
SOCIAL MANUFACTURING: A RISING TREND OR A SIDE NOTE?

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B. Synonyms (if applicable)

Do-It-Yourself (DIY) movement is personal involvement and use of skills to improve one's living standards by producing personalized goods. Usually the DIY movement is connected, partially overlapping, to the Maker-movement, which is empowered by open design platforms, communities of practice and 3D printing possibilities. 3D printing is a general audience and/or commercial term for additive manufacturing technologies. Social manufacturing is associated to the maker and DIY movement. It appears also as a synonym in certain articles discussing of locally distributed manufacturing.

C. Definitions

Social manufacturing is characterised with high level of utilizing the power of communities to design and manufacture of goods. In general, the social manufacturing is strongly associated to high personalization of goods, point of need manufacturing, and production via additive manufacturing technologies. However, other forms of social manufacturing exist.

Main Body Text

Introduction

The world is getting smaller and smaller. By observing from the manufacturing industry perspective, the manufacturing value chains are complex, highly interconnected locally and globally, and rapidly changing. Manufacturing leaders are increasingly responding to competitiveness pressures to attract the best from a global pool of talent, along with the capital, capabilities, and the global customers and revenues necessary to

maintain their competitiveness and viability (Deloitte, 2013). On one hand, increased quality requirements force the companies to invest in a variety of technologies and at the same time, to adapt to constant production and market changes. While the pressure is high, the opportunities to take advantages of the new emerging technologies offer companies are multitude. The era of the Industrial Internet and digitalization of manufacturing is just in the beginning phase. The development of a talented workforce and trustful collaborative relationships with stakeholders, as well as a powerful technological and industrial base, are essential to address the challenges ahead. In order to achieve high levels of employment and social cohesion the boosting at the same time to the innovativeness and competitiveness is needed (So Smart 2015).

However, the industrial needs are not the only driving force today. The raise of social awareness, communities and social media have made Do-It-Yourself (DIY) production and product modification approaches highly visible. As a phenomenon it is a well-established in most developed countries and involves substantial consumer awareness, interest and activity. DIY consumers can be concurrently both willing DIYers doing so for pleasure (the choice model) or seeking self-identity from the end-product (post-modern theory) and at the same time reluctant DIYers doing so out of economic necessity reasons (economic determinism model) or due to the lack of appropriately skilled labor (a market failure model) (Gurtoo et al, 2010). The new technology and new thinking have enabled significant expansion in the scope of DIY. In particular, it can now encompass the invention and the sale of physical goods, as well as their assembly and use (Fox, 2013).

This chapter will combine views from manufacturing industry to the consumer based social manufacturing phenomenon and show where these two will merge. The chapter is organized as following, first we discuss the pathway from idea to innovation in general terms. Then the chapter will discuss of the emerging paradigms and manufacturing trends affecting to both manufacturing industry and consumers. The analysis will continue with the assessment of manufacturing trends in general, and then will proceed to discuss of open platforms and communities supporting the social manufacturing. And, finally, we assess critically the current status and challenges on this field.

From idea to innovation

The terms idea, invention and innovation have a multitude of explanations, and meaning of the terms usually varies cross sector. Business dictionary defines innovation as “The process of translating an idea or invention into a good or service that creates value or for which customers will pay” (World water forum, 2016). The innovation success among industry is generally measured with “time-to-profit” (Shleifer and Wishny 1990). To be called an innovation, an idea must be both disruptive and replicable at an economical cost and must satisfy a specific need (Business Dictionary 2018; Teece, 2010). There can be extreme public perceptions of technological innovations. In particular, the same technological innovation can be described as a miracle bringing salvation to human kind and industry alike, or it is described by others as a doom bringer (Achterhuis 2002; Fox 2016). Traditional economic theory implicitly assumes that trades take place around tangible products. This may lead to the situation where intangibles are not valued or taken fully into account. According to Teece (2010) in standard approaches to competitive markets, the problem of capturing value is quite simply assumed away: inventions are often assumed to create value naturally and, enjoying protection of iron-clad patents, firms can capture value by simply selling output in established markets, which then are further assumed to exist for all products and inventions (Teece 2010). This, however, is changing.

The manufacturing is about producing physical products. In the manufacturing field the innovations are most often method-, process- or organizational-related. These cannot be patented easily, thus it may seem to the general audience that the manufacturing does not deliver innovations measured in patents. An innovation often draws from existing technologies and models but uses these elements creatively in combination with

new ones to form a uniquely different product. Moreover, the characteristics of the innovation are molded by forces of competition, invention, and customer needs until they crystallize into a product or a process with a certain standardized form, set of features, and technical capability (Utterback 1994). The manufacturing industry acts as the innovation enabler and at the same time offers opportunities for technology push and pull. The technology push and pull bring emerging technologies and political agendas in to the surface. It is also very important to realize that a new manufacturing process or technology can enable the production of products that used to be totally impossible or extremely expensive to manufacture. By this, innovation in manufacturing can be also an important enabler for innovation in all final products. Nevertheless, with the increase of development of so-called smart services, new ideas are no longer generated via technology-push innovation and market-pull innovation (Geum et al. 2016), but a set of combination of these.

The definitions regarding innovation types, and more specifically, measuring the innovation or its impact have been under discussion in various forums. The nature of the innovation, however, makes the simple measuring in most of the cases difficult. The time line, for example, is very elusive. Based on the analysis of Finnish national funding agency for technology and innovations (Tekes, 2014) the impacts of R&D activities among companies are generally manifested only after a certain time lag. Sometimes this lag can be of several years. Thus, the full implications and impacts of research activities cannot be measured and fully understood right after the completion of an R&D project since they need time to be materialized and its full impact appreciated (Tekes 2014). In the manufacturing domain one simple-appearing technology might take decades to mature into industrially relevant level, and years to compliment and finally replace old methods and technologies in the industry.

To understand the nature of innovation, the time perspective can be examined via sustaining and disruptive technologies. According to Sommarberg's definition (2016) *Sustaining technologies* have in common that they improve the performance of established products along the dimensions of performance that mainstream customers in major markets have historically valued. The incremental development that aims at maintaining or further improving a product feature or a technology belongs to this category. *Disruptive technologies* bring to market a very different value proposition than had been available previously and will most likely undermine established products markets. The disruptive technologies may not be mature or fully economically feasible, at least for the mass-production, but they have other features a few (and generally new) customers value and may be suitable for smaller batch-sizes.

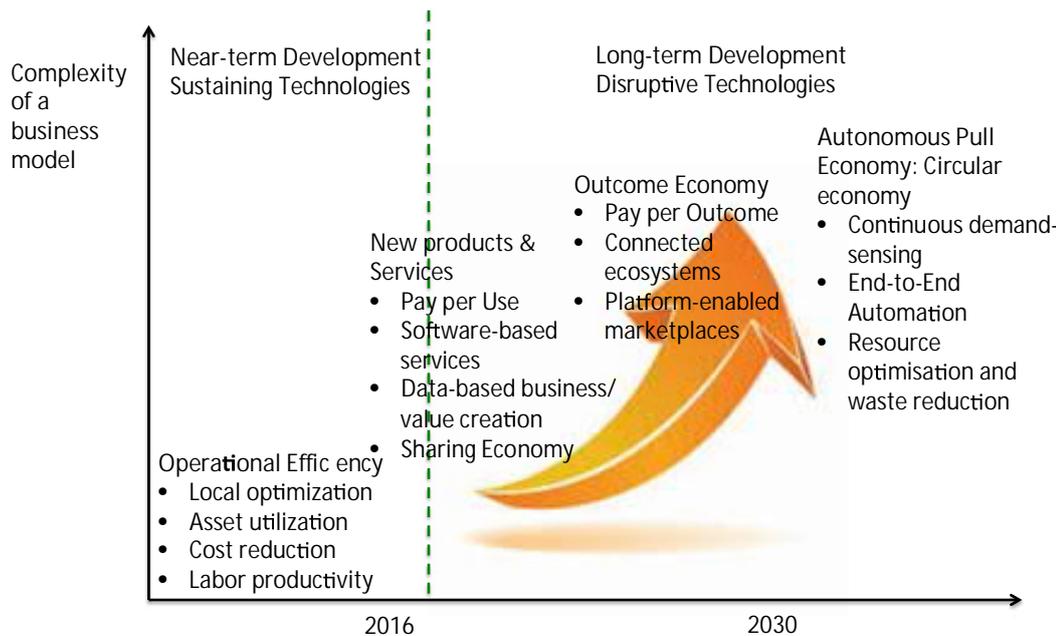


Figure 1 Near-term and Long-term development expectations (adapted from Sommarberg 2016)

Technological innovation can alter the competitive status of the companies. However, the purposeful management is rather complex by its nature as it involves the effective integration of people, organizational processes and plans (Roberts 2007). Traditionally, companies developed new technologies for their own products internally either by iterative development or by radical, more innovative, approach that results new products that are protected with patents. Thus, most companies pursued relatively “closed” innovation strategies, with limited interactions with the outside environment (Lichtenthaler 2017).

Open innovation with consumers/end users was mainly ‘outside-in’, i.e. consumers were used as a source of ideas for new products or improvements of existing products. Consumers are no longer simply regarded as external sources of ideas or test-subjects providing feedback in reactive manner from outside to in, but they can also provide external paths to market in proactive manner e.g. inside-out. (Rayna et al. 2015). Co-creation can either be autonomous or sponsored (Zwass 2010). When autonomous, consumers co-create independently (even though tools and platforms provided by the company may be used), without any incentive provided by the company. In contrast, sponsored co-creation takes place at the initiative of a company or any other established organization (Rayna et al. 2015). In recent decades, these strategies have begun to change as firms across industries have increasingly acquired external technologies to complement their internal knowledge bases e.g., by means of strategic alliances, open design or in-licensing, which involves acquiring the right to use external knowledge. A similar development could recently be observed in knowledge exploitation. Firms across industries started to actively commercialize their technological knowledge, either exclusively or in addition to using it internally for their own products by means of out-licensing or strategic alliances, where firms allow external partners to use some of their own technology (Lichtenthaler 2017).

Emerging Paradigms

A sharing economy is an economic concept with few realized models in which individuals are able to borrow or rent assets owned by someone else. On the manufacturing domain few ideas exist, but in broader scale such service as airBnB and Uber could be raised as examples. Previously the sharing economy was

associated to grass root level and/or non-profit organizations. The extensive non-profit and voluntary sector literature identifies the tendency of non-profit organizations to become more commercially-oriented over time (Martin et al. 2015). In the manufacturing sector a sharing economy model could be used when the availability of a certain capability is rather good, e.g. the asset is not used all the time or use periods are well known, and/or the price of a particular asset is relatively high. It has to be noted that sharing economy has several different definitions depending on the context and domain. On the information and communication technologies point of view the sharing economy takes place in a form of online platforms that promote user-generated content, sharing, and collaboration (Kaplan and Haenlein 2010; Hamari et al. 2015). More well-known examples of these include open source software repositories like SourceForge and Github, collaborative online encyclopedia like Wikipedia, and other generic content sharing sites such Youtube, Facebook, Instagram, or even peer-to-peer file sharing such as The Pirate Bay. More recent examples are peer-to-peer financing such as microloans with Kiva and crowdfunding services such as Kickstarter (Hamari et al. 2015).

In the outcome economy the purpose of business is to ensure the production of measurable outcomes for the clients and customers and business will use its customers success parameters as their own. Outcome economy has pay-per-outcome; new connected ecosystems and platform enabled market place as its attributes (Sommarberg and Mäkinen 2017). In outcome economy, companies will shift from competing through selling products and services, to competing on delivering measurable results important to the customer (Gierej 2017). Companies become completely committed to delivering quantifiable value for their customers. The product, process and service innovation are completely re-modelled as the focus is in the outcome itself, rather than in the enabling technology. The World Economic Forum (2015) defined outcome economy as "*The outcome economy will be built on the automated quantification capabilities of the industrial internet. The large-scale shift from selling products or services to selling measurable outcomes is a significant change that will redefine the base of competition and industry structures.*"

With the circular economy industrial players can have an opportunity to reinvent economy, making it more sustainable and competitive. The circular economy considers the products and processes location both along the value chain and across the product's multiple life-cycle phases offering new business opportunities with increased visibility among stakeholders and introducing new competitive factors. Traditionally the circular economy has been considered as waste management approach, however, as the recent review on scientific papers shows the view is wider. (King and Ijomah 2006; Ghisellini et al. 2016; Leider and Rashid 2016) CE aims at reducing solid waste, landfill and emissions through activities such as reuse, remanufacturing and/or recycling. Underpinned by a transition to renewable energy sources, the circular model builds economic, natural and social capital. (Leider and Rashid 2016; Umezawa et al. 2017)

The likelihood of paradigm change is heightened if changes take place at the same time in political, economic, social, and technological factors, which has been succinctly coined as a Creative Destruction (Schumpeter, 2008). According to Sommarberg (2016) new industries can emerge from new discoveries or they can be formed by allowing a subset of existing industry to form its own industry. Structural transformation takes place when two or more existing industries merge which is in literature referred as Industry Convergence (Sommarberg and Mäkinen 2017).

Open design and Social Manufacturing

There exist several different manufacturing paradigms. For manufacturing, it is natural that the change in the operating environment will affect to the manufacturing paradigm and spur its evolution over the time. Based on Mourtzis and Doukas (2014) the various patterns witnessed up to now can be roughly correlated to movements from stages 1-4: (i) craft shops that employ skilled artisans, (ii) long-linked industrial systems using rigid automation, (iii) post-industrial enterprises characterized by flexible resources and information intensive intellectual work, and (iv) age of personalization and v) rise of social manufacturing, illustrated in Figure 2.

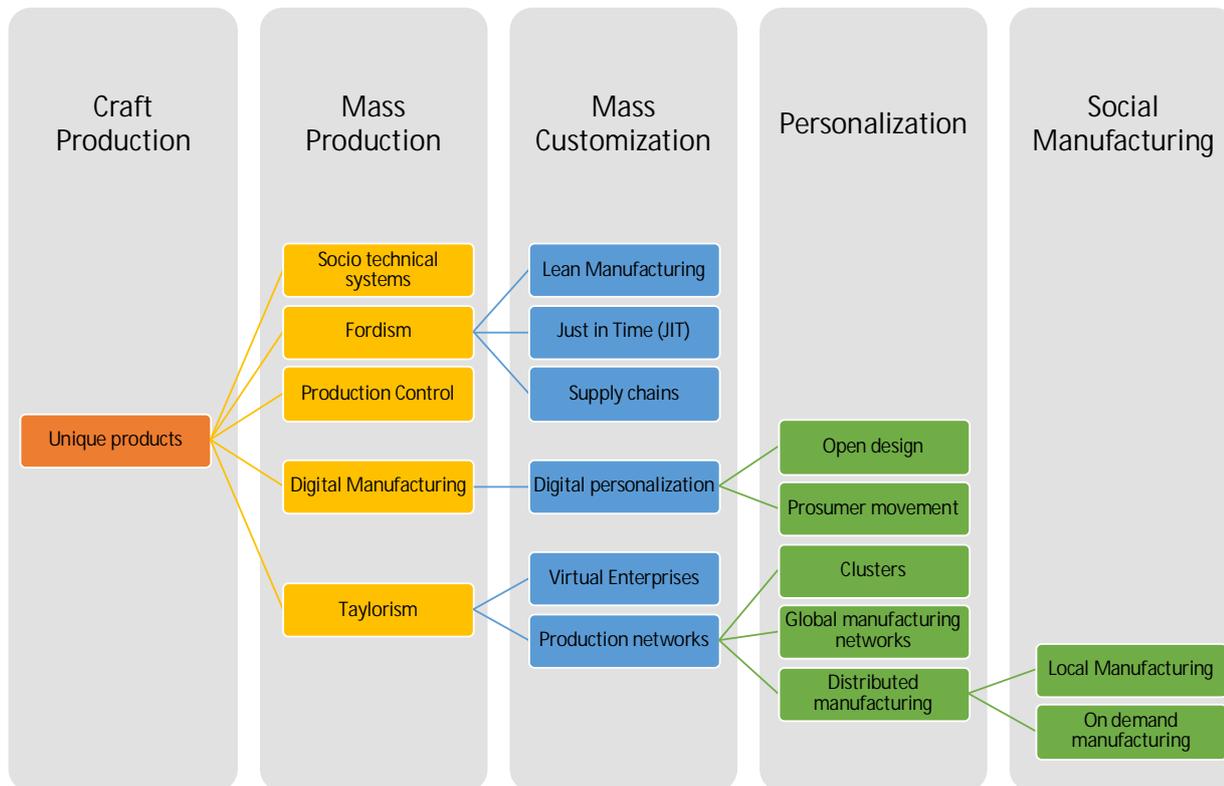


Figure 2 Evolution of manufacturing paradigms (adapted from Mourtzis and Doukas 2014)

The history usually starts with the craft-production of unique products pre-dating the first industrial revolution, the invention of steam power and electricity. The craft production is characterized with uniqueness and cost (Hu 2013). The Ford production line and Taylor management principles lead the way to the era of mass production, which later on supported the development (market pull) of fixed automation system, and lead to increased production efficiency and quality control procedures. The manufacturing paradigm “Mass customization” emerged as a new production paradigm in the 1980s to satisfy the customer needs for increased product variety in a highly competitive and segmented market (Mourtzis and Doukas 2014). In the mass-customization, the manufacturers generally design the basic product architecture and options while customers are allowed to select the assembly combination that they prefer most (Hu 2013). The fourth manufacturing paradigm is personalized production. The boundary between mass-customized products and personalized products is hard to draw. Personalized production aims at the procurement of truly unique products, through the tight integration of the customer in the design process (Hu 2013). In order to respond the customer needs in terms of personal features and delivery times in cost-efficient manners, several enabling technologies and features must be developed, such as: methods and tools for understanding and capturing consumers’ needs and preferences, design by non-designers techniques, cyber-physical systems for collaboration, on- demand manufacturing and assembly systems, process, product, volume and production flexibility among other (Mourtzis and Doukas, 2014). While the mainstream manufacturing in industrial products are either mass-production, mass-customization or personalization, new emerging trends are rising. Especially the prosumer movement has been a rising trend relating to the personalization needs

and to social manufacturing. As society moved to the Post-Industrial Age, the number of pure consumers started to decline slowly and were replaced again by "prosumers," people who produce many of their own goods and services Kotler (1986).

Traditionally advanced manufacturing has been highly focused on the company premises and their supply networks. The business has been considered business-to-business (B2B), with very little connection to the consumers. The manufacturing has been and still is characterized with certain key performance indicators that measure the production efficiency. The word advanced describes the situation rather well, as the use of advanced manufacturing systems, tools and processes requires high competence level from the operators. The systems used in traditional fields of manufacturing require large investments for the equipment and maintenance. In terms of manufacturing as well as service industry, resource sharing is still the key point to pursue the efficient and effective use of available resources with the ever-increasing demand for competitiveness (Samaddar et al. 2005; Tao et al. 2017). The effective sharing of resources between companies has previously been challenging due to the non-existing real-time operation management methods and required information and communication technologies ICT (Tao et al. 2017). Few of concepts for resource sharing among manufacturing SME network has been developed (Nylund et al. 2011, Lanz and Tuokko 2017).

More recently, the utilization of internet-based communities for design and consumer manufacturing have been emerging. These usually are referred as open design communities. The communities range from semi-open business-related design communities to non-profit organizations targeted for consumer products. Open design is characterized with the concept of "openness" of product development projects, a concept that consists of more shades than initially obvious (Bonvoisin and Boujut 2015). Openness refers to the use of non-pecuniary inbound and outbound flows of information/expertise/resources, i.e. from inside the project team to the public domain and vice versa (Dahlander and Gann 2010). Open innovation has been defined as a distributed innovation process based on purposively managed knowledge flows across organizational boundaries (Chesbrough and Bogers 2014). "Open Design" is a term that applies to the investigation and potential of open source and the collaborative nature of the internet to create physical objects (Bonvoisin & Boujut, 2015). In the open design people apply their skills and time to projects for the common good or they may be interested on less serious competition or challenges organized by the community regardless the funding possibilities or the prizes.

The age of Internet, and emergence of content independent platforms have increased again the participation of users in the production process. Based on the observations by Rayna et al (2015) the increased participation has been particularly visible since the birth of Web 2.0 technologies and for some of the most successful Web 2.0 outlets (e.g. Facebook, Instagram, Flickr, Twitter), the content provided by users' accounts for most of the value of the service. This increased user participation blurs the line between consumption and production activities since users both consume and produce digital content. This has spurred the interest towards creation of physical products. Once more the consumers are becoming prosumers in western countries, but now with their own choosing rather than need born in necessity. Previously this has been strongly associated to the 3D printing for consumer purposes (Rayna et al. 2015). Jiang et al. (2015) described the social manufacturing as following. Personalized products are developed and produced by online social communities in an outsourced and service-oriented way. This situation paves the way for social innovation. According to Jiang et al. (2015) Social Manufacturing can encourage open innovation through social collaboration and intellectual resources sharing. The social manufacturing is strongly related to the prosumer movement discussed by Kotler (1986).

What platforms exist today for open design and social manufacturing?

The table 1 collects a number of communities and marketplaces for open design and social manufacturing. While there exist a vast amount of open source and/or free tools for sharing the data and design (e.g. Hamari et al. 2015; Tao et al. 2017), the selection of following tools and communities is based on their use in terms of design and/or manufacturing. The companies or communities doing only printing services have been excluded from the table.

Table 1 Examples of open and social manufacturing platforms

| Example | Community | Licensing | Open Design | Social Manufacturing | Business model |
|--|--------------------------------|-----------------------|--|--|---|
| Quirky (2018) | Co-creation | Creative Commons (CC) | Community support for idea generation | Transforms lead users' ideas into actual products by using socialized resources and | brokering services, creates a marketplace for the realized products |
| Company Haier (Tao et al. 2017, Haier Global 2018) | Open manufacturing | Not defined | Not defined | employees and social individuals are mobilized as independent social micro-entrepreneurs to compete for its crowdsourcing orders | Brokering service, manufacturing is crowdsourced |
| Sensorica Platform (2018) | Knowledge sharing, co-creation | Not defined | design and deployment of intelligent, open sensors, and sense-making systems | Not defined | Those who developed these products will be rewarded in proportion to their contributions, Offers consultancy services |
| RipRap (2018) | Knowledge sharing | CC | Community to share 3D models | general-purpose self-replicating manufacturing machine | Non-profit |
| GrabCAD: Design Community, (2018) | Knowledge sharing, co-creation | CC | CAD Library, 3D Printing Software, Hosts design challenges | No direct support, contact to printing service provides via community | Non-profit, Companies propose challenges and offer rewards |
| Open Source Ecology (2018) | Knowledge sharing, co-creation | Not defined | development open source industrial machines | Not defined | Non-profit, most designs are "in planning phase" |

| | | | | | |
|-----------------------------|--|-------------|-------------------------------|---|--|
| i.Materialise (2018) | Printing service, knowledge sharing | Not defined | Support via open forum | Offers printing services, hosts an open forum for discussions | Pay per use printing and consultation services, web shop platform host |
| Shapeways (2018) | Printing service, co-creation | Not defined | Co-creation, community portal | Offers printing services, hosts an open forum for discussions | Brokerage services, Pay per use printing and consultation services, web shop platform host |
| Trinkle (2018) | Printing service, knowledge sharing | Not defined | Community portal | Offers printing services, hosts an open forum for discussions | Pay per use printing and consultation services |
| Makerbot Thingiverse (2018) | Knowledge sharing, co-creation, printing service | Not defined | Co-creation, community portal | Offers printing services, hosts an open forum for discussions | Brokerage services, |

Most of the sources for social and/or open manufacturing are focusing on the 3D printing. A few of these platforms such as Shapeways, Trinkle, i.Materialise offer printing services either straight or via brokering. RipRap and Makerbot Thingiverse are connected to the specific 3D printing machines. The community-based services are not entire economically feasible. The lifetime is relatively short, as compared to the list of 3D printing service providers and associated communities presented in Rayna et al. (2015), 30-50% are no longer available or have merged with larger communities.

Conclusions

In most of the cases the open manufacturing is used when a consumer or a prosumer designs and creates manufacturing procedures (such as path planning for 3D printing) and either manufactures the product him/herself or orders it from a service provider. The open manufacturing is most dominant in 3D printing field and its services. In the industrial case, term is simply subcontracting. While the do it yourself (DIY) and prosumer and makers movement are trending in consumer side, the industrial players seem to be reluctant to join the movement. Most of the companies participating to design challenges, hackathons or crowdsourced designs tasks are selecting the cases very carefully. In many challenge cases the designed product is not intended to be included into product offerings but is used for solving another design problem or simply to find new experts for the company.

According to Kotler (1986) the traditional businesses might find it increasingly hard to sell goods and services which people can produce themselves. Therefore, the companies positioned in this particular boundary need to assess which goods and services people are most likely to start producing by themselves. The rise and fall of the 3D printing communities service providers indicate the fluctuating market situation. Based on Kotler's analysis (1986) the prosumption activities that are likely to attract consumers will have four characteristics, which are 1) promises high cost saving, 2) require minimal skill, 3) consume little time and effort, and 4) yield

high personal satisfaction. Instead of marketers fighting prosumers, they should look for opportunities to facilitate prosumption activities. One way to facilitate prosumption is to develop better tools for the new generation of prosumers to use and interact globally. Thus, prosumer-oriented marketers can seize on a number of opportunities. They need to identify the most popular prosumer activities and think through appropriate product and service responses.

The DIY, Maker and presumption movements should not be discussed without a healthy dose of criticism. While they indeed facilitate the emergence of new ideas, inventions and perhaps even innovations, there are severe drawbacks that need to be considered. One of the challenges in open design and social manufacturing relates to the product quality, or more precisely the lack of verified quality assurance. The criticism could be addressed to the uncontrolled manner on how the production is controlled and how the quality can be assured. It is challenging to assess if the end-product follows the safety regulations, and how the customer rights and care is considered in a case of product defects.

The second grand challenge in crowdsourcing and open design is the patents. One of the largest gaps in the literature review, including academic publications and community sites, is the consideration towards existing patents in a case of openly shared design. The end result may be licensed under creative commons license, but what may not have been considered is violations against existing patent. Prosumers rarely seem to consider pure reverse engineering as a violation against existing patents. The literature review did not indicate considerations towards patents and/or legibility of reverse engineering.

The third challenge or a drawback is the environmental sustainability in production. As the prosumers are encouraged to (re)create their own products, the amount of waste increases. There is a large amount of material available for 3D printing. While some of these materials are recyclable, if clean enough, most will become a waste. The creation of 3D printable powder is energy intensive tasks. The powder needs to be of certain quality. The re-use of excessive powder from the printing process may or may not be possible depending on the next product's needs. The 3D printed object will most likely have no connection to the design such as product number or labelling of any kind. Once this 3D printed product has finished its lifecycle, it will become waste. In Scandinavia and western part of Europe, these will most likely to be burned for energy. Only seldom of these products can be identified, sorted and recycled. On other parts of the world, these products may end up to the landfills, thus burdening the environment further. The impact to the sustainability in economic sense, as envisioned in the existing circular economy frameworks, is rarely considered in literature.

The fourth challenge may also be in the regulations towards occupational safety e.g. is the design, that is openly shared, in-line with the machine directive if manufactured and sold in Europe or are the working conditions safe work the workers in the case of distributed manufacturing.

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