

Status and Development Trends of Intelligent Manufacturing in China's Furnishings Industry

Xian-qing Xiong

Ying-ying Yuan

Lu Fang

Hui Liu

Zhi-hui Wu

Abstract

This paper analyzes the transformation of manufacturing in China's furnishings industry and the status of intelligent manufacturing on the basis of the industry status quo, corporate development around custom furnishings and digital manufacturing, and management and control of manufacturing information. On the basis of an understanding of smart homes, the guiding ideology and key technology in intelligent manufacturing in the furnishings industry involve digital manufacturing. This article comprehensively analyzes the influences of intelligent manufacturing on the furnishings industry related to diverse structure, sales, service, and competition among enterprises. We propose that the development direction of the intelligent manufacturing of furnishings includes digital transformation, collaborative platform construction, and continued improvements to distribution. This article also provides new ideas for the development and transformation of the personally customized furnishings industry and offers implications for digital manufacturing in the furnishings industry in the future.

The Chinese furnishings industry has gained widespread attention and exerted a broad influence worldwide throughout the past 40 years (Cao et al. 2004). Under the backdrop of manufacturing industries such as "Internet+," "Industry 4.0" (Chang 2013, Luo 2014), and "Made in China 2025" (State Council of the People's Republic of China 2015), the Government Work Report in 2016 proposed personalized customization and flexible production to enhance the quality of consumer products and encourage enterprises to promote these features. The report promoted cultivation of excellent craftsmanship in variety, quality, and brand (Li 2016). In promoting "Made in China + Internet," the report also encouraged upgrades in the manufacturing industry and provided fresh modes of thinking, business, and manufacturing in the traditional manufacturing industry (Wu 2017). These information management and innovative business models and services have become the driving forces behind the transformation and enhancement of traditional industries and economic development in customizing furnishings companies.

Realizing flexible manufacturing through digital design and manufacturing has presented new challenges and opportunities for the traditional home furnishings industry (Yang 2013). Moreover, because of the influence of the mobile Internet such as Tencent QQ, WeChat, Taobao, mobile APP, and Alipay, people's consumption patterns and information exchange modes have undergone tremendous changes. Demand for personalized consumption is growing, and producer services and service-oriented manufacturing

have emerged. Meeting customers' expectations of personalized products amidst new circumstances is a hot topic for furnishings manufacturing enterprises.

Given the labor-intensive nature of furnishings manufacturing and traditional interior decoration industries, these fields are greatly influenced by the times, national policy directions, and industrial restructuring and upgrades. The Chinese furnishings industry has gradually shifted toward new models such as factory renovation, decoration, custom furnishings, whole-family custom furnishings, integrated homes, whole homes, whole custom wood, and smart homes. The industry has also realized digital and intelligent processing in product development and design, manufacturing, process control, business management, and marketing services, thus transforming the industry from product manufacturing to home-systems integration service provision (Wu 2016). Development trends will also be driven by innovation via Industry 4.0, Internet +, cultural integration,

The authors are, respectively, Associate Professor and Director, Postgraduate Student, Lecturer, Postgraduate Student, and Professor, College of Furnishings and Industrial Design, Nanjing Forestry Univ., Nanjing, Jiangsu, China (xiongqianqing@njfu.edu.cn [corresponding author], 1002237264@qq.com, fangluyang@126.com, 648654397@qq.com, 20337061@qq.com). This paper was received for publication in January 2018. Article no. 18-00002.

©Forest Products Society 2019.

Forest Prod. J. 68(3):328–336.

doi:10.13073/FPJ-D-18-00002

and personalized customization and flexible production to upgrade the furnishings industry, customize furnishings, and shape furnishings manufacturing. Home information industry control presents an important direction for future change in the home industry (Zhu 2017).

Evolution of Furnishings Manufacturing Industry and Intelligent Manufacturing Trends

Evolution of Chinese furnishings manufacturing patterns

China established a modern furnishings manufacturing industry by transforming since launching in the mid-1980s. The industry initially transformed the mode of manual production into a preliminary industrialized mass-production mode, but failed to fully address economies of scale, namely due to changing market demands and factory operations focused only on semi-industrial modes of production (Xiong and Wu 2013). After the 1990s, a fundamental change emerged as consumption demands became increasingly personalized and diverse, pushing consumers' individual needs to the limit and exhibiting distinctive characteristics of the high-tech era. Personalization has since become a new consumer pursuit and selection criterion. Therefore, small-batch furnishings production represents a new lifestyle that is growing in popularity. This change in consumption is due to the widespread use of information technology (IT) and new technologies that have given consumers novel ideas and pursuits (Kotha 1989, Pine 1993, Svensson and Barford 2002).

New technologies and demands have been accompanied by new production modes. In one sense, the formation of a new competitive element enables more enterprises to compete on equal footing, which is conducive to innovation. Mass-customized enterprises have competitive advantages because they can better meet individual needs, resulting in an element of competition during innovative times. By contrast, improved customer consumption and new demand will lead to the development of many related enterprises. As manufacturing technology is an important means of product innovation, production development, and technological competition, its rapid development has created conditions for the manufacturing industry. Enterprises can make full use of advanced manufacturing technologies to increase production efficiency and profit and enhance customer satisfaction (Pine et al. 1993, Christopher 1995, Mitchell et al. 1997).

Since the 1990s, many developed countries, especially the United States, have introduced manufacturing modes alongside large-scale customized production (Anderson 2000, Pine 2000). Yang proposed the concept of the customized economy in 1999; in 2002, Yang published "The new manufacturing model: Mass customization" (Wen 2002) and wrote that changes in marketing modes would surely bring evolutions in manufacturing. He also proposed the concept of mass customization and explained how the furnishings industry can realize the key process of mass customization. This article became the basis for mass customization in production and information management and embodied the launch of intelligent furnishings manufacturing in China. Yang also put forth the idea of decentralized production combined with Chinese urbanization, pointing out that enhancements in the furnishings

business can shape modes of production via intelligent manufacturing.

Despite being published in 2005, "Interpreting the third industrial revolution concerned in Chinese urbanization" remains an important reference, providing an early perspective on the home industry 4.0 as a decentralized model. In 2003, Professor Wu Zihui of Nanjing Forestry University published the serialized "Advanced furnishings manufacturing technology in the information age" in *Furnishings Magazine* (Wu 2003a, 2003b), noting that human society has entered the information economy era based on computers and IT. Modern manufacturing technology has systematically introduced advanced technology in furnishings manufacturing. Influenced by the notion of mass production of customized furnishings and decentralized production as inspired by advanced manufacturing technology, Nanjing Forestry University coordinated a research team based on large-scale furnishings customization and informatization construction beginning in 2002. The team has focused on topics such as Chinese furniture manufacturing industry information and competitiveness enhancement, furniture flexible production research, furniture enterprise product data management, barcode technology for furniture, automatic information collection technology for mass custom furniture, modular design of mass custom furniture, and process optimization (Jia et al. 2016). The team has also conducted innovative research, applying theory to practice to realize significant developments and offer notable contributions to research on key technologies in the mass customization of furnishings production and digital manufacturing. Findings have provided an important theoretical basis and practical experience for the Chinese intelligent manufacturing furnishings industry.

Status of Chinese furnishings industry

Because of evolving manufacturing modes and the impact of China's new economic normal, the furnishings industry has solidified a new status quo. The industry must constantly grow in product structure, manufacturing, and innovation services to adapt to this new phase of development. Although the expansion of the Chinese furnishings manufacturing industry has decelerated, its output value continues to increase steadily. Since 2011, the growth rate of the main operating income in the industry has remained around 10 percent for 5 years. The main business income in 2015 was \$115.77 billion, up 9.29 percent over the previous year, with a profit of \$7.37 billion (14.03% higher than the same period of the year prior), positioning it fourth in light industry and 6.46 percentage points higher than the average growth rate in light industry. In 2016, the main business income of the Chinese furnishings industry increased to \$125.87 billion, with a profit of \$8.01 billion and nearly the same growth rate as in 2015 (China Furnishings Yearbook 2016), as depicted in Figure 1. After nearly 40 years of development, the Chinese furnishings industry has evolved from traditional handicrafts to machine-automated production with advanced technology and equipment and a large-scale industry. Its brands, technical standards, standardization, scale, and market circulation have improved (Wu 2013, Han 2017), with internet technology and big data accelerating industry development.

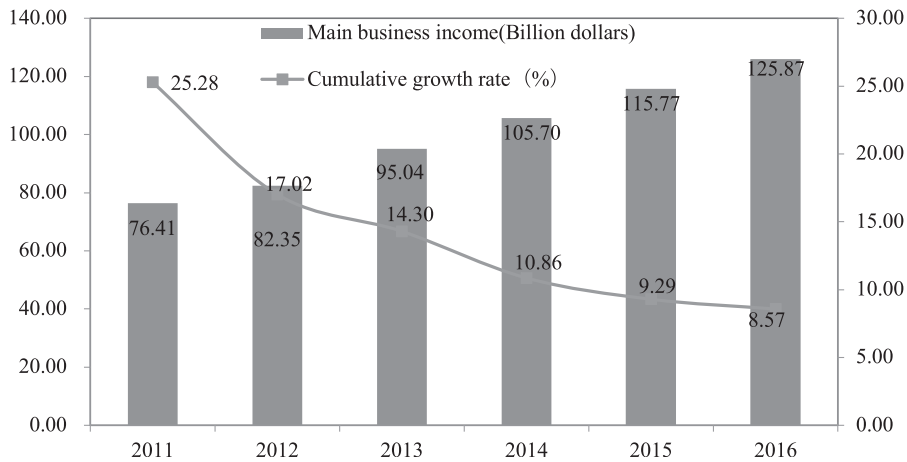


Figure 1.—Main business income and cumulative growth rate of the Chinese furniture industry.

Rapid development of custom furnishings

With a gradual increase in the rate of customization, the penetration rate of custom furnishings has increased rapidly alongside expansion of the home improvement industry. The average revenue of custom furnishings enterprises has been significantly higher than that of finished furnishings enterprises. According to statistics from the National Statistics Center and Guang-Fa Securities Development Research Center, an annual report from 2016 identified the sales revenue of large-scale customized furnishings enterprises as boasting a top sales volume of \$1.05 billion and profit of \$139.71 million. Of \$115.77 billion of main business revenue from enterprises in 2015, the market share of customized furnishings in China was approximately \$23.16 billion (China Furnishings Yearbook 2016). The market for customized home furnishing in 2016 was around \$30.15 billion, accounting for 23.95 percent of the total furnishings market in China. However, customized penetration rates were different; custom cabinets were highest (roughly 48.78%), with custom closets reaching 21.6 percent, custom doors reaching 19.51 percent, and overall customization rates around 9.75 percent, as shown in Figure 2. In addition, more custom furnishings companies continued to become listed. As of 2017, there were 11 custom-

made home-listing companies, namely the Shangpin Home Collection, Suofeiya Home Collection, OPPEIN, Holike, Zbom, Gold Home, OLO, Piano, KLF Home Furnishing, Topstrong, and Lo-sung Intelligent Kitchen. Many regional and special custom companies began to grow larger and stronger, such as the Shangpin Home Collection, which accrued \$1.03 billion in revenue in 2016 to be named the industry leader. According to Guang-Fa Securities Development Research Center, the new trend of household consumption has gradually shifted to customized homes, smart homes, and environmentally sustainable timber. Users who are more concerned about whole-house customization tend to consider key factors such as decoration style, storage, and environmental protection. The above developments suggest that the greatest change in the Chinese furnishings industry has been the development of customized homes, with the fourth industrial revolution dominated by smart manufacturing and integrating traditional manufacturing technologies with Internet technology (Xiong et al. 2017a).

Digital manufacturing model

With the rapid development of custom furnishings, IT presents a new impetus for the economy. Furnishings

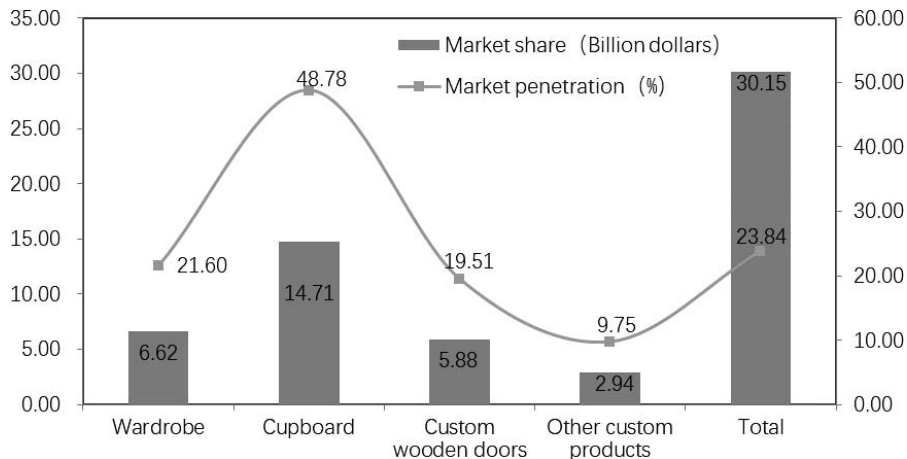


Figure 2.—Market share and market penetration rate of custom furniture in China.

companies are also changing businesses' value creation by modernizing information and communication technologies. Digital technology is being incorporated gradually into home products, services, and processes (Wu 2017, Zhou 2012). Enterprises are involved in business processes as well as service delivery, customer involvement, and supplier and partner exchange. Digital transformation is also shaping the cross, blend, development, and applications of furnishings product design technology, manufacturing technology, computer technology, and network technology, along with management science. Many typical cases of digital manufacturing have emerged in the furnishings industry, such as Oppein, Shangpin Home Collection, Suofeiya Home Collection, Holike, Zbom, Gold Home, OLO, Piano, KLF Home Furnishing, and Moganshan Home Collection. In China, leading home e-commerce companies are being formed, such as Mei-Lele Company, Lin Wood Company (no. 1 brand in Chinese Internet furnishings market), Chinese Furnishings E-Commerce Production, and Sales Town (Shaji Dongfeng Village). The success of digitalized furnishings enterprises has defined the basic mode of survival for home-based enterprises in the future and avenues for transformation and upgrading. The trend toward digital transformation and enhancement has become commonplace and constitutes the strategic core of relevant enterprises.

Maturation of furnishings information management and control technology

Given the weak foundation of furnishings informatization in China, a relatively mature set of information management and control methods has formed after more than 10 years of development. The focus is on design and optimization, standardization, normalization, and product serialization. By improving and developing information collection and processing while emphasizing foreign advanced management ideas, tools, and methods, China has developed extensive information management and control software to reduce the degree of management and informatization among enterprises (Duray et al. 2000, Legleiter and Goodchild 2005). In 2006, the National Medium and Long-term Science and Technology Development Plan (2006–2020) proposed using “high-tech to transform and upgrade traditional manufacturing industry” and “vigorously promote manufacturing informatization”; Weishang Factory and Yuanfang Software Company cooperated to construct the first (and most successful) furnishings information transformation in China. It remained the only smart manufacturing demonstration base in the furnishings industry in 2016. In 2010, Nanjing Forestry University made significant developments in declaring the National “863” Plan for scale-based customized agile manufacturing technology of wood–bamboo manufacturing. Moreover, as information management and control software have been widely implemented in furnishings enterprises (e.g., enterprise resource planning [ERP], 2020, IMOS, Topsolid, and Solidworks), on the basis of the background of Made in China 2025 and Internet +, IT gradually spread to cabinets, wardrobes, and whole-house customization enterprises in 2015, including Moganshan Household, Sophia Household, and Fei-Mei.

Core Ideas and Key Technologies in the Smart Furnishings Manufacturing Industry

Connotation of furnishings intelligent manufacturing

Intelligent manufacturing (IM) refers to a human–machine integrated intelligent system composed of intelligent machines and human experts who conduct intelligent activities such as analysis, reasoning, judgment, conception, and decision making in the manufacturing process (Xiong 2013, Wang and Zhou 2016). IM is an application of traditional IT and was born of a new generation including big data, the Internet of Things, cloud computing, virtual reality, and artificial intelligence. It represents the core of a new round of scientific and technological revolutions and the main direction of digitization, networking, and intelligence in manufacturing. Smart manufacturing is the cornerstone of Industry 4.0 and Made in China 2025. Industry 4.0 states that the manufacturing process is based on a cyber-physical system (CPS) that enables real-time connectivity, mutual recognition, and effective communication among people, devices, and products through the CPS network to create highly flexible and personalized digital products and services. The Made in China 2025 medium- to long-term plan mainly focuses on the Chinese industry at present with an emphasis on industries and policies, including clarifying operating costs, production cycles, and defective products. The goal is to reduce by 30 percent by 2020 and 50 percent by 2025. IM embodies fulfillment of this condition (Zhou 2015); that is, whether in Industry 4.0 or Made in China 2025, the essence is IM.

Thinking and philosophy around furnishings IM

The rapid development of IM in the furnishings industry cannot be separated from innovative, useful ideas and philosophy. Lines of thinking should include leveraging the Internet, namely through big data, cloud computing, the Internet of Things, and other scientific and technological means to promote business development goals and directions. The second is to have multidimensional networklike ecological thinking, which is decentralized (interconnected and circular) and focused on mobile Internet (PC Internet) by using nodes (equal) and the partner economy. The third is connecting machines, facilities, system networks, advanced sensors, controls, and software applications to improve production efficiency and reduce resource consumption. The fourth is integrating thinking and philosophy to form the Internet + thinking (Wu 2017). This mode of thinking has been reflected in mass customization of furnishings. The thought process is based on mass production, treating each consumer as a separate market segment, and creating individual furnishings on the basis of design requirements (Xiong et al. 2017a). The process of IM should make full use of furnishings manufacturing + Internet in smart manufacturing technology, production, plant planning, logistics, and service formation. Customer requirements, standardization, and group technology theory should use modular and standardized design ideas to propose manufacturing ideas. These include lean manufacturing, integrated manufacturing, concurrent engineering, agile manufacturing, and the transformation of production from

concentrated to dispersed. Trends should also shift from convergence to personality and frame users' participation in the whole process to provide low-cost, high-quality efficient delivery of custom home products (Xiong 2013, Xiong et al. 2017a).

Key technologies in furnishings IM

Through the connotation and development of IM, the goal is to achieve personalized (on-demand), flexible, high-quality, low-power manufacturing that is digital, networked, and intelligent. Digitalization is the basis of IM and key technologies. Drawn from computer technology, digitalization enables people to encode and decode sounds, texts, images, data, and processes using simple techniques. It can also collect, analyze, store, transmit, apply, and process information to facilitate standardization and high-speed processing. The creation of more data-driven models through refactored business operations has allowed for the delivery of better products, services, and experiences that improve operational efficiency, increase customer bases, and promote employee engagement (Xiong 2013). The furnishings industry requires four technical supports for IM: IM centers and production lines, intelligent warehouse transportation and logistics, intelligent production process control, and intelligent production control centers. IM centers and production lines include intelligent equipment, intelligent robots, automatic acquisition of equipment data, and intelligent management tools. Intelligent warehouse transportation and logistics involve automated three-dimensional library creation, automatic guided vehicles, and resource positioning systems. Intelligent production process control focuses on advanced planning and scheduling, implementation process scheduling, digital logistics control, and digital quality testing. Intelligent production control centers contain a control room, on-site monitoring equipment, and Andon on site (Xiong et al. 2017b).

Impact of Smart Manufacturing on the Home Industry

Changes in industrial structure

IM has shaped the furnishings industry and industrial chain. In the past 5 years, the performance of traditional furnishings such as civilian furnishings and mass production enterprises has declined, faced with challenges such as shuffling and bankruptcy. By contrast, the custom furnishings market is constantly expanding. First, traditional mass production in furnishings companies is heavily invested in the construction of new production lines. Second, some other industries are gradually entering the custom furnishings industry, such as Wanke's hardcover room, Haier's home integration resources platform, and Huawei's customized furnishings in the IT industry; therefore, the nature of the pan-home floor industry has become gradually involved in custom furnishings. Third, whole-house custom furnishings and whole-wood custom furnishings are on the rise. Because whole-house custom furnishings involve improved product quality, lower production costs, and meet consumers' needs by being customized to achieve their goals and win-win business, the next 10 years are likely to be the peak of its development.

Sales and service changes

Smart manufacturing has led to great changes in sales and service throughout the home industry (Zhu 2013, Xiong et al. 2017b). Changes involve the product sales model, sales of a single product change to the form of sales package, which includes main material, soft packs, whole house, and transnational brand cooperation to form multibrand packages (e.g., the Haojiaju union package or Tianmao integration Dongpeng and St. Elephant formation package). Second, in terms of product promotion, the transition from a single product display to scene-based packaging display mode has resulted in the gradual transformation of single product sales into whole-home customized home solutions. There has also been a marketing shift from focusing on product advertising to scene-based advertising. Third, customers' cognitions around products have changed from store + facade to reality + virtual reality (VR) (e.g., IKEA, GU, and TATA), which gives consumers a different experience via VR. Fourth, the sales channel has gradually shifted from offline to online to offline (O2O) mode.

Changes in core competitiveness of enterprises

Given the development of smart manufacturing and Internet thinking (e.g., interconnection, integration, coordination, interaction, demediation, and efficiency) along with technologies such as big data, three-dimensional (3D) printing, VR, fifth-generation (5G) communication, and artificial intelligence, the core competitiveness of home enterprises has evolved from low-cost competition such as resource elements to improving technology content and added value of products. Changes include moving from simple products to "products + services" and from furnishings product manufacturers to home system solutions providers (Wu 2017). Enterprise competition has been extended to the entire industrial chain, requiring the capacity for collaborative product development and design, flexible manufacturing, and access to customer needs. Three key technologies are paramount (Xiong et al. 2017a). First, the whole industrial chain must include mechanized, automated, flexible processing equipment and a computer-integrated manufacturing system, necessitating industrialization. Second, every manufacturing process in the industrial chain should adhere to the manufacturing idea that "the part is the product." By applying principles of group technology and modularity, standardization of technology, management, and work are necessary. Third, the industrial chain must have an advanced information management system of control and integration of resources and processes related to people, property, production, supply, and marketing; that is, informatization is needed. The manufacturing process can then be digitized, intelligentized, flexibleized, punctualized, personalized, and serviced to meet customers' individual needs. The coordinated development of the custom home industry chain will be beneficial for supplying better product manufacturing and services. Therefore, home furnishing enterprises should strengthen internal lean production management through informatization while equipment is upgraded and intelligentized. Sustainable development and core competitiveness should also be maintained.

Development of Chinese Furnishings IM

Digital transformation

Digital transformation refers to the use of IT, digital technology tools, and ideas for enterprise structure and workflow optimization along with fundamental reform that involves more than simple technical skills (Zhou 2012). The key point of digitization of the furnishings industrial chain is to adapt to changes in the online market and establish a business model from an ideological point of view. This model embodies new values and increasing efficiency. Digital technology is gradually being used in products, services, and processes to change business processes and service delivery methods. Digital transformation has also transformed customer engagement and shifted the core business processes, employees, and entire industry chain of suppliers and partners. It is the result of the intersection, integration, development, and application of design technology, manufacturing technology, computer technology, network technology, and management science within the whole home industry chain. It is also the inevitable result of digitization in manufacturing enterprises, manufacturing systems, and production processes, systems, and services. The industry chain must focus on three levels: design-centric digital design technology, control-centric digital manufacturing technology, and management-centric digital management technology.

Collaborative platform

Collaborative manufacturing or control platforms in the furnishings industry should use software and Internet tools based on the industry in all manufacturing enterprises. Such features will ensure information norms, engage in interactive information processing, and provide all types of business feedback to improve the level of contact between enterprises to allow sharing of information and data resources (Xiong et al. 2017b). Many companies can thus change the current situation of independence. At present, although many enterprises have advanced equipment, the command system is insufficiently strong, resulting in low productivity and difficult communication. Information sharing allows the entire industry to reduce energy consumption and production costs, ensure product quality, and increase business efficiency and market competitiveness. Collaborative platform construction exemplifies the integration of the entire industrial chain, which can be understood from three aspects. One is based on the microperspective, namely the enterprise supply chain, which forms an alliance with related industries to cultivate auxiliary cooperative relationships. The second involves value network procurement of materials into products through appropriate steps to sell the functional network chain. The third integrates development of the regional economy, enterprise technology, and capital in accordance with the degree of formation of the industrial chain between enterprises (Robb et al. 2008, Cheng et al. 2012). The furnishings industry chain therefore pertains mainly to the home environment, especially indoor household products and the relationships among them (Fig. 3). Although the entire industry chain and value chain are large, they are mainly based in the forestry industry, considering various ecological factors of the environment, machinery and equipment industries, chemical industry, auxiliary industry,

design industry, and furnishings manufacturing industry. Furnishings products from circulation extend to the logistics industry, and personnel training extends to the furnishings education industry via the home environment to the entire real estate and building materials industries. Building a furnishings industry chain collaboration platform can make the whole home industry chain become “multi-wing” (Guo et al. 2009, Zeng and Nie 2010) and develop a research-and-development (R&D) team, brand cultivation, and service improvement. Moreover, enterprises should combine for a cluster advantage to extend the domestic industrial chain to improve innovation and development in the household industry to realize IM.

In addition, from a digital transformation perspective, the construction of collaborative platforms should leverage software and Internet tools to fully integrate furnishings production (factories), product design (R&D), equipment manufacturers, and sales end stores. Demolition tools, CNC equipment, automatic docking data tools, intelligent scheduling tools, and order management tools should be carried out on the production side (factory) for convenient product resource-sharing platforms. On the product design side (R&D), the following are necessary: product content digital and sharing tools, product standardization, modular, and a raw and auxiliary material-matching platform. For equipment manufacturers, building a CNC operating system, matching equipment, R&D software development, and a cost-effective CNC controller hardware platform is required. For sales end stores, intelligent drawing tools, intelligent quotes, orders, process management tool optimization, and a convenient supporting product resource-sharing platform are needed to realize the sharing and coordinated development of manufactured resources.

Continuous improvement

Revolutionary progress should lead the furnishings industry toward smart manufacturing. Businesses must innovate unique equipment needed for their industrial base and technological experiences to explore new products and markets (Virasa and Tang 1998, Diao and Cheng 2013). To adapt to the rapid development of IM, the industry needs a comprehensive system that includes standardization and reference architecture, management of complex systems, establishment of a comprehensive broadband infrastructure, safety and security for industries, work organization and design, training and continuous career development, rules and regulations, and resource efficiency. The industry should also rely on the integration of Internet technology, IT, manufacturing technology, and management technology to enhance industrial quality, allocate global resources, and improve production efficiency. It needs to integrate enterprise resources through information systems (client information management system [ERP], and manufacturing execution system [MES]) and promote “people, finance, property, production, supply and sales” to effectively control and cooperate with enterprises to realize rapid response market and risk control. IT and advanced applicable technologies should be used to render enterprises highly mechanized, automated, CNC machined, mass customized, and flexible alongside the transformation and upgrading of existing industries. The development of the Chinese furnishings industry can thus move from labor intensive to “labor + technology-intensive” by using cutting-edge IT (Zhu 2012a, 2012b).

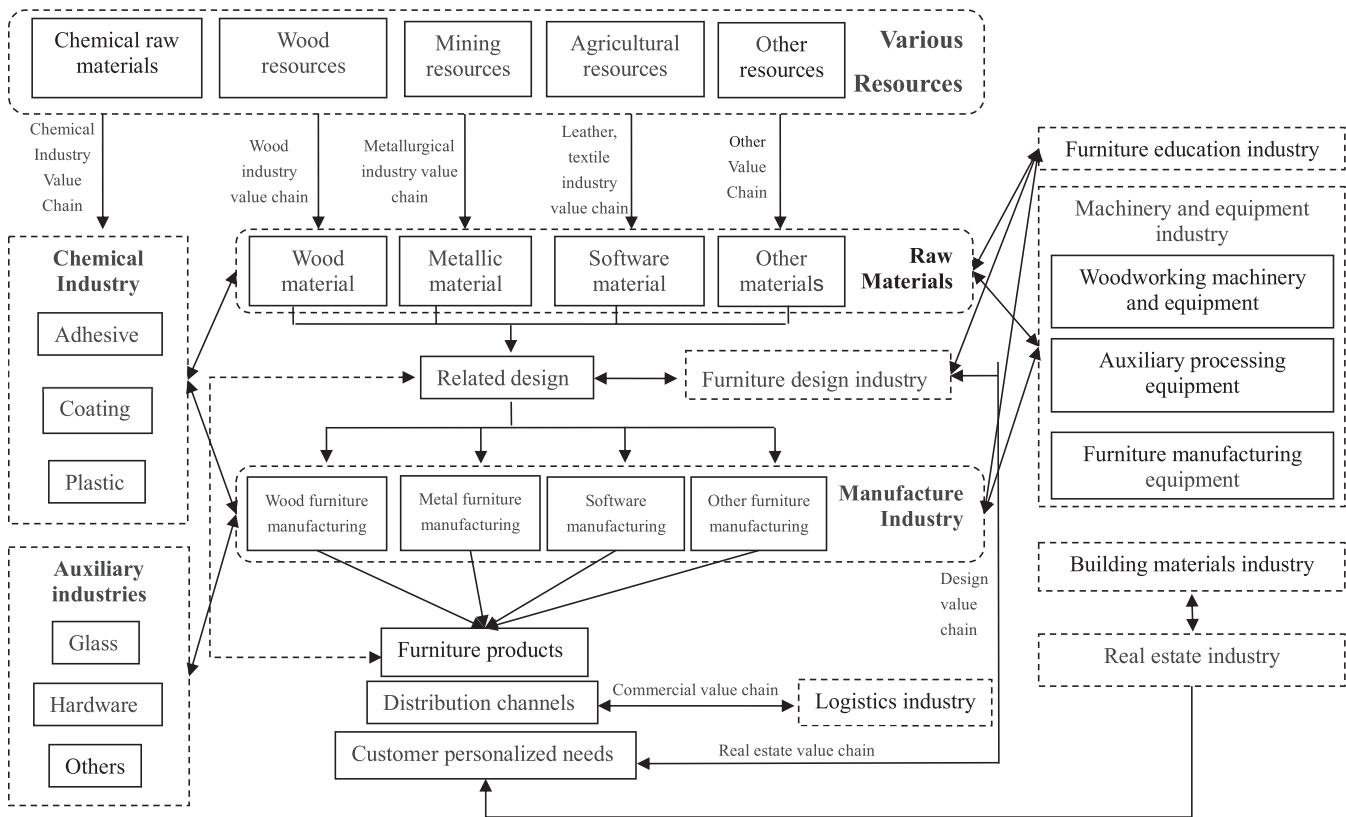


Figure 3.—Home furnishings industrial chain collaboration platform diagram.

Step-by-step IM strategy

Because smart manufacturing has spurred transformation across the entire home industry, the panel furnishings business has been a major breakthrough but remains a starting point for solid wood enterprises with a large market share. Therefore, the coordinated development of the furnishings industry chain and a gradual process of adaptation should be based on the actual situation of the industry chain or independent enterprises (i.e., distribution of management and control processes) from easy to difficult and shallow to deep. The first step is achieved online and offline (OAO), such as through dealers and businesses to achieve OAO interaction. The second step involves visiting related enterprises to promote business management of business process information and progress tracking in production departments. The third step is to strengthen the understanding and application of bill of material, computer-aided process planning, and MES, deepen production workshop management, and ensure that the entire industrial chain is profitably managed by the management system (ERP). The fourth is to achieve the ultimate goal of the whole furnishings industry chain 4.0, including smart manufacturing and 3D store design, automatic planning based on data centers, and inputting sales information directly into production equipment CNC to achieve IT for a truly smart furnishings manufacturing industry and digital manufacturing transformation.

Interpretation of Typical Cases

Chinese first whole-house furnishings digital customization: Shangpin Home Collection

Profile of Shangpin Home Collection.—Weishang Factory is in the South China Sea, Yanbu, Guangdong Yongji, known as Foshan Weishang Furnishings Manufacturing Company (Co., Ltd.). The initial stage includes a furnishings brand sales company (Shangpin Home Collection), a furnishings network (Xinju Network), and a furnishings and interior professional software company (Yuanfang Software). Long-term cooperation has led to service-oriented manufacturing called Shangpin Home Collection (Group), which owns Shangpin Home Collection, Weiyi Customized, Weishang Factory, New-Home Network, and Yuanfang Software; this collaboration dominates IM in the Chinese home appliance industry. Major features include whole-house customization, 100 percent customization, free cloud design (cloud design + big data), Industry 4.0, and O2O + C2B (new home) models. Weishang Factory was established in 2004 to transform the traditional furnishings manufacturing industry through IT and advanced manufacturing technology. Guangzhou Yuanfang Software Company introduced mass customization in furnishings design, manufacturing, and sales.

From 2009 to 2012, the company's annual output value increased by 100 percent, reaching more than \$0.12 billion in 2012. This trend is especially impressive given year-after-year lows in the global economy and domestic furnishings

sales. In 2014, the annual output value exceeded \$0.29 billion and over \$0.44 billion in 2015. In 2016, the annual output value reached \$0.59 billion. The company receives 4,000 to 5,000 orders per day; the production cycle has been reduced to about 10 days, including 8- to 12-hour production, 1-day sorting, and 2.5 to 3 day temporary storage, packaging, and outsourcing. Daily output of up to 100,000 parts has achieved manual sorting and vertical automatic inventory. The company has 800 IT staff services in the production process.

Dr. Zeng Ming, who belongs to Alibaba's chief of staff and is Executive Vice President, published an article "C2B: The New Business Model in the Internet Age" in the *Harvard Business Review* (Chinese version) in February 2012. He noted that Shangpin's mode of operation will be regarded as a China sample of the C2B model (Virasa and Tang 1998). The proposal of C2B mode quickly aroused the attention of many authoritative media in the world. Chris Anderson, chief editor of *Wired* (United States) magazine, published a book entitled *Maker: A New Industrial Revolution* in 2012 and gave a special introduction about Alibaba's Mayun and C2B models (Zeng and Song 2013). The miraculous growth and practices suited to Chinese national conditions have played central roles in the transformation and upgrading of the Chinese furnishings manufacturing industry. In 2016, the Ministry of Industry and Information Technology awarded the company the only IM demonstration base in the Chinese home industry.

Success of Shangpin Home Collection.—Shangpin Home Collection paid early attention to market demand and discovered and dug out the custom market. In the domestic furnishings industry, Shangpin Home Collection implemented mixed production of parts and components according to the principle of "parts that are products" and produced tailor-made products according to the speed of large-scale production based on processed parts and the advantages of software development. Second, early in mass customization, the Shangpin Home Collection factory took the lead in adopting standardization, modularization, flexibility, and informatization along with advanced and applicable technologies, making great strides in combining flexibility and informatization. Third, regarding the chosen flexibility scheme, the Shangpin Home Collection factory proceeded from reality and transformed conventional high-volume production equipment via informatization. Then, it started from the preparation time for compression to produce a series of low-cost and high-output flexible systems. Finally, the factory pursued manufacturing data throughout the entire process. The factory established a flexible processing system, used advanced manufacturing technology, and devised an innovation of the crystal body.

Shangpin Home Collection has averaged 1.5 years of construction for a new plant, continuous independent R&D, and upgrading and optimization of the production process. The 5G robot factory was involved in production beginning in 2016. The future will move toward intelligent (highly flexible and personalized) and coordinated (decentralized) production under a network environment, which is the core of Industry 4.0, Made in China 2025, and IM.

Suofeiya Home Collection

Profile of Suofeiya Home Collection.—Suofeiya Home Collection Co., Ltd. was established in 2003, involved in custom closet and matching custom furnishings R&D with

production and marketing enterprises. With the concept of a new product tailored to the combination of custom closets and closet doors, Suofeiya successfully brought customized closets to market and gained the attention of Chinese customers. By applying IT to custom wardrobes to solve the contradiction between customized and large-scale-production closets, Suofeiya launched an era of custom-made wardrobe-scale production, changing the industry pattern and result of the Chinese custom closet industry.

From 2003 to 2013, Suofeiya's annual output rose from \$4.41 million to \$0.26 billion. In 2013, it began to implement the "customized home Suofeiya" strategy by cooperating with the French company SALM S.A.S (now Schmidt Group) to enter the domestic cupboard market in China under the SCHMIDT • Division cupboard brand. In 2014, the annual output value increased by 32.39 percent and reached more than \$0.29 billion. In 2015, the annual output value also increased by 32.39 percent and reached \$0.47 billion. In 2016, the era of whole-house customization exploded with a revenue of \$0.67 billion, an increase of 41.74 percent compared with 2015 (see Table 1). Suofeiya has nearly 4,000 employees and an annual output of \$73,529/person with a flexible production line in Germany and daily output of 3 to 4 million parts. The production cycle is approximately 2 to 3 days with 10-day delivery (no longer than 15 days) and 4,000 daily orders, about 2,000 of which are in Guangzhou, Guangdong Province.

Success of Suofeiya.—Suofeiya has seized spending in this era as well as physical upgrades and personal awareness so consumers will be willing to pay for the brand and personalized service. Second, Suofeiya produces products and pays attention to product services. Since the establishment of the brand, it has spearheaded traditional products + new services to better meet consumers' needs. Third, Suofeiya makes full use of mobile Internet, big data, and the cloud era to transform manufacturing into wisdom-making and cross-industry integration. With the help of technology, traditional wardrobe manufacturing has generated new business models and developed new commercial channels with a marketing model shifted from traditional offline marketing to the e-commerce era. Finally, Suofeiya has seized the essence of mass customization, considering individual needs to achieve large-scale, personalized production via intelligent, automated processes focused on quality, efficiency, and cost effectiveness. In 2016, Suofeiya opened a full-house customization model and transitioned from custom closets to whole-house customization. The furnishings industry is facing unprecedented opportunities. According to the development of the Suofeiya model, the custom model of whole houses will likely develop; Suofeiya

Table 1.—Suofeiya annual output value.^a

Year	Output (\$, billions)	Growth rate (%)	Cumulative profits (\$, billions)	Profit growth year-on-year (%)
2003	0.004	—	—	—
2011	0.15	21.6	0.02	36.7
2012	0.18	20	0.03	40
2013	0.26	32	0.04	47.1
2014	0.35	36	0.05	32
2015	0.47	32.39	0.07	39.4
2016	0.67	41.74	0.10	43.4

^a Source: Suofeiya Home Collection Co., Ltd. Annual Report.

may well represent the future of the home decoration market.

Conclusions

The furnishings industry will continue to transform in the customization era, but new ideas are needed. The next 10 years will be the peak of smart manufacturing. Identifying business positioning, manufacturing modes, and business models for enterprises in the whole furnishings industry chain to facilitate synergetic development are important. The use of IT and communication modes to serve customers and integrate digital technologies into products, services, and processes to transform business processes and service delivery are also essential. Full participation of customers and industry chains are key to the transformation and upgrading of customized home-based businesses and innovation-driven development. Custom furnishings and the corresponding industrial chain must involve smart manufacturing as the strategic core of the enterprise, not as a choice but a requirement.

Acknowledgments

The authors are grateful for the support from National Key R&D Program of China (2018YFD0600304), Postgraduate Education Reform Project of Jiangsu Province (JGLX18_101), Technology Innovation Alliance of Wood/Bamboo Industry (TIAWBI201808), Postgraduate Research & Practice Innovation Program of Jiangsu Province, and Natural Science Foundation of Jiangsu Province (CN; No. BK20150881).

Literature Cited

Anderson, M. 2000. The 21st Century Enterprise Competition Foreword: Agile Product Development in Mass Customization. Mechanical Industry Press, Beijing.

Cao, X. Z., E. N. Hansen, M. Q. Xu, and B. M. Xu. 2004. China's furniture industry today. *Forest Prod. J.* 54:14–23.

Chang, B. 2013. Industry 4.0: Intelligent factory and production. *Chem. Eng.* 11:21–25.

Cheng, B. D., Y. Tian, K. Hao, and L. Wan. 2012. Analysis on the dynamic relationship between the research and development capacity, net exports, and profits of China's furnishings industry. *Forest Prod. J.* 62:590–596.

China National Furniture Association. 2016. China Furniture Yearbook of 2016. China Forestry Publishing House, Beijing.

Christopher, W. L. H. 1995. Mass customization: Conceptual underpinnings, opportunities and limits. *Int. J. Serv. Ind. Manag.* 2:36–45.

Diao, G. and B. D. Cheng. 2013. Analysis on the dynamic relationship between the R&D capacity and trade of China's furniture industry. Presented at the 20th International Conference on Management Science and Engineering, July 17–19, Harbin, China. pp. 1054–1061.

Duray, R., P. T. Ward, and G. W. Milligan. 2000. Approaches to mass customization: Configurations and empirical validation. *J. Oper. Manag.* 18(6):605–625.

Guo, C. L., W. W. Guo, and L. L. Zheng. 2009. Discussion on formative mechanism of the industrial chain in forestry. *Issues Forestry Econ.* 29:56–60.

Han, Q. S. 2017. Status and development trend of the wood furniture industry in China. *China Wood Ind.* 31:10–13.

Jia, Y., J. Li, and Y. Ding. 2016. Customized cabinet part classification manufacturing technology based on fuzzy clustering algorithm. *J. Forestry Eng.* 1(3):133–138.

Kotha, P. 1989. From mass marketing to mass customization. *Plan. Rev.* 17:10–47.

Legleiter, C. J. and M. F. Goodchild. 2005. Alternative representations of instream habitat: Classification using remote sensing, hydraulic modeling, and fuzzy logic. *Int. J. Geogr. Inf. Sci.* 19(1):29–50.

Li, K. Q. 2016. 2016 Government Work Report, the Twelfth National People's Congress of the People's Republic of China, March 5, 2016.

Luo, W. 2014. The enlightenment of German industry 4.0 strategy on promoting industrial transformation and upgrading in China. *Program. Control. Factory Autom.* 9:36–39.

Mitchell, M., M. L. Tseng, and J. S. Chuan. 1997. Collaborative control system for mass customization manufacturing. *CIRP Ann. Manuf. Technol.* 46:373–376.

Pine, B. J. 1993. Mass Customization: The New Frontier in Business Competition. Harvard Business School Press, Boston.

Pine, B. J. 2000. Mass Customization—A New Frontier in Business Competition. Translated by Cao Yunfu. Zhongguo Renmin University, Beijing.

Pine, B. J., B. Victor, and A. C. Boynton. 1993. Making mass customization work. *Harv. Bus. Rev.* 71:108–119.

Robb, D. J., B. Xie, and T. Athanari. 2008. Supply chain and operations practice and performance in Chinese furniture manufacturing. *Int. J. Prod. Econ.* 112:683–699.

State Council of the People's Republic of China. 2015. Notice on Printing and Distributing "Made in China 2025," May 8, 2015.

Svensson, C. and A. Barfod. 2002. Limits and opportunities in mass customization for build to order. *SMES Comput. Ind.* 49:77–89.

Virasa, T. and J. C. Tang. 1998. The role of technology in international trade: A conceptual model for developing countries. *J. High Technol. Manag. Res.* 9:195–205.

Wang, Y. F. and X. Z. Zhou. 2016. A review of research on domestic and international intelligent manufacturing. *Forum Sci. Technol. China* 10:154–160.

Wen, J. 2002. A new manufacturing model: Mass customization. *Furniture* 22:42–46.

Wu, Z. H. 2003a. Advanced manufacturing technology of furniture in the information economy age. *Furniture* 23:18–24.

Wu, Z. H. 2003b. Advanced manufacturing technology for furniture in the information economy age (part 2). *Furniture* 23:11–16.

Wu, Z. H. 2013. Present situation and development trend of Chinese furniture industry. *Furniture* 34:1–4.

Wu, Z. H. 2016. Manufacturing model of furniture industry in industry 4.0. *China Forest Prod. Ind.* 43:6–10.

Wu, Z. H. 2017. New thinking and new models of the Chinese home furnishings industry in the industry 4.0 Era. *China Wood Ind.* 31:5–9.

Xiong, X. Q., W. J. Guo, L. Fang, M. Zhang, Z. H. Wu, R. Lu, and T. Miyakoshi. 2017a. Current state and development trend of Chinese furniture industry. *J. Wood Sci.* 63:433–444.

Xiong, X. Q., W. J. Guo, Q. T. Huang, L. Fang, X. R. Pang, and Z. H. Wu. 2017b. Study of the quality control technology in furniture digital manufacturing. *J. Forestry Eng.* 2:152–157.

Xiong, X. Q. and Z. H. Wu. 2013. Development and application technology of the mass customization furniture. *J. Nanjing Forestry Univ.* 4:156–162.

Xiong, Y. L. 2013. Intelligent manufacturing. *Sci. Technol. Rev.* 31:1.

Yang, W. J. 2013. Influence of the new industrial revolution on furniture industry. *Furniture* 34:5–7.

Zeng, J. J. and Y. Nie. 2010. Interaction study between China's furniture industry and the global furniture value in China. *World Forestry Res.* 23:70–74.

Zeng, M. and P. Song. 2013. C2B Internet era of the new business model. <http://www.ebusinessreview.cn>. Accessed June 4, 2013.

Zhou, J. 2012. Digitization and intellectualization for manufacturing industries. *China Mech. Eng.* 23:2395–2400.

Zhou, J. 2015. Intelligent manufacturing—Main direction of made in China 2025. *China Mech. Eng.* 26:2273–2284.

Zhu, C. L. 2012a. Achieve the power of furniture and strive. *Chin. Furn. Assoc. Newsl.* 5:10–13.

Zhu, C. L. 2012b. Do a good job in the standardization of furnishings—To ensure the healthy development of the furniture industry. *Chin. Furn. Assoc. Newsl.* 4:10–11.

Zhu, C. L. 2017. The status quo of Chinese furniture industry and the focus of the 2017 China Furniture Association. *Furn. Inter. Des.* 1:6–7.

Zhu, M. 2013. Play a good role in urbanization of the pulling effect of consumption. *Econ. Daily* 5:31.