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Research on the Practical Application of Mass Customization Balance Theory from the Perspective of Supply Chain

Xin Song

City Institute, Dalian University of Technology, Dalian, China
Email: 17573693@qq.com

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Abstract

Mass customization is the main direction of the transformation and upgrading of manufacturing mode. Based on the theory and perspective of supply chain, this paper reinterprets the content of the mass customization balance model, and summarizes the key technical conditions for the selection and implementation of the best dividing point between the balance point and the balance area in the mass production and customization production modes, and analyzes the actual cases, so as to break through the gap between the various theoretical knowledge modules. The purpose is to simplify the complex problems, which can be used for reference and guidance for enterprises in various industries.

Keywords

Mass Customization Balance Model, Mass Customization, Customization-Massing, Modularization

1. Research Status of Mass Customization at Home and Abroad

Mass customization is a hot topic in research and application. In 1970, Alvin Toffler put forward the basic idea of mass customization for the first time in his book "future shock", which triggered a research upsurge of scholars. In 1993, Pine et al. (1993) pointed out that mass customization is a production mode which aims at low cost and high speed of mass production and provides customized personalized products and services. Mccutcheon et al. (1994) pointed out that the basis of customer needs and enterprise capability should be considered when selecting mass customization strategies implemented by enterprises. Feit-

zinge and Lee (1997) proposed that the key to effective mass customization is to move back the customization point, and comprehensively consider the influence of various factors. Jiao et al. (1998) considered that the life cycle of products should be considered in mass customization product family model, and proposed three aspects to identify Customization: design customization, process customization and customer perceived customization value. Tseng et al. (2003) pointed out that there are a lot of similarities in tools, production plans and product design in mass customization manufacturing systems. If these similarities are used correctly, it will help reduce the complexity of manufacturing systems. Mccarthy (2004) introduced the goal, scope and content of mass customization, and gave different definitions and explanations of mass customization. Smith et al. (2013) put forward the goal, configuration, integration technology, modular design technology, flexible manufacturing system and supply chain management method of mass customization.

Chinese scholars also have done a lot of research on mass customization. Qi et al. (2000) put forward that the separation point of customer order is different in the production process. Mass customization can be divided into four categories: sales-to-order (STO), assembly-to-order (ATO), make-to-order (MTO) and engineer-to-order (ETO). They also pointed out that the key technologies of mass customization mainly include product development and design technology, management technology, customer demand analysis technology, re-configurable manufacturing system and cost control technology. Wu & Qiu (2001) believed that mass customization is a new embodiment of group technology in the information age. Shao et al. (2001) described the content of mass customization, and pointed out that mass production should have four conditions to transform to mass customization. Zhou et al. (2003) put forward that the strategy of mass customization depends on the enterprises' demand and supply chain strategy. Yang & Qi (2007) believe that the key of mass customization is to identify and utilize a large number of similarities existing in different products and processes, and transform the similarity into reusability.

The current research mainly explores and refines from the perspective of technology, strategy, strategy, mode, etc., but if these contents can be included from the perspective of supply chain, this paper will carry out research and summary based on the theoretical basis and perspective of supply chain.

2. Overview of Mass Customization Balance Theory

2.1. The Relationship between Mass Customization and Customization-Massing

Based on the research theory of domestic and foreign scholars on mass customization, Wang et al. (2014) proposed that mass customization can be divided into two different processes: mass customization and customization-massing.

Mass customization is a process of mass production integrating with customization. While maintaining the scale effect of products, it can deepen customers' personalized demand for products, subdivide customer groups, and make

use of product family to realize the diversification of final products, so as to better meet customers' personalized demand for products, balance mass production and customization, and help enterprises achieve maximum efficiency Benefit.

Customization-massing is a process of integration of customization and large-scale production. While meeting the individual needs of customers, it seeks the commonness or similarity between products, and uses modularization to build product family, so as to expand the customer group and expand the scale of products or parts, so as to achieve the balance between customization and large-scale production and maximize the benefits of enterprises.

Mass customization and customization-massing have the same purpose, that is to seek compatibility and optimization between mass production and customized production. It can not only realize the advantages of scale economy through modularization and generalization of parts, but also pursue the individualization and diversification of products to meet the customized needs of customers. However, there are some differences between the two modes in production mode, technical method and application. As shown in **Table 1**. Enterprises with different natures can adopt different production modes. For products requiring mass production, mass customization should be adopted; for products requiring customized production, mass customization should be adopted.

2.2. Mass Customization Balance Model and Strategy

The market characteristics of the current stage are personalized and diversified customer demand, and at the same time, there are higher requirements for the service, product quality and delivery time. Therefore, enterprises must take customer demand as the guidance and adapt to the personalized needs of customers through product diversification.

However, any demand has cost constraints, and increasing scale is an effective means to reduce the unit cost of products. Therefore, any product needs to balance customization and scale, which is also the driving force for enterprises to implement mass customization. In the important market environment, Wang et al. (2020) propose the mass customization balance model and strategy for what strategies should be adopted to achieve mass customization balance, as shown in **Figure 1**.

In a certain market environment, if an enterprise seeks and achieves the balance point or balance area of mass customization, it will bring the best benefits to the enterprise. When the market environment changes, the original equilibrium point or balance area will be broken as much as possible. Enterprises need to seek new mass customization balance points or balance areas. The main factors of mass customization in product characteristics and customer group demand lead to the direction of mass customization adjustment; the level of ability in the resources available to enterprises, modularization and product family and other product R & D and manufacturing technology are the cornerstone of mass customization implementation, which plays an absolute support role in achieving the balance of mass customization.

Table 1. Main differences between mass customization and customization-massing.

Main differences	mass customization	**customization-massing**
Production mode	Research-production-marketing	Order-Research & Design-production -customer
Production direction	Mass production-customized production	Customized production-mass production
Application	Make-to-stock enterprise	Make-to-order enterprise
Production method	Postponement strategy and modularization technology	Product family technology and group technology

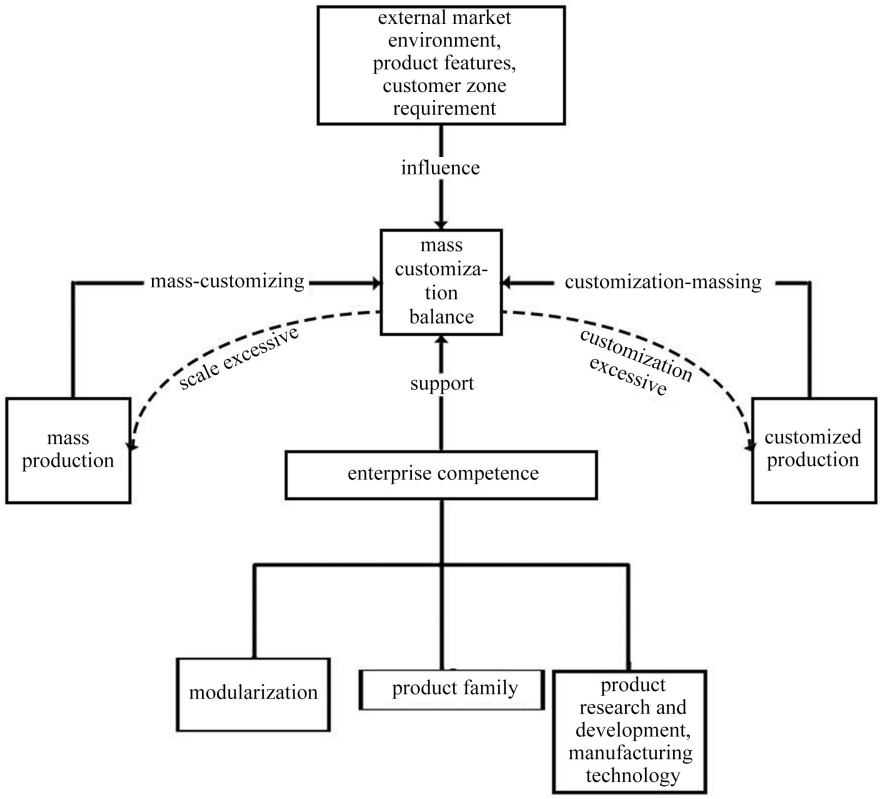

Figure 1. Mass customization balance model and strategy.

3. Interpretation and Case Analysis of Mass Customization Balance Model from the Perspective of Supply Chain

3.1. Interpretation of Supply Chain of Four Core Models

Based on the theory and perspective of supply chain, this paper first explains several core terms:

1) Mass production refers to push system in the supply chain, which is make-to-stock, which is suitable for the model adopted by the make-to-stock enterprises. Its core feature is to promote sales by production, excessively obtain the scale benefits of production and sales, but lose the market of customer personalized demand, and forced to hold a higher inventory level, making the bullwhip effect in such enterprises far-reaching influence, cannot be eliminated.

2) Mass customization refers to push-pull supply chain which sets the boundary on the process of "assembly", which can also be called "assembly-to-order". In the upstream of the supply chain, the mass production of the general module is completed, and then the general module is transformed into the "assembly" process of personalized products, which is delayed to the downstream enterprises of the supply chain. This mode is especially suitable for the make-to-stock enterprises which are transforming from the push system to the push-pull system. The core technology methods to realize this kind of mass customization are forming delay strategy and modular design technology.

3) Customized production refers to the pull system in the supply chain, which belongs to engineer-to-order. The production enterprise designs, produces and sells products according to the real customer demand received. Its core feature is demand driven production. Although it can fulfill customers' individual demands to the greatest extent, it has lost the economic advantages of large-scale procurement, production and transportation. Generally, the price of finished products is higher and the production cycle is longer. The applicable product types are limited to high-value and high-tech products, which are usually suitable for make-to-order enterprises.

4) Customization-massing refers to the push-pull supply chain with the boundary set on the "production", which can also be called "make-to-order mode", This mode is to implement the idea of personalized customization of customer demand in the order, R & D and design stages. It is only the general parts and customized parts divided in the production stage of product parts. It needs to integrate the scale production of general parts of product family to reduce the production cost and shorten the production cycle. The core technology method is product family technology and customization group technology. Generally, this mode is suitable for the make-to-order enterprises which are transforming from pull system to push-pull system.

3.2. Implementation Conditions and Case Analysis of the Transformation from Mass Production Mode to Mass Customization Mode

From the perspective of supply chain, the transformation from mass production mode to mass customization mode is the process of transformation from push system to push-pull system, that is, the transformation from make-to-stock mode to assembly-to-order mode for the make-to-stock enterprises such as clothing, home appliances and mobile phones. The key point of this transformation is the supply chain design strategy of MC equilibrium point. The implementation conditions of this transformation are divided into three points: First, we should judge whether it is necessary to carry out the reform of personalized customization according to the product attributes and business philosophy; The second is whether the products of the enterprise can be divided into modular designs, Usually, the finished product after transformation is to be a combination of general-purpose module and personalized module, or a configuration

combination of N general-purpose modules. Therefore, whether the finished product can be divided into several parts or can be upgraded to innovative R & D and production of module technology is the key point. The third is whether it can shorten the customization time to meet the consumers' requirements for the lead time. The core method is to postpone the assembly and other customization processes to the downstream enterprises of the supply chain, which will be closer to the market and enhance the ability of rapid response. However, the inventory cost and logistics cost should also be taken into account. Therefore, the distribution center is the ideal place to complete the customization process, not the retailer.

Dell is the most classic case of such transformation. In the 1990s, Dell put forward the concept of providing personalized computer customized service for consumers, and built a "direct selling" mode, successfully building a mass customization supply chain structure. First of all, DELL provides consumers with a variety of computer accessories, including motherboard, CPU, hard disk, sound card, graphics card, display and chassis. Consumers complete the selection of online personalized computer configuration through online direct selling mode, and place the order. Then, Dell will immediately pick, assemble and package the necessary accessories in the logistics center according to the order information of consumers, and produce customized computers to meet the consumer's requirements. Dell model accurately meets the merger and mining the consumers' personalized needs for customized products, and skillfully uses modular technology and postponement strategy to find the MC balance point, which shows the beauty of mass customization balance.

Nowadays, this mode of mass customization has been widely used in the computer industry.

3.3. Implementation Conditions and Case Analysis of the Transformation from Customized Production Mode to Customization-Massing Mode

From the perspective of supply chain, the process of transformation from customization mode to customization-massing mode refers to the transformation from engineer-to-order to make-to-order of large-scale equipment such as large cranes and generator sets, as well as make-to-order enterprises such as customized automobiles and high-end clothing. The purpose of this transformation is to obtain the economics of scale of the upstream parts/components production in the supply chain to reduce the product cost, so that the advantage of personalized customization can obtain a broader market. The key to this transformation lies in how to achieve large-scale benefits in the production of customized parts.

The implementation conditions are divided into three points: First, whether the same or similar parts in a series of products can form enough scale requires enterprises to explore the design of common parts in the whole product series and expand their scale to a certain extent, so as to obtain the cost advantage of mass production; The second is whether the highly customized products can

evolve into the perfect integration common parts and customized parts after adopting the product family technology; The third is whether the group technology can realize the parallel process, because the group technology increases the possibility and quantity of the same or similar parts that can be produced at the same time, thus forming the economics of scale. Whether the whole line products can form multiple group technologies is the key.

For example, the bridge crane is a typical engineer-to-order product, because its product structure and process are very complex, and the size requirements of structural parts vary greatly under different use conditions. In the operation of a crane manufacturer in China, it is found that the designers have designed too many customized parts and ignored the similarity between these customized parts, which increases a lot of design and manufacturing costs, and also leaves a lot of hidden dangers for product quality and maintenance. Therefore, the enterprise decided to apply modularization and product family design technology to mass customization transformation.

Through a lot of analysis and research, the enterprise summarizes the product structure and functional characteristics, and uses modular technology to divide the bridge crane into primary module and secondary module. The first level module includes the bridge of bridge crane, crane running mechanism, trolley frame, trolley lifting mechanism and trolley running mechanism, and summarizes four common structural forms. At the same time, they are further subdivided into secondary modules. The secondary modules of bridge and trolley frame: main beam, auxiliary main beam, end beam, track, platform, base, ladder and railing are all structural parts, which can be further divided into plate or profile parts, and can be analyzed and summarized into several common structural forms. The common basic modules of trolley running and lifting mechanism are motor, reducer, brake, wheel set, coupling and buffer, which can be called standard parts or general parts. There are nearly 40,000 general modules at all levels of the bridge crane, each of which has a different number of specifications; at the same time, some special modules serve for high-end customized products. Usually, when placing an order, customers can give priority to the common forms of modules at all levels. When the common modules can not directly meet the customization requirements, they can use the next level module selection, or special modules, or design new parts/components. After modular practice, the enterprise realized the standardization and generalization rate of bridge crane parts and components, increased about 20%, shortened product design and manufacturing cycle by about 15%, and reduced product cost by about 18% under the condition of meeting customer demand.

At the same time, according to the theory of group technology, the enterprise organizes the production reasonably according to the delivery time, and outsources the specialized manufacturing of some modules with other manufacturers, so as to realize parallel processes, thus shortening the lead time of ordering. After the implementation of customization-massing, the number of parts/components produced by outsourcing manufacturers increased from 18% to 55%, and the

number of directly purchased parts/components increased from 15% to more than 25%.

It can be seen that through the application of product family, modular technology and group technology, the product line of the enterprise has been expanded. At the same time, the enterprise has obtained the scale utility of parts standardization and parts generalization. The long-term stable cooperation with outsourcing manufacturers has also expanded the scale of products, reduced the cost of products, shortened the manufacturing cycle of products, and better met the needs of customers. The enterprise has successfully found the key balance area of the transformation from customized production to customization-massing, and its experience also provides reference for the transformation of other customized enterprises.

3.4. Interpretation and Case Analysis of Mass Customization Balance Point or Balance Region from the Perspective of Supply Chain

The scope of mass customization balance point or balance area includes not only assembly-to-order from mass production to mass customization, but also make-to-order from customized production to customization-massing, From the perspective of supply chain, it is to weigh how to achieve win-win integration between production driven and demand driven. Its essence is push-pull supply chain mode, and the key lies in the establishment of push-pull boundary. Here, the author thinks that the establishment of push-pull boundary should consider two factors: the selection of customized production process and the place to complete the process. The author sums up the comprehensive analysis of the two factors into two kinds of options of the boundary:

The first kind of boundary is the production of "assembly", and other customized processes in the downstream enterprises of the factory (mostly distribution centers or distribution centers). This is a typical finished product postponement strategy. The core technology is to transform the finished product design into a combination of general-purpose finished products and personalized modules, so as to obtain the large-scale production advantages of general-purpose finished products in the production line of the factory, separate the personalized modules and delay them to the downstream enterprises of the supply chain, so as to be closer to the consumer market, enhance the rapid response ability and facilitate the channel management. This kind of situation is suitable for enterprises and products with weak degree and difficulty of customization, such as Dell, HP printer, etc.

The second kind of boundary is to complete modular and customized production on the production line of the factory. That is to say, the process usually holds all kinds of modular parts. Only after receiving the real consumers order, N kinds of modules are put on the production line to complete the customized production of personalized products, according to the order information. This kind of push-pull supply chain is usually presented by two situations:

1) The parts of customized products are divided into general-purpose parts and customized parts. By seeking the advantages of general-purpose parts in large-scale production of series products, this situation is suitable for products with high degree of customization, such as large cranes.

2) The customized product is designed by modularization, and then N kinds of modules are combined and configured to complete flexible production to produce customized products. The key point of this situation lies in the complexity of modular design, flexible production capacity and information technology level. Generally, if more modular options are provided to consumers, it means stronger personalization. We can introduce consumers to participate in design and other projects, extend and enlarge the development space of modular design, greatly enhance its value-added, and match the development of the current popular C2B mode, for example, customized furniture and red collar suits. But at the same time, the demand for flexible production and manufacturing capacity of the production line is also higher. Therefore, enterprises will use the thinking mode of series products to improve the sales of the whole line of products and obtain the scale effect of modular production. According to the different business models of different enterprises, this kind of mass customization balance has its own characteristics.

"Red collar" is a model in the clothing industry. Driven by customers' requirements, "Red collar" provides consumers with more than 100 details of their choice, including the type, style, fabric, color and button, etc., with the help of the Internet platform and the idea of modularization. Customers can automatically complete the body data collection of 22 sizes of 19 parts in 7 seconds through the patented body measurement tools and methods independently developed by "Red collar". At the same time, the customers can freely match and combine the options provided according to their own preferences to form a unique order. Then, this personalized customized information will be transmitted to its RCMIM data center to form a digital model of the suit, which will be printed by the computer, and then decomposed into independent processes and corresponding material BOM, which will be sent to the machines and workers on the assembly line, and finally the customized production of the suit will be completed in the factory production line. The success of "Red collar" lies in the integration of Internet, Internet of things and other information technology into large-scale production, realizing the flexible collocation and free combination of different data, specifications and elements on the assembly line, so as to produce flexible and changeable personalized products on one assembly line. Of course, what promotes the sustainable development of "Red collar" is its unremitting innovation investment in various technical fields: Red collar's Kute intelligent company has established four databases of version, style, fabric and BOM, which have reached the level of one million trillion, and can meet 99.99% of the personalized customization needs of human body. At the same time, Red collar's Kute intelligent company also solves the problem of automatic intelligent docking and

transformation between sales system and production system. In addition, the production line of "Red collar" has 28 elaborate individual cutting processes, 238 exquisite sewing processes and 32 three-dimensional ironing processes. It has applied for national patents in nearly 100 practical production equipment, breaking through hundreds of technical bottlenecks. The R & D and upgrading of these technologies are to explore the perfect integration of customization and scale in the field of garment production, which is also worthy of reference and learning for many enterprises.

4. Conclusion

Mass customization is a hot spot at present and in the future. It is also the main production mode to realize C2B business model and made in China 2025. Many traditional large-scale production enterprises and industries will have to face the problem of transforming to mass customization mode because they want to meet the increasing personalized needs of consumers, which is very difficult for leaders and managers of many traditional enterprises. Because the core links involved in the transformation of supply chain reform, enterprise structure reorganization, modular design, manufacturing process reset, etc. need scientific theoretical research as the basis, and a large amount of practical experience accumulated by enterprises as shared resources. Obviously, this is a relatively long way to explore. Of course, many experts and scholars at home and abroad focus on this and continue to explore how to develop mass customization strategies according to different product characteristics and business philosophy, so as to provide scientific basis and foundation for theoretical research of enterprise innovation and practice reform. The author of this paper also hopes to break through the gap between different knowledge modules, and provide some reference significance and value for mass customization application and development in different fields and enterprises. The paper focuses on reinterpreting the strategy model of mass customization proposed by Wang et al. (2014) from the perspective of supply chain theory, and analyzes the selection method and key technology of the core equilibrium point and the best dividing point of the balance area by combining with the examples. In addition, this paper does not focus on the in-depth study of modularization and external factors of the balance strategy model, which is also the deficiency of this paper. I hope to have the opportunity to continue to complete a comprehensive study in the future.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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