure caused by face-to-face interaction. This is especially suitable for fast-moving consumer goods and service customization. Nike, for example, provides a customized shoe section in its shopping app. Firms should also provide reasonable room for trial and error, including allowing customers to revise plans and adjust details free of charge.

These three dimensions support each other. Lowering the threshold makes customer participation feasible. Satisfying psychological needs activates intrinsic motivation. Optimizing the interaction experience runs throughout the process. Together, they form an incentive loop for customer participation under mass customization. This loop meets customers' needs for personalized experience and resonates with firms' goal of improving customization accuracy through customer participation.

3.4. Service-dominant Logic

Traditional manufacturing follows goods-dominant logic, which holds that firms producing and providing goods are the core of the value chain and the creators of value, while customers who consume goods are value destroyers. As customers increasingly participate in value production and creation, traditional goods-dominant logic has gradually shifted toward service-dominant logic. Service-dominant logic holds that all participants in social and economic activities are resource integrators and participants in value co-creation. This generalization of actors emphasizes attention to their activities within exchange systems [11]. From this theoretical perspective, customers are no longer passive recipients of value, but active value creators.

In mass customization, the essence of customer participation is that customers input their needs and combine their own knowledge and preferences with the firm's resources to jointly create customization solutions and form customized value. This theoretical logic provides a foundation for customer participation and explains the rationality and necessity of customers' deep involvement in the production process under mass customization.

3.5. Technology Acceptance Model

The Technology Acceptance Model (TAM), developed by Davis, is a model in the field of information technology used to explore user experience [12]. It mainly studies which variables affect users' attitudes toward information systems and then influence behavioral intention [13]. The model distinguishes two types of users. The first are perceived-usefulness users, who believe that technology can help them achieve their goals. The second are perceived-ease-of-use users, who believe that technology is understandable, simple, and requires no additional learning. In mass customized production, customer customization activities rely heavily on modern digital tools. Therefore, whether customers are willing to participate in customized production, and the degree to which they participate, largely depend on their perceptions of these tools. If customers believe that digital tools can help them accurately express their needs and preferences without excessive effort, their willingness to participate will be stronger. If the tools are complex and difficult to understand, their willingness to participate will be lower. This indicates that, in mass customization, a necessary condition for attracting customer participation is ensuring that the tools required for customization are acceptable to customers. Only then can firms effectively stimulate their interest in participation.

4. PRACTICE OF VALUE REALIZATION IN CUSTOMER PARTICIPATION UNDER MASS CUSTOMIZATION

Nike, known in Chinese as Naike, is a globally recognized sports brand. It was founded in 1972 and is headquartered in Portland, Oregon, United States. Nike's current production and sales cover clothing and footwear for men, women, and children, as well as professional sports equipment. It also owns several sub-brands.

In 1999, to further shape its brand tone and provide personalized services to customers, Nike launched the 'Nike By You' customization service. Its core purpose was to allow customers to participate in the personalized design of footwear and apparel through an online digital platform. Nike By You also belongs to mass customization because customers' personalized designs are based on Nike's existing shoe models, such as Air Force 1 and Dunk. Customers can select preferred styles on the platform, adjust product colors, and add personalized marks. Nike also provides digital modeling for customer-designed products, allowing customers to directly view the finished design. After customers confirm that their customization plan is correct, the product enters the factory production line. This model preserves Nike's brand premium and production efficiency while satisfying customers' need for self-expression through participation. By 2024, customized products contributed more than 15% of global revenue, making Nike a benchmark case of mass customization among sports brands.

In Nike By You, the customer's customization plan is not only a personalized product but also a carrier of interaction between the brand and users. During this process, Nike solicits customers' finished designs on social media, selects 'best customization cases,' and converts outstanding designs into store products for sale. This upgrades customers from 'designers' to 'brand co-creators.' This form of mass customization strengthens customers' sense of achievement and autonomy. It also allows the firm to accumulate a large amount of information on customer consumption preferences, providing data support for future product design.

The practice of Nike By You verifies the core logic of customer participation in mass customization: balancing personalization and efficiency through a modular framework and digital tools. As long as customer customization behavior is placed within reasonable boundaries set by the firm, mass customization services can achieve a win-win outcome for user experience and enterprise efficiency. As Nike's customization services have continued to upgrade, new technologies have also been introduced. AR technology and object-tracking technology are used to display shoes customized by consumers, and consumers can receive the sneakers they designed in about two hours.

Nike By You decomposes finished-product production into standardized functional modules, such as shoe type and technology, and customized differentiated modules, such as color and marks. Customers create personalized products within the range set by the firm and usually do not affect the product's core performance. For example, Air Force 1 is a commonly used shoe type in Nike By You. The firm provides an undesigned version of this model, and customers can only adjust upper materials and customized marks. This arrangement protects mass production efficiency while attracting consumers through customization.

To keep pace with the flexible needs of customization services, Nike divides its supply chain into different cooperation modes. For standardized module components, such as sole materials and upper leather, Nike maintains long-term relationships with suppliers to meet the needs of large-scale production. These suppliers sometimes play a role in inventory management, helping the brand improve inventory turnover and avoid material shortages or backlogs. For customized module materials, such as special-color dyes and threads, suppliers are usually found near the production location. On the one hand, these suppliers can accept small-batch orders and respond quickly with timely delivery. On the other hand, sourcing suppliers from the production location can reduce transportation costs. Under this differentiated production and supply model, both core components required for large-batch production and small-batch customized materials can be produced and shipped in a timely manner, ensuring flexible operation of the production line.

5. VALUE ANALYSIS OF CUSTOMER PARTICIPATION IN MASS CUSTOMIZATION

In the mass customization model, the significance of customer participation is not merely demand feedback. It creates breakthrough empowerment for traditional production models by balancing

scaled production and individualized demand. Unlike traditional production, which is characterized by 'enterprise dominance and passive customer acceptance,' mass customization uses digital tools and modular design to accurately match dispersed individualized needs without sacrificing production efficiency or cost. This feature of flexible production gives customer participation a clear cost-reduction and efficiency-enhancement effect. It also increases the socialization of the firm and becomes a core element in balancing enterprise efficiency and competitiveness.

In mass customization, user participation can accurately capture demand, reduce the probability of information asymmetry, and lower the cost increases and resource waste caused by imbalances between supply and demand. In traditional mass production, firms rely on market forecasts for batch production and often suffer order losses or inventory backlogs because of misjudgments of real demand. Through participation in customized production, users enable 'direct transmission of demand to production' and shorten the information transmission path. At the same time, user feedback at the design stage can reveal potential product problems in advance and reduce later production rework and after-sales costs. This helps maintain the cost advantage of scaled production while satisfying individualized needs.

Customer participation brings innovation input from the demand side. During customization, customers reveal latent needs and creative ideas for products, which can become directions for future product optimization and promote upgrading of the modular production system. In addition, behavioral data accumulated through user participation help firms identify market trends in a timely manner. This allows research and development resources to shift toward areas with greater need and value, avoiding the blindness of traditional innovation. By surveying customers who participate in customization, firms can obtain direct feedback on product design, quality performance, and other aspects. This information helps firms respond to customer demands at lower cost and higher speed, optimize service processes in targeted ways, and improve service levels so that customization services better fit customers' actual needs. This feedback mechanism based on customer participation reduces waste caused by blind improvement and increases customers' satisfaction with and recognition of customization services through accurate demand matching [14]. Under this form of mass customization, product iteration can better align with real consumer market needs and continuously improve the flexibility and market adaptability of the customization system.

Customer participation also brings a significant value advantage to mass customization: it strengthens emotional connections with customers and thereby increases relational stickiness between customers and firms. During customization, the time and creativity customers invest generate a sense of belonging to the brand. This encourages emotional identification with the product and brand that goes beyond a simple consumer transaction, thereby increasing repurchase probability and satisfaction. Such emotional dependence formed through participation is difficult for competitors to copy merely by imitating product modules, and it becomes a core barrier for differentiated competition. In the long run, user participation pushes firms to transform from product providers into value co-creation platforms. Through user community effects, firms can expand brand influence and establish unique competitive advantages in homogeneous markets.

6. CHALLENGES OF CUSTOMER PARTICIPATION IN MASS CUSTOMIZATION

The realization of value from customer participation first faces a potential conflict between willingness and ability. On the one hand, some customers have strong demands for personalized expression but are sensitive to the time cost and decision cost required by the participation process. In mass customization, even when firms provide modular options, customers still need to make choices across multiple dimensions. This 'choice pressure' may reduce willingness to participate. When facing some products, customers may even prefer standardized options over customized products in order to save effort. On the other hand, customers differ significantly in their participation

ability. Some customers lack systematic understanding of products, which leads to vague demand expression and makes it difficult to match their needs accurately with the firm's modular design. Moreover, current mass customization mostly relies on digital platforms, which creates an invisible threshold for participants. This further intensifies the problem of insufficient ability and forces some customers to abandon participation despite having the willingness to participate.

In customer participation in mass customized production, firms face the problem of value conversion efficiency. The first issue is information fragmentation generated by customer participation. In customization services, customer feedback forms and needs differ across platforms, such as offline stores and online platforms. Firms therefore need to invest additional resources in standardization. If integration is not timely, demand distortion can occur and costs can increase. The second issue is the difficulty of balancing individualized demand and scaled production. Customer participation increases customization options, which may complicate material management. Especially when customization demand exceeds preset module boundaries, firms must temporarily adjust processes, causing efficiency losses. The third issue is the absence of a value evaluation system. The long-term value of customer participation for firms, such as brand identification and innovation momentum, is usually difficult to quantify. Because short-term investment may not match visible returns, some firms may reduce resource input into customer participation, creating a vicious cycle in which participation becomes a mere formality. These bottlenecks make it difficult to release the potential value of customer participation effectively and may even turn it into an operational burden.

Technical tools are the carriers of customer participation, and their adaptability directly affects the effect of value realization. Some firms' customization platforms provide diverse options but fail to guide customer decision-making effectively because their functions are disconnected from participation scenarios. For example, they may not indicate the compatibility of module combinations or visualize customization effects. Customers then find it difficult to judge whether their choices are reasonable, which reduces the participation experience. Insufficient system coordination is another obstacle. Front-end tools for customer participation and back-end production systems, such as enterprise resource planning (ERP) and manufacturing execution systems (MES), often have poor data connectivity. A situation may arise in which, after a customer submits a customization plan, the production side cannot recognize or execute it. This directly weakens the credibility of participation behavior. In addition, security and stability risks cannot be ignored. During participation, customers must submit data such as personal preferences and sizes. If the platform has privacy leakage risks, customer trust will decline significantly. Technical failures such as system crashes and loading delays may directly terminate participation behavior. These defects in technical tools cannot support smooth customer participation and may instead become obstacles to value realization.

The individualized demand brought by customer participation under mass customization also increases the complexity of production. In material management, personalized customization increases the types and specifications of required materials. In standardized production, only a few core materials may need to be purchased and stored according to production orders and historical data. Now firms may need to deal with dozens or even hundreds of auxiliary materials, which increases the difficulty and risk of warehouse management and material kitting. Cost pressure also arises. Because the increased material types are needed only for customized products, they cannot be purchased on a large scale, and procurement costs therefore rise.

Quality management also becomes more complex. In standardized production, stable processes and unified procedures ensure consistency in product quality. Customized production involving customer participation, however, requires frequent process adjustments or component replacements. Workers must constantly adapt to new operating requirements, which can easily cause quality fluctuations because of insufficient proficiency. At the same time, customized components are often produced in small batches, making it difficult for traditional sampling inspection to cover quality risks comprehensively. Some minor customized details may also become hidden risks in quality inspection, increasing the workload and complexity of quality control.

7. CONCLUSION

This paper concludes that customer participation in mass customization is not a completely free process of personalization, but a form of value co-creation under the constraints of modular design, digital tools, and flexible production systems. In this process, customers enter the product life cycle through demand expression, module selection, and collaborative design within the framework predefined by firms. Its core logic is constrained personalization, which both protects customers' individualized needs and meets firms' efficiency requirements for scaled production.

Customer participation creates multidimensional value for firms. On the production side, the direct transmission of demand to production reduces information asymmetry, lowers inventory and rework costs, and improves resource allocation. On the innovation side, customer feedback and behavioral data promote the upgrading of product modularization and strengthen the production system's adaptability to market changes. On the strategic side, emotional connections formed through participation help build differentiated competitive barriers and push production models from forecast-driven logic toward demand-pull logic. However, the realization of this value still faces challenges, including mismatches between customers' willingness and ability to participate, bottlenecks in enterprise value conversion efficiency, and coordination barriers between technical tools and production systems. Among these challenges, insufficient production system flexibility is the key constraint on value release.

At the theoretical level, this study integrates service-dominant logic and the Technology Acceptance Model to explain the mechanism of customer participation in mass customization. It shows that customer participation is not merely a process of demand collection. Through the real-time input of individualized needs, it forces the production system to optimize the dynamic allocation of resources and enhance flexibility. This finding provides a useful explanation for how production and operations management can balance demand fluctuation and production stability in the context of mass customization.

At the practical level, firms should optimize production and operations management around modular design, flexible coordination, and precise evaluation. Core functional modules should be standardized to ensure batch production efficiency, while customized modules should be controlled within reasonable boundaries. Flexible equipment and differentiated supply chain arrangements should be used to support rapid response to customized demand. Performance evaluation should also include both traditional efficiency indicators and customization-specific indicators. In this way, firms can better achieve a dynamic balance between individualized demand and production efficiency.

Overall, customer participation is an important path for realizing the value of mass customization, but its effectiveness depends on whether firms can transform individualized demand into manageable production tasks. Future research may further examine how different industries design participation boundaries, how digital platforms affect customer participation efficiency, and how firms evaluate the long-term value created by customer participation.

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