

The social dimension of the production process through 3D printing

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Abstract

Smart manufacturing, another aspect of Industry 4.0, is related both to production and distribution-storage management, human-computer interaction, and 3D printing technology. Using social networking, and 3D printing technology, anyone can involve in the production process and any computer can become a small factory. 3D printing can change the traditional manufacturing and mass production, which is focused on centralized factories with tooling requirements and low labor costs, to a manufacturing of mass customization and distributed manufacturing, where the choice of location of the factory and production process will be based on the demographics of demand and not on supply economics. The goal of this study is to present how 3D printing technology can revise the traditional business models, offering the opportunity to consumers to transform their idea into a tangible object, in “social manufacturing” production process.

Keywords: 3D printing, social manufacturing, revised business models.

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I. INTRODUCTION

The development of Industry 4.0 strengthened the competitive position of factories and producers as well as highlighted global and national challenges, such as saving resources and energy, designing and manufacturing “smart” or/and “green” products. A typical example is the 3D printing technology, in which objects are printed in layers from 3D digital models. Unlike subtractive manufacturing technologies, manufacturers save material and produce less industrial waste. The above is inevitable that they created significant changes not only at a technological level, but also at a social level.

Innovation is one of the key drivers of success that a business must use to develop a competitive advantage. A distinct challenge for product designers is to meet customers’ requirements. Traditional industrial production methods can no longer meet the social aspect of manufacturing requirements, in contrast to the development of flexible production process that will meet the individual consumers’ needs.

One of the biggest features of the use of 3D printing technology in the production process is the “social manufacturing”, which offers the possibility to everyone to turn easily his/her idea into a tangible object. Anyone who either owns or has access to a 3D printer has now the ability to produce (print) an object as he/she has imagined it. Therefore, 3D printing technology has been characterized as the technology that contributes to the democratization of the production process.

The scope of this paper is to present how 3D printing technology can revise the traditional production process and business models. The creation of economical and local production facilities for innovative consumers, the mass production of high-quality products at an affordable price and the relations between consumer and industry will be examined in the light of technological innovation with the appropriate business model.

The remainder of this paper is organized as follows. Section 2 presents a brief review of the ecosystem of 3D printing technology. Section 3 defines the social manufacturing in the era of 3D printing technology. Section 4 proposes the new business models in 3D printing process. Finally, Section 5 summarizes the conclusions of this work and suggests further research.

II. THE 3D PRINTING ECOSYSTEM

3D printing technology has developed significantly in recent years, finding applications in many industries, such as construction, aeronautics, medicine, education, and culture. Engineers from different industries are attracted to 3D printing because of its easiness to design objects without taking into account limitations arising from difficult object shapes or from production cost.

3D printing is changing the way we produce and/or consume products. 3D consumer printing is the latest addition to the digital revolution. As 3D printing technologies become available to consumers, it is

changing the way consumers think about the production of goods. 3D printing shops, web-based service bureaus, shared 3D printers, and even home 3D printers have become readily available to customers over the last years. 3D design software is available free and can be easily used by anyone.

3D printing is a manufacturing process that works additively. Instead of removing excess material from a large piece of raw material, it adds successive layers of material until the final, actual physical product is created. As part of digital manufacturing technology, additive manufacturing systems are able to manufacture 3D parts and products directly from material and 3D design data. Customized or awkwardly shaped products can now be redesigned and printed. Additive technology enables customers to design products that perfectly fit their needs.

3D printing technology allows the production of a wider variety of products, most of which are custom-made products, without incurring additional manufacturing costs. Customers gain access to their own design, based on their own needs and expectations, without limitations on the geometry of the object or the size of the production. Although 3D printing technology is about 40 years old, its outspread to society and consumers has only occurred in recent years. The mass use of desktop 3D printers is the reason for the great spread and use of these products.

A recent example of the widespread of 3D printing technology was during the pandemic Coronavirus, in which 3D printing technology used for mass production with a different production model. The production took place in workstations, scattered in different geographical areas and a new procedure structure arised. Numerous initiatives had developed in Europe and USA as the global supply chains were disrupted and supported the production of urgently needed health care equipment through 3D printing technology.

Fronimaki and Mavri [2] presented a typical production chain of 3D printing that consists of customers, suppliers, 3D printing industries, workforce (including designers), 3D printers, distribution centers and business partners, as well as the links among these entities, through which printed goods flow (Figure 1).

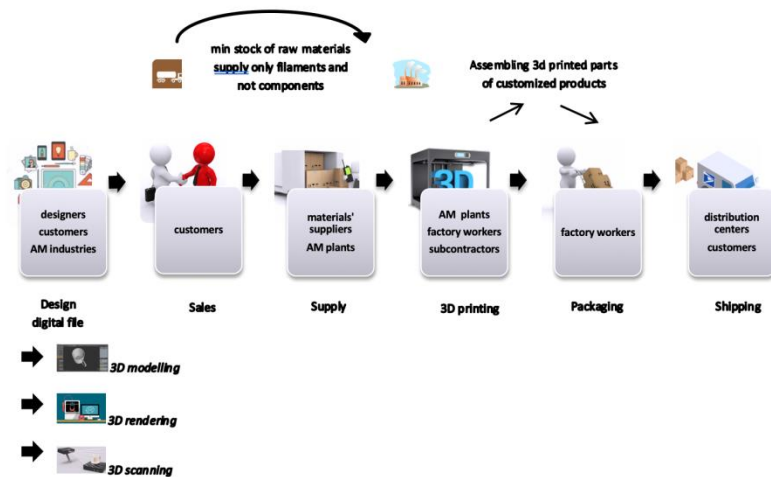


Figure1: Graphical representation of 3D printing: the production chain [2]

At the first step, a digital file is sketched and customers could either order the printed object or the digital file. Sales are at second stage, as 3D printed objects are produced (printed) after they have been sold. After sales, the 3D printing industry supplies the necessary materials. Before printing the customized object, a rendering of the product is necessary. Finally, quality of the printed object is under examination, then packaging and shipping via post or e-mail (if the customer orders only sketches), are the last steps.

Cost and minimization of processes in product production are perhaps the most important characteristics that distinguish 3D printing. The marginal production cost of 3D printing remains either the same or, in some cases, higher than that of manufacturing objects in the traditional way, mainly due to the high cost of the required materials and energy consumption. The cost of production, of course, changes, since the production process becomes simpler with fewer steps and minimal intermediate processes, but with high investments in the purchase of equipment. The printing process begins after the sale (order) of the digital file of the object has been completed and the storage processes of finished products and materials are absent [8]. Perhaps this is the most revolutionary element of 3D printing, the fact that the consumer is buying the “promise” of a product and not the object itself.

Regarding the issue of production size, which also determines the cost per unit of product, it is true that with the traditional manufacturing method, the cost per unit decreases significantly as production volume increases. However, this happens when identical objects are produced. The use of 3D printing allows the

production of similar but not identical objects at the same cost, since a small variation in the digital file leads to different products, which meet specialized consumer needs.

III. SOCIAL MANUFACTURING

With the rapid development of electrical and electronic technology, information technology and advanced manufacturing technology, the production mode of manufacturing enterprises is shifting from digital to “smart”.

Industry 4.0 has two main themes, one is the smart factory, which aims to study the intelligent production system and complete networked distributed production facilities. Smart factory does not mean unmanned. In the operation of the smart factory, many people can take part in the production process via Internet (not physical). The smart factory integrates technologies to improve the efficiency, quality, controllability and transparency of production processes. The smart factory functions as a fully connected production system, operating essentially without human power to produce, transfer, receive, and process the necessary data to perform all required tasks and produce all kinds of goods [9].

The other is smart manufacturing, which is mainly related to production and distribution-storage management, human-computer interaction and 3D printing technology. Smart manufacturing aims to manufacture products that integrate information technology and industrialization. Using social network and 3D printing technology, every customer or producer can participate in the production chain process, and we can have a small factory through a computer.

In the new era of intelligent technology and Industry 4.0, the use of modern additive manufacturing skills and ICT play a crucial role in industrial economic competitiveness. 3D printing technology is leading the next great industrial revolution. More and more industries are adopting additive manufacturing. Smart factories of the future have all processes interconnected via the Internet of Things, incorporating greater flexibility and personalization of production processes [4].

The purpose of making the production system more “smart” and “flexible” is to enable this system to meet the demands of a more flexible and personalized market. The social element of manufacturing must be able to operate in a personalized manner, while at the same time, the production system must also ensure real-time efficiency and savings.

The typical approach for Industry 4.0 is social manufacturing. Social manufacturing can directly connect customer needs and industries, but it must rely on enabling technologies such as embedded systems, wireless sensor networks, industrial robots, 3D printing, cloud computing, and big data. Our lives will change to be more efficient, fast, safe and convenient due to the development of Industry 4.0.

The social network is the basis of social production. Only if the social network has deeper development will we have enough ideas, projects, opinions and feedback comments to produce custom products. The biggest feature of social production is that anyone can directly turn their idea into products (from mind-to-products). Social production allows anyone to take part in the design, improvement and marketing of their products through social media [15] (Figure 2).

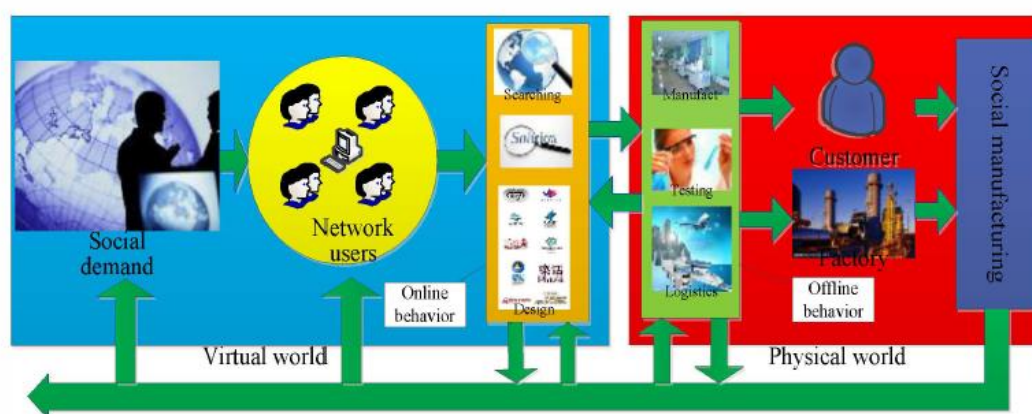


Figure2: The integration of social demand and social production [15]

Social manufacturing is the strategy that uses 3D printing, network technology, and social media to produce products and make them work in real time. Personalization and savings will come through the integration of online and offline behavior [15].

Consumers are no longer passive buyers of the production process. Instead, they are now the designers of their customized products before order them. Therefore, there is a need to satisfy the social element of consumer demands by developing flexible production methods that will meet the individual needs of many

customers. However, the traditional production methods of the industry (which follow the prescribed order and passive way in the supply chain) can no longer meet the social aspect of the development requirements of manufacturing. In addition, there is always an information barrier between manufacturing enterprises and market supply chains [14].

Industry 4.0 as an abstract concept can closely integrate the physical world with the virtual world. The typical approach for Industry 4.0 is social production. In fact, social production can directly connect customer needs and factories, but it must rely on enabling technologies, such as embedded systems, wireless sensor networks, industrial robots, 3D printing, cloud computing, and big data.

In the environment of social production, with the social network, many 3D printers will form the production network, which can be integrated with the Internet of Things and the logistics network to compose a large social production system that can meet the timely demand of customers [1]. Every computer that can access the Internet will become a small factory when combined with 3D printing technology [13].

3D printing is the technology that will democratize the production chain. More people will participate in the design of objects, either by using software to build a design, or by downloading a digital design from open access libraries, and customizing the file based on personal preferences, or by using a 3D scanner.

Hobbyists have access to free online libraries with numerous digital designs. 3D printing can effectively meet customer needs and help achieve service-oriented manufacturing. This process transforms consumers into “makers” and changes the role of individuals from simple buyers to innovative manufacturer-producers (“prosumers”).

IV. THE NEW BUSINESS MODELS IN 3D PRINTING PROCESS

Technological development has pushed businesses to produce new products and services, seeking strategies that will offer them a competitive advantage. The development of technology creates new needs in the demand for products and services, products with a shorter life cycle and consumers who increasingly seek personalized products and services that will be designed specifically for their needs. The production of these products is based on the existence of resources and the recording of production processes.

The transactions that bring profit to a business are those that are made to satisfy personal preferences and involve products custom-made designed for the needs of specific people. High technology, variety and personalization through customized products are available to customers at lower prices and where the value for money equation offered to global consumers has been transformed with the emergence of new players with new kinds of business models.

Profitable business models of companies do not simply focus on low-priced, undifferentiated offerings, but emerging multinationals use their cost advantages in creative ways to offer high technology, variety, and customization at lower prices and by redirecting specialized offerings to market segments. This gives rise to the emergence of a new type of general strategy, cost innovation.

Disruptive technologies bring about radical changes in business models and ecosystems [11]. 3D printing technology has been identified as a disruptive technology for future advanced manufacturing systems. Additive manufacturing will impact processes from production and supply chain design to consumer behavior [5].

3D printing is the technology that has the potential to change the manufacturing industry. 3D printing will impact every sector of the manufacturing value chain: Design - Manufacturing - Supply Chain - Distribution. 3D printing technology allows the production of a wider variety of products, most of which are custom-made products, without incurring additional manufacturing costs. 3D printing is the technology that will democratize the production chain [11].

The use of additive manufacturing specifically for the creation of highly complex parts can be an economically viable alternative to conventional manufacturing technologies [3]. Low-cost open-source 3D printers can reduce costs by enabling the distributed manufacturing of substitutes for both specialized equipment and conventional mass-produced products [10].

In additive manufacturing, the classic stages of design, production and sales are changing. Traditional demand models are no longer valid, as products are made to order. Different manufacturing technology is used, with fewer suppliers, no distribution and storage requirements. Production costs are reshaped as the production process becomes simpler. 3D printing production starts on an order basis and, therefore, inventory holding due to uncertain demand along a supply chain will be minimized.

When consumers directly produce goods using digital design and 3D printing, all steps between raw materials and consumer become redundant. The supply chain is shortened, with the specialization of its functions and the digitization of the production chain.

In a production network consisting of 3D printers, a customer can choose a 3D printer located near him/her to print the desired product, thus reducing the delivery time, distance and cost of delivering the product, which increases the efficiency of the logistics system. Furthermore, it is possible to find a 3D printer that can

print a 3D object just-in-time, considering the customer's location, the required order delivery date, and the required printing and transportation times (depending on the customer's location) [6].

Manufacturing companies have been pressured to adopt 3D printing through increasing global competition, the huge rise in 3D printing applications, and the ever-expanding range of technical, economic, and social benefits [12].

In the environment of social production, with the social network, many 3D printers will form the production network, which can be integrated with the Internet of Things and the logistics network to compose a large social production system that can meet the timely demand of customers.

Every computer that can access the Internet will become a small factory when combined with 3D printing technology. The use of personal 3D printers could not only change manufacturing methods but could also reshape business processes from the design of an object to its consumption.

Additive manufacturing techniques allow for rapid response to markets and create new production capabilities outside of factories, such as mobile units that can be placed close to raw material suppliers.

New types of business services are becoming possible as individuals who own a 3D printer only purchase digital files from the physical or online store. Products (final good or digital design) can be distributed through a direct channel via mail or email that includes three stages between the sender and the customer or through intermediate distribution channels.

The 3D printing network is open and accessible to everyone and helps all interested parties turn their ideas into objects. It is an innovation hub and tries to find ways to solve the everyday problems of individuals and businesses. Consumer 3D printing will evolve into a social manufacturing rather than a personal manufacturing.

V. CONCLUSION

3D printing technology allows for the production of a wider variety of products, most of which are customized, without incurring additional manufacturing costs. Markets can be served without requiring companies to store goods at great expense. An opportunity for the additive industry is to create cost-effective and local manufacturing facilities for innovative consumers.

With the development of Industry 4.0 and the emergence of the concept of smart factory, the traditional philosophy of manufacturing systems will change. Smart factory introduces changes to the factors and elements of traditional manufacturing systems and integrates the current requirements of smart systems so that it can become competitive in the future [7].

3D printing will accelerate product development cycles, reduce product lead times, alter corporate profit structures, and reshape future professions and jobs. The additive manufacturing process could be decentralized. Adopting a consumer co-creation concept allows manufacturers to shift their business model from mass production focused on manufacturing to mass innovation or customization focused on the consumer.

In this study we tried to answer how 3D printing technology can revise the traditional production process and business models. Consumers are no longer passive buyers of the production process but have become potential designers who want to participate in the personalization of their products before purchase. The development of Industry 4.0 will not only strengthen the competitive position of factories but will lead to solutions to both global challenges (e.g. saving resources and energy) and national challenges (e.g. managing demographic changes). In addition, it will change the traditional way of production and bring a greener product. The creation of economical and local production facilities for innovative consumers, the mass production of high-quality products at an affordable price, and the relationships between consumer and industry will be examined in the light of technological innovation with the appropriate business model.

A further research will include quality requirements and regulations concerning the intellectual property of personal 3D printed objects.

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