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Social manufacturing: When the maker movement meets interfirm production networks

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Abstract New business models harnessing the power of individuals have already revolutionized service industries and digital content production. In this study, we investigate whether a similar phenomenon is taking place in manufacturing industries. We start by conceptually defining two distinct forms of firm-individual collaboration in manufacturing industries: (1) social cloud manufacturing, in which firms outsource manufacturing to individuals, and (2) social platform manufacturing, in which firms provide manufacturing services to individuals. We then empirically investigate the nature of firm-individual collaboration within these forms, focusing on the role of individuals. We find that the individuals are often makers who view their participation primarily as a hobby and are driven mainly by nonmonetary benefits, that the design process often involves both parties, and that the two forms of collaboration exploit different enabling technologies. Our findings suggest that firms working with individuals can potentially reap multiple benefits, including fresh ideas, broader design support, and quick delivery times. This article contributes to an improved understanding of how firms can build potentially disruptive business models in manufacturing industries by leveraging individuals, thereby adding to the emerging stream of literature on social manufacturing.

1. Changing business models in service industries and in content production

Rapid technological development in information and communications technologies, especially in relation to social media applications (Kaplan & Haenlein, 2010; Kietzmann, Hermkens, McCarthy, & Silvestre, 2011), has resulted in new business models that emphasize cooperation between firms and individuals. Service production has already been revolutionized by the use of diffuse private agents. Well-known examples are Uber and Airbnb (Zervas, Proserpio, & Byers, in press). The same is true for digital content production in the vein of YouTube and Wikipedia (Benkler, 2006; Bruns,

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2008). This sharing economy trend is disrupting established industries around the world. Beyond the content production, transportation, and lodging industries, many others have been affected, such as household work (Isaac, 2015), consumer goods recycling (Arsel & Dobscha, 2011), and personal financing (Kuppuswamy & Bayus, 2015).

We are just beginning to understand the sharing economy (Cheng, 2016). Some scholars see individuals as its central actors (e.g., Belk, 2014); others emphasize the roles of companies and governments (e.g., Laamanen, Pferrer, Rong, & Van de Ven, 2016). While the term sharing economy might evoke ideas of individuals sharing their excess resources with or without compensation, what is perhaps more central to the concept is collaboration between participants.

But what about firm-individual cooperation in manufacturing industries? In his book on 'produsage'—that is, user-led content creation—Axel Bruns (2008, p. 389) stated: "As von Hippel [2005] points out, clearly 'production and diffusion of physical products involves activities with significant economies of scale,' and a direct translation of produsage to the physical realm is therefore unlikely." In this article, we look at the current situation in manufacturing to find out if this view is still accurate. We begin with a brief review of recent research in this area.

2. Previous research: Social manufacturing and value creation by individuals

The term *social manufacturing* captures the phenomenon of shared participation between firms and individuals in the production of physical goods. However, there is no established definition of how exactly this sharing might happen. When this term appeared in a *BusinessWire* (2011) release, it referred to the use of in-house social media applications for managing distributed manufacturing. The following year, Paul Markillie's (2012) article in *The Economist* gave the term a more individual-oriented meaning: "A new industry is emerging. It might be called social manufacturing . . . much of what is coming will empower small and medium-sized firms and individual entrepreneurs." Markillie's definition was less firm centric than that in *BusinessWire*, allowing for the possibility that personal fabrication might be re-entering the manufacturing scene, which has been dominated by companies since the industrial revolution. These firm-centric and individual-centric views could be termed 'institutional' and 'diffuse,' respectively.

In the practitioner-oriented context, the term social manufacturing has tended to follow Markillie's view of diffuse individual agency, whereas academic scholars in operations management research have taken a more firm centric or institutional view (e.g., Cao & Jiang, 2012; Jiang, Ding, & Leng, 2016; Shang et al., 2013). They, too, have recognized the importance of individuals, but more as consumers than as producers, since their focus is on social manufacturing as an advanced form of mass customization. We try to strike a balance between the different views on social manufacturing by seeing it as significant cooperation between established firms and independently operating individuals.

Looking more broadly beyond just the manufacturing field, the idea of independent individuals working cooperatively with organizations is a little-researched area. Even scholars who have focused on the importance of individuals in value creation have not accorded them full agency, instead tending to perceive individuals as filling assisting roles, either as creative employees (e.g., Lepak, Smith, & Taylor, 2007) or as sophisticated consumers (e.g., Prahalad & Ramaswamy, 2004). Even stakeholder theory (Freeman, 1984), which is appreciated for its pluralism, fails to depart from firm-centric thinking. A recent article by Tantalo and Priem (2016, p. 314) identified the "key unanswered questions" in stakeholder theory research: "How can *firms* create different types of value for different stakeholders?" (Parmar et al., 2010, p. 432) and "How [can *firms*] create value simultaneously for multiple stakeholders?" (Freeman, Harrison, & Wicks, 2007, p. 53). Another topic that stakeholder theory has not yet addressed is what value creation actually means to different stakeholders (Harrison & Wicks, 2013).

To shed light on this under-researched area, we set out to study how the social manufacturing phenomenon is unfolding in the current manufacturing scene. More particularly, we wanted to know why now and what for: That is, what might be the present factors facilitating this phenomenon, and what are the motivational drivers for the participants, both firms and individuals?

3. Methods

Because firm-individual cooperation in manufacturing industries remains a little-researched area, our approach to data collection and analysis is qualitative (Patton, 1990). A case study such as this one is particularly suited for creating a general understanding of a larger phenomenon by focusing on specific situations (Eisenhardt, 1989; Yin, 2013).

We started by conceptualizing interfirm manufacturing networks as dyads between subcontracting firms, on one hand, and firms providing manufacturing services, on the other hand. We set up the empirical part of our study by locating and selecting two settings in which similar dyads existed between firms and individuals: in one setting, firms subcontracted to individual agents; in the other, a firm offered manufacturing services to individual agents. For the purposes of this study we use the terms 'individual (agent)' and 'entrepreneur' interchangeably to designate a self-employed person working at a particular activity, without any connotations of whether the protagonist works alone or employs others, whether the activity is full- or part-time, and what the legal structure of business may be.

We collected data primarily through semi-structured interviews and searches of publicly available secondary material. Our sample consisted of two firms, SeeedStudio and 3D Hubs. SeeedStudio provides electronics manufacturing services to many individual clients. 3D Hubs is a platform that provides firms and individuals with access to a network of 3-D printing services, many of which are run by individual agents. Detailed firm case descriptions are presented in Table 1. At these firms, we conducted six interviews altogether. We interviewed two makers and one manager associated with SeeedStudio and three makers associated with 3D Hubs. All three SeeedStudio interviewees were based in North America. The two SeeedStudio maker interviewees were experienced users of this service. All three interviewees at 3D Hubs were individual providers of 3-D printing services, located in the capital region of Finland. The interviews typically lasted 30 to 45 minutes. Detailed descriptions of the five maker cases are presented in Table 2.

We analyzed the case data by an inductive ground-up approach (Yin, 2013) built on the grounded theory method (Glaser, 1978; Glaser & Strauss, 1967). Similar incidents in data are named to form concepts, which in turn are organized and related to each other to form theories by abducted conceptual models.

Table 1. Firm cases

<u>**SeeedStudio**</u>

SeeedStudio is a hardware innovation platform helping makers turn their ideas into products. Seeed's services range from prototyping to mass-production and sales. The company was established in 2008 by a maker who wanted to make tinkering with electronics more easily accessible to a larger public. The company offers programmable open source hardware components that makers can use to construct their prototypes easily in a plug-and-play fashion.

Makers often present their designs to SeeedStudio and request it to manufacture printed circuit boards (PCBs) to which different components subsequently can be added. SeeedStudio also helps makers finalize their designs, turning them into commercially viable products. Makers can then sell through the SeeedStudio website on a revenue-sharing basis. Finally, SeeedStudio hosts an online forum through which makers exchange ideas about designs and interact with the company.

SeeedStudio's development projects have included a robotic arm, an RF analyzer, and an open-source development platform for a small-sized quadcopter.

<u>**3D Hubs**</u>

3D Hubs is an online service for 3-D printing, a form of additive manufacturing in which layers of material are built up to create objects. Established in 2013, the company currently offers around 7,000 3-D printing services around the world, provided predominantly by individuals who own 3-D printer capacity that they want to sell. 3D Hubs is thus a platform that operates on a revenue-sharing basis, meaning that each fee collected from a customer is shared between 3D Hubs and the party actually providing the 3-D printer service.

The platform allows customers to login, upload the desired 3-D printer files, and select printing material. The system then automatically calculates price estimates for each service provider. The customers then make their choices based on price, ratings, and proximity, and submit their orders. The designated 3-D printer service operator then checks the order and especially the 3-D printer files, and gives a price quote that may be different from the system-generated estimate.

A request for payment is sent to the customer. When payment is received, the order goes into production with a lead-time of usually 1 to 4 days. Customers can choose to pay for shipping or to pick up their orders in person.

The variety of manufactured product is limited only by the range of available 3-D printing capabilities. The individual makers who we interviewed for this study had made anything from electronics enclosures to architectural scale models to protective helmets for brain surgery convalescents.

Table 2. Maker cases

Maker #1 at 3D Hubs The first maker we interviewed sold his slack 3-D printer capacity through 3D Hubs. Located in Finland, he was a serious 3-D printer hobbyist who started his hobby several years ago by building life-size Star Wars figures. He was constantly on the lookout for new 3-D printing techniques and often acquired new equipment just to enjoy it and improve his skill. According to him, 3-D printing techniques often involve a learning curve that has to be personally experienced to fully understand the technology. He wanted to recoup some of the money he had invested in his printers and participated in 3D Hubs' network because that was the only practical way open to him to do so. He served both individuals and companies, printing out prototypes and small batches of all sorts of objects ranging from miniature gifts to prototypes of industrial electrical equipment covers. Before printing a customer order, he spent time diligently going through the 3-D printer files, often tweaking them and making suggestions for minor improvements. His customer ratings were high; customers often returned with larger order sizes.
Maker #2 at 3D Hubs Also located in Finland, the second maker we interviewed was a serious 3-D printer pioneer with over 10 years of experience. He was a robot-building enthusiast and had used 3-D printer technology since its birth. At the time of the interview, he was running his 10th generation of 3-D printers. Serving both companies and individuals, his main focus, however, was on design services to companies. For many of his corporate clients, he focused on iterating several kinds of industrial designs and used 3-D printing merely as a way to better communicate and visualize his designs. Examples ranged from electrical equipment covers to miniature models of buildings. He said that he could do 3-D design and printing for a living but enjoyed his full-time day job so much that he was not willing forgo it; rather, he enjoyed running these lines of work in parallel. He had a diverse range of 3-D printers at his home, and he often utilized his home printer farm during the daytime by putting it into action before he left to his day job, checking the printing outcomes in the evening after returning from his day job.
Maker #3 at 3D Hubs The third maker we interviewed was a serious tinkerer and technology enthusiastic. Again located in Finland, he had 2 years of experience in 3-D printers. He had a 'Frankenstein' 3-D printer, meaning that he had built it by himself. He mainly served individuals but would like to expand to serving more corporate clients. He participated in 3D Hubs, making small amounts of money, but his primary reasoning was that he saw each order as a challenge and an opportunity to learn. Because of the limitations of his 3-D printing technology, he needed to adjust the printer frequently. He was interested in entrepreneurship, but at the time of the interview he did not see enough attraction in the market. Nevertheless, he felt that he was learning all the time alongside his full-time day job and could be ready when/if the market took off. He also saw that his daytime job supported his 3-D printing aspirations, and vice versa. During visits to clients of his daytime job, he often discussed what 3-D printing could do for them.
Maker #4 at SeeedStudio Located in the U.S., the fourth maker we interviewed was an experienced and passionate user of SeeedStudio services. He used SeeedStudio in parallel with his daytime job, which was a technology-oriented corporate job. During his limited free time, however, he enjoyed tinkering with experimental electrical hardware projects that were not possible on his day job. He wanted to see his free time designs turn into actual products. According to him, SeeedStudio enabled him to work on his maker passion. The ability to outsource manufacturing, storage, sales, shipping, and even design was tremendously helpful, he said.
Maker #5 at SeeedStudio The fifth maker in our study was another user of SeeedStudio services. Located in Canada, he was a technology enthusiastic and a tinkerer. He had made an initial hardware design, including a printed circuit board (PCB) and the components, and submitted it to SeeedStudio, which took care of packaging the product and the components according to his specification. No assembly was required on SeeedStudio's part. The components were delivered in a package to customers who themselves inserted the plug-and-play components into the PCBs. SeeedStudio marketed and sold the product on its website. The interviewee saw it as a not-too-serious way of making some money out of his free time designs.

4. Maker movement and two modes of social manufacturing

This study yielded four main results, one conceptual and three empirical:

1. Conceptually, we identified two distinctive subcategories of social manufacturing, which we call social platform manufacturing and social cloud manufacturing. They are differentiated by the roles taken by the firms and by the individual participants—in particular, which party is outsourcing and which party is offering manufacturing services.

2. We found that makers (i.e., people who gain hobbyist enjoyment from engaging with physical

production) are prominent among individual participants in social manufacturing.

3. We found that while ideation and initial design typically come primarily from the outsourcing party, refinement and developmental design often involves cooperation between the parties.

4. We found that nonmonetary payoffs and hybrid entrepreneurship contribute significantly to the resilience of the individual agents.

Figure 1 is a simplified visual presentation of the results, which we examine in detail in the subsections that follow.

4.1. Conceptual elaboration: From interfirm networks to social manufacturing

Our conceptual starting point was quite simple: In a normal organizational context, manufacturing takes place in interfirm manufacturing networks and, more particularly, in outsourcing/service-providing dyads. When similar cooperation takes place between firms and individuals, there are two possibilities: individuals outsourcing to firms or firms outsourcing to individuals.

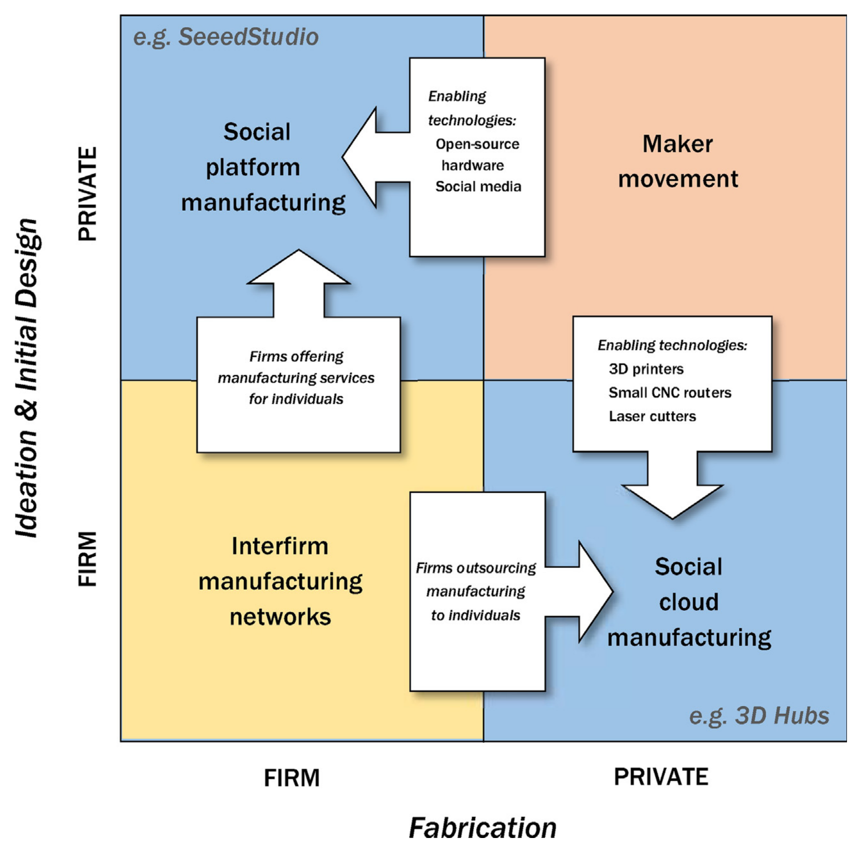
In the case of firms outsourcing to individuals, we perceived that these individuals could be seen as a pool of relatively homogeneous agents to whom smaller portions of a large manufacturing task could be allocated, so we termed this configuration *social cloud manufacturing*. In the case of individuals outsourcing manufacturing services to a firm, we perceived the firm as providing an arena for the participation of individuals, which led us to the term *social platform manufacturing*.

Figure 1 also presents another conceptual proposition that reflects particular (relatively) low-priced manufacturing technologies (identified from a review of secondary sources) that could enable individuals to join social cloud manufacturing. These technologies are presented in the arrow pointing down from the upper right quadrant.

4.2. Empirical finding: Maker movement and hobby-enabled entrepreneurship

For each of the five individual agents we interviewed, their enterprise was also a serious hobby. All three 3D Hubs providers had acquired their first

Figure 1. Two sub-types of social manufacturing



printers to pursue a personal interest; providing 3-D printing services to others was an afterthought. The same pattern appeared among SeeedStudio platform users; one of our interviewees labeled his undertaking as a "fun project." We thus see all five as participants in the maker movement and, accordingly, use this label for the upper right quadrant in our typology to characterize the pattern in which ideation, design, and fabrication are all in the hands of individual agents (the makers). Because these makers leveraged their hobbyist resources as they engaged in social manufacturing, they can also be termed hobby-enabled entrepreneurs.

As they tackled projects for others, the makers' engagement with social manufacturing allowed them to increase their expertise. A 3D Hubs service provider's comment illustrates this point: "Every customer order teaches me something. I accept them without knowing if I can do them."

Social manufacturing also allowed the makers to step up their hobbyist pursuit beyond their own area of expertise:

> I knew a little bit about electronics and circuit design but I'm not a hardware engineer. Seeed [Studio] was really good in the sense that I could give them a high-level design, a functional design if you will, 'Here is what it's supposed to be. You go and make me the PCB [printed circuit board] and help me with some of the electrical engineering and then we will sell that on your site and advertise it' . . . Without that kind of service, you know, I didn't have the technical expertise to actually design a full product like that. So they helped very much in that sense. Kind of got you off the ground.

4.3. Empirical finding: Shared design processes

On its website, 3D Hubs presents a simple business idea: The customer sends a completed 3-D file, and the supplier then "pushes the button" and prints the object. This simple process is supported by quick delivery times. 3D Hubs boasts an average turnaround time of just 48 hours.

We decided to test 3D Hubs' service to see how it functions. We found several providers within 20 miles of Helsinki and randomly chose three of them. We sent each a different printing job (toys with multiple closely fitting parts, the print files for which we had obtained from Thingverse free of charge). One of the providers delivered in 2 days; the two others needed only 1 day—very fast, as promised on the website.

However, we discovered something surprising. In all three cases, the first printed toys were dysfunctional (i.e., the parts did not properly fit together). In two of the cases, the service providers noticed this and tweaked the files and reprinted the product free of charge (they both got it right on the second try). In the third case, we had not given the service provider a picture of the assembled toy, so he was not able to test it. We ourselves carved out some material with a knife and made the toy functional. In short, the experience was not merely a matter of pushing a button.

When we asked our interviewees about these unexpected iterations, we heard that this is the case with most of the orders for two reasons: (1) 3-D files often include small measurement errors, (2) 3-D printer tolerances can be relatively big, especially in the low- and mid-priced devices that many individual service providers use.

However, our interviewees added that dealing with technological limitations was not the only reason they offered design services in addition to simple fabrication. Their clients occasionally asked them to take care of the design, which they gladly accepted as a learning opportunity. One of our 3D Hubs informant's main work with 3-D was the design of products, the actual printing being incidental:

> The printing itself doesn't really pay off. I do a lot of design, that's my thing. People want to have anything from a cover plate up to a robot. I just designed a casing for a firm. A lot of times there can be five iterations, and the printing itself is just an additional thing.

The hobbyist approach appears to be beneficial not just in social cloud manufacturing but also in social platform manufacturing. In our sample case, the maker peer community and SeeedStudio together were sustaining an open-source hardware ecosystem that utilized social media (presented in Figure 1 as technologies that enable social platform manufacturing). Their interaction has benefitted ideation and initial design on the part of the makers and appears also to have helped smooth the evolving cooperation between makers and SeeedStudio, as the following quote reveals: "To be honest, at least in my case, we never had a discussion about the ownership of IPRs [intellectual property rights]. A lot of the designs are actually open source, so it doesn't really matter."

Hence, we discovered that while the ideation and initial design are usually done by the subcontracting party and fabrication by the service providing party, design refinement and development are often conducted by both parties in cooperation. In Figure 1, we include only the phases that differentiate between the parties; ideation and initial design appear on the Y-axis, fabrication on the X-axis.

4.4. Empirical finding: Resilience and nonmonetary payoffs

Our fourth result (not presented in Figure 1) relates to resilience. The five makers who we interviewed all persevered in their pursuits even though they were not generating significant income through them. For example, the makers engaged with 3-D printing reported that, after material and electricity costs and equipment cost amortization based on wear and tear and obsolescence, their hourly return on time spent with customers, and then on setup and tweaking print files, in some cases worked out to only a few euros.

However, for a hobbyist, making money rarely appears to be the primary objective. Wanting to recoup some of their investment in equipment that might be hard to justify solely by their hobby was an initial motivation reported by our interviewees for providing services to others. One commented: "Last week I made 20 casings. It took about 4 hours. The profit was 15 euros. The idea is to get the printer paid for, 10 euros here, 20 euros there." But nonmonetary considerations rapidly appeared. It is fun to be in the vanguard, to have the latest toy, to 'make stuff' valued by one's friends and associates (e.g., printing new earrings for a girlfriend or refrigerator spare parts for neighbors).

There was another reason our informants tolerated low payoffs from social manufacturing: all five of our maker informants were part-timers. Two of the five had created some organizational form to host their activities; the other three had not. One of the 3D Hubs interviewees had had an opportunity to scale up to full time, but he did not want to give up his interesting day job. The other two did not have enough business to support a transition to full-time entrepreneurship. Yet one of them was aspiring to do this, and was constantly scouting for new ideas in his day job. For example, he had noticed that architectural offices mostly still use costly handmade scale models, and perceived this as an opportunity for 3-D printing.

All three 3-D printing providers were operating from their homes. This makes sense, since a 3-D print can take several hours to run once it is started. The long waiting time allows some other paid activity, which could even be a day job. It was common practice to start a printing job and then turn to some other home activity (or go to work or go to bed).

Beyond accepting low payoffs, another feature of the hobbyist approach that we see contributing to the perseverance of the makers was their willingness to deal with the teething troubles of emerging technologies. As mentioned earlier, 3-D printing in its current state of development is not just a matter of hitting the print button and letting the machines do the job. Designs often need modification to correct for some design failure or to accommodate particular properties and limitations of the equipment. As one interviewee pointed out:

> People have had big disappointments with these printers. They were expecting them to behave like an A4 ink printer. But they don't work like that, they don't work out of the box. If you are not a tinkerer, you will get disappointed.

This additional work can be frustrating to an entrepreneur who expected printing to be easier, probably one reason for the sharp drop in the number of 3D Hubs' service providers from more than 25,000 in 2015 (Ford & Despeisse, 2016) to slightly fewer than 7,000 in March 2017. However, for some maker-providers, the unexpected additional work is not a drawback; rather, this additional work contributed to their nonmonetary payoffs.

5. Academic discussion

We began by noting that firm-individual cooperation in physical production can usefully be conceived as occurring in two distinct forms, which we termed social platform manufacturing and social cloud manufacturing. We then offered empirical evidence for both forms.

Our research contributes to an emerging field. Only 9 years ago, Bruns (2008) suggested that a user-led revolution in physical manufacturing, similar to what had emerged in digital content production, was unlikely to take place. However, the barriers he identified to such a development are quickly vanishing. New manufacturing technologies—such 3-D printing (Berman, 2012) and laser cutting—open new possibilities for customized production, not only by companies but also via personal fabrication by makers (Gibson, Rosen, & Stucker, 2010).

The change has been so rapid that researchers have yet to agree on a standard vocabulary, much less elaborated theories to deal conceptually with the phenomena of individual agents creating value with and alongside established firms. While some researchers (e.g., Cao & Jiang, 2012; Jiang et al., 2016; Shang et al., 2013) have presented social manufacturing as an advanced form of mass customization with individuals having a relatively limited role, our study shows a much more equalitarian setting with individual participants as significant contributors.

As a term, cloud manufacturing is only a couple of years older than social manufacturing (Li et al., 2010; Wu, Greer, Rosen, & Schaefer, 2013; Xu, 2012). Xu (2012, p. 79) has defined it as "a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable manufacturing resources . . . that can be rapidly provisioned and released with minimal management effort or service provider interaction." One connotation of cloud manufacturing is that a large manufacturing task can be divided into smaller portions that are then realized through distributed independent agents. Indeed, this is how 3D Hubs advertises its services. However, the cases we studied suggest that the central value of social cloud manufacturing may lie elsewhere: in the contributions of individual agents as they handle one-off tasks and provide input to the design phase.

We noticed that our interviewees had a passionate hobbyist approach to making things. As a result, we identified them as makers. The maker movement is a mode of manufacturing in which individuals handle the entire process from ideation to design to fabrication (Dougherty, 2012). An example is a single person tinkering in a garage, but peer networking in platforms such as maker spaces is becoming increasingly popular. Makers are often motivated by personal growth.

Our results show that nonmonetary payoffs matter in social manufacturing, at least to individual agents. This resonates with previous research in related fields. New community-based business models in maker peer production also are not driven purely by profit maximization (Wolf & Troxler, 2016). Studies of entrepreneurship and self-employment have called attention to the importance of nonmonetary value. For example, self-employment intentions have been explained as maximization of personal satisfaction (Douglas & Shepherd, 2002). Empirical investigations have found that more than 50% of new business founders in the U.S. cite nonmonetary reasons as their primary motivations (Hurst & Pugsley, 2010). Further, nonmonetary payoffs have been claimed as the only plausible explanation for persistence of the self-employed in their work even when they earn less on average than people working for others (Hamilton, 2000).

New manufacturing technologies and the business models that they enable for individual agents seem to be particularly suited to part-time or hybrid entrepreneurship. All three reasons—supplementary income, nonmonetary benefits, path to full-time entrepreneurship—given by Folta, Delmar, and Wennberg (2010) for hybrid entrepreneurship in their seminal article could be observed in our cases. Raffiee and Feng (2014) have suggested a fourth: The intense learning that takes place during part-time entrepreneurship increases the probability of success when the individual becomes a full-time entrepreneur.

6. Some practical considerations

Within this study we have tried to understand social manufacturing—defined as significant cooperation between firms and individuals in physical production—as it is currently unfolding and evolving in manufacturing industries. We have done this by looking at two particular settings: one in which firms outsource their 3-D printing needs to individual service providers, and another in which a firm offers electronics manufacturing services to many individual innovators. Although this study is limited to just two of the many possible arenas of social manufacturing, we suggest some general takeaways that may be of interest to firms and individuals currently active in or thinking of participating in this mode of production.

6.1. Outsourcing firms

Our results suggest five practical benefits that companies could derive from social cloud manufacturing if they would consider the use of 3-D printing (e.g., for rapid prototyping). We suggest that these benefits (apart, perhaps, from ease) could be realized in other technological settings as well.

6.1.1. Ease

For a company that uses very little 3-D printing, it could be troublesome to acquire proficiency in running their own printers, which often involves tweaking the design files. Using an external service like 3D Hubs might be a better option.

6.1.2. Speed

The individual makers who provide these services are highly distributed, often several within a reasonable distance. Some of them have large printer farms. Combined with their generally short lead times, the scale and ready availability of 3-D printing services means that the ordered components or prototypes usually can be delivered very quickly, even within 24 hours.

6.1.3. Flexibility

Customer contact with such providers tends to be more personal and less bureaucratic, based on the particular service provider's desire to help. Transaction terms are negotiable with no minimum order quantity.

6.1.4. Lower cost

The makers who we interviewed priced their services very modestly. They appeared to want primarily to cover their raw materials and pay off their printer investments. They were not in the market for big money.

6.1.5. Design support

The individual makers we interviewed were more than happy to assist in the design process with the firms they serviced, rather than merely providing 3-D printing services. They appeared to us to present an untapped trove for outsourcing.

6.2. Firms offering manufacturing services

Over the last several decades, electronics manufacturing services have become common in interfirm networks. The idea of providing such services to individual makers, however, is novel. Our examination of the phenomenon demonstrates that models of such cooperation are still evolving. Although maker projects generally entail relatively small production lots, we can nevertheless see that social platform manufacturing may offer two interesting possibilities, especially to smaller manufacturing companies.

6.2.1. Access to innovation

Many disruptive innovations in software-related industries have come from individual hackers. On the hardware side, however, individual initiatives have been less conspicuous. Yet our research strongly suggests that hackers/makers have much they could contribute to manufacturing. Moreover, the interviewees in our study appeared to be quite open to co-creation with firms. From the company point of view, exploiting their skills and motivation could result in significant benefits, such as shared projects with spillover effects.

6.2.2. Expanding to related business

Cooperation with makers can give companies insight into the maker market, suggesting new products that makers and hackers would purchase, such as modular electronic building blocks for creating prototypes. By providing such products, a company could also increase the probability that these makers will then later ask for their services in production and manufacturing.

6.3. Individual makers

Although the arena of social manufacturing is still in a relatively early stage of emergence, there is some practical advice that can be extracted from our study.

6.3.1. Starting with personal passions

All five makers whom we interviewed for this study had started their engagement with social manufacturing through a hobbyist pursuit. Hence, looking at your passions might provide a good entry point to social manufacturing.

6.3.2. Expanding the range

From the hobbyist point of view, collaboration with companies through social manufacturing provides a way of accelerating your learning curve and upgrading your hobbyist activity to a new level. This path is suitable for makers who are not afraid of going out of their comfort zones and expanding to new areas, such as design and customer service.

6.3.3. Going professional

If your interest in social manufacturing is professional and you are planning to make a living out of it, it might still be a good idea to keep your day job as long as possible. Also, you should inform yourself about design-related intellectual property rights, as the practices relating to them are only emerging. Although the platforms you are using may be global, intellectual property issues can differ from one country to another.

6.3.4. Harnessing social media

Although the two platforms studied in this article both include social media applications, they are still far from fully utilizing the potential connections between social media and manufacturing. We suggest that the true power of social manufacturing could lie in this uncharted intersection. It may well be individual makers who have the creativity to release this potential fully.

7. Concluding thoughts

Despite revolutions in service industries and digital content production, many think that manufacturing is sheltered by economies of scale. Platforms such as Uber, Airbnb, and YouTube are seen as belonging to another reality. But the landscape is changing quickly. Manufacturing technologies are emerging that are inexpensive and small in scale, giving individual makers local access to resources that were earlier the privilege of companies. Although they may cooperate with companies in their use of these distributed technologies, makers' attitudes toward and uses of these resources vary significantly from what is typical of firms. Instead of focusing on profit, many makers take on projects primarily to boost their own learning, to cover at least some of the costs they incurred as hobbyists, or for other personal reasons. If companies are able to acknowledge and support these goals, they can expect to attract enthusiastic and committed co-creators who may in some cases develop into longer-term partners in cooperative firm-individual social manufacturing.

We suggest several ways in which these emerging forms of firm-individual cooperation can be beneficial. On the one hand, highly distributed maker networks can provide a firm with manufacturing response times that would be unimaginable with larger subcontractors. In the other direction, individual makers may bring product ideas and prototypes to a company to get help with production and fabrication. Interestingly, both cases commonly include a cooperative design process between the firm and the individual maker. This intertwining is something that sets social manufacturing apart from pre-industrial cottage industries and from established ideas of modern crowdsourcing, which often include connotations of thin cooperation on a narrow stretch of the value chain.

The rapid development of social media and the sharing economy has lowered entry barriers for individual agents practically to zero in many service and content-production industries. A dramatic example of this democratization is the media field: Almost anybody can start a virtual TV channel or newspaper overnight. When this virtual world becomes connected with the physical world of social manufacturing, the consequences can be interesting. Imagine the opportunities that a YouTube star would have when leveraging his or her rapidly increasing popularity by branding a wide selection of consumer goods, contracting the manufacturing to individuals and firms, and selling the results through the internet—possibly without ever seeing the actual products.

References

Arsel, Z., & Dobscha, S. (2011). Hybrid pro-social exchange systems: The case of Freecycle. *Advances in Consumer Research, 39*, 66—67.

Belk, R. (2014). You are what you can access: Sharing and collaborative consumption online. *Journal of Business Research, 67*(8), 1595—1600.

Benkler, Y. (2006). *The wealth of networks: How social production transforms markets and freedom*. New Haven, CT: Yale University Press.

Berman, B. (2012). 3-D printing: The new industrial revolution. *Business Horizons, 55*(2), 155—162.

Bruns, A. (2008). *Blogs, Wikipedia, Second Life, and beyond: From production to produsage*. New York: Peter Lang.

BusinessWire. (2011, September 1). *Kenandy delivers social manufacturing application on Force.com, bringing social, mobile, and open cloud computing technologies to global, distributed manufacturing*. Available at http://www.businesswire.com/news/home/20110901006181/en/Kenandy-Delivers-Social-Manufacturing-Application-Force.com-Bringing

Cao, W., & Jiang, P. (2012). Cloud machining community for social manufacturing. *Applied Mechanics and Materials, 220*, 61—64.

Cheng, M. (2016). Sharing economy: A review and agenda for future research. *International Journal of Hospitality Management, 57*, 60—70.

Dougherty, D. (2012). The maker movement. *Innovations: Technology, Governance, Globalization, 7*(3), 11—14.

Douglas, E. J., & Shepherd, D. A. (2002). Self-employment as a career choice: Attitudes, entrepreneurial intentions, and utility maximization. *Entrepreneurship Theory and Practice, 26*(3), 81—91.

Eisenhardt, K. M. (1989). Building theories from case study research. *Academy of Management Review, 14*(4), 532—550.

Folta, T. B., Delmar, F., & Wennberg, K. (2010). Hybrid entrepreneurship. *Management Science, 56*(2), 253—269.

Ford, S., & Despeisse, M. (2016). Additive manufacturing and sustainability: An exploratory study of the advantages and challenges. *Journal of Cleaner Production, 137*, 1573—1587.

Freeman, R. E. (1984). *Strategic management: A stakeholder approach*. Cambridge, UK: Cambridge University Press.

Freeman, R. E., Harrison, J. S., & Wicks, A. C. (2007). *Managing for stakeholders: Survival, reputation, and success*. New Haven, CT: Yale University Press.

Gibson, I., Rosen, D. W., & Stucker, B. (2010). *Additive manufacturing technologies*. New York: Springer.

Glaser, B. G. (1978). *Theoretical sensitivity: Advances in the methodology of grounded theory*. Mill Valley, CA: Sociology Press.

Glaser, B. G., & Strauss, A. L. (1967). *Discovery of grounded theory: Strategies for qualitative research*. Chicago: Aldine Publishing Company.

Hamilton, B. H. (2000). Does entrepreneurship pay? An empirical analysis of the returns to self-employment. *The Journal of Political Economy, 108*(3), 604—631.

Harrison, J. S., & Wicks, A. C. (2013). Stakeholder theory, value, and firm performance. *Business Ethics Quarterly, 23*(1), 97—124.

Hurst, E. G., & Pugsley, B. W. (2010). *Non pecuniary benefits of small business ownership*. Available at http://cep.lse.ac.uk/seminarpapers/15-02-11-EH2.pdf

Isaac, E. (2015). Innovative clusters and new work: A case study of TaskRabbit (Working paper No. 2015—2). *Berkeley Roundtable on the International Economy*. Available at http://www.brie.berkeley.edu/wp-content/uploads/2015/02/Innovative-Clusters-New-Work.pdf

Jiang, P., Ding, K., & Leng, J. (2016). Towards a cyber-physical-social-connected and service-oriented manufacturing paradigm: Social manufacturing. *Manufacturing Letters, 7*, 15—21.

Kaplan, A. M., & Haenlein, M. (2010). Users of the world, unite! The challenges and opportunities of social media. *Business Horizons, 53*(1), 59—68.

Kietzmann, J. H., Hermkens, K., McCarthy, I. P., & Silvestre, B. S. (2011). Social media? Get serious! Understanding the functional building blocks of social media. *Business Horizons, 54*(3), 241—251.

Kuppuswamy, V., & Bayus, B. L. (2015). *Crowdfunding creative ideas: The dynamics of project backers in Kickstarter* (UNC Kenan-Flagler Research Paper No. 2013—15). Available at https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2234765

Laamanen, T., Pferrer, J., Rong, K., & Van de Ven, A. H. (2016). Call for papers: Business models, ecosystems, and society in the sharing economy. *Academy of Management Discoveries, 2*(2), 218—221.

Lepak, D. P., Smith, K. G., & Taylor, M. S. (2007). Value creation and value capture: A multilevel perspective. *Academy of Management Review, 32*(1), 180—194.

Li, B.-H., Zhang, L., Wang, S.-L., Tao, F., Cao, J.-W., Jiang, X.-D., et al. (2010). Cloud manufacturing: A new service-oriented networked manufacturing model. *Computer Integrated Manufacturing Systems, 16*(1), 1—7.

Markillie, P. (2012, April 21). A third industrial revolution: Collaboration manufacturing. *The Economist*. Available at http://www.economist.com/node/21552902

Parmar, B. L., Freeman, R. E., Harrison, J. S., Wicks, A. C., de Colle, S., & Purnell, L. (2010). Stakeholder theory: The state of the art. *Academy of Management Annals, 4*(1), 403—445.

Patton, M. Q. (1990). *Qualitative evaluation and research methods*. Thousand Oaks, CA: Sage Publications.

Prahalad, C. K., & Ramaswamy, V. (2004). Co-creation experiences: The next practice in value creation. *Journal of Interactive Marketing, 18*(3), 5—14.

Raffiee, J., & Feng, J. (2014). Should I quit my day job? A hybrid path to entrepreneurship. *Academy of Management Journal, 57*(4), 936—963.

Shang, X., Liu, X., Xiong, G., Cheng, C., Ma, Y., & Nyberg, T. R. (2013). Social manufacturing cloud service platform for the mass customization in apparel industry. In *Proceedings of the 2013 IEEE International Conference on Service Operations and Logistics, and Informatics* (pp. 220—224). Dongguan, China: IEEE.

Tantalo, C., & Priem, R. L. (2016). Value creation through stakeholder synergy. *Strategic Management Journal, 37*(2), 314—329.

von Hippel, E. (2005). *Democratizing innovation*. Cambridge, MA: MIT Press.

Wolf, P., & Troxler, P. (2016). Community-based business models: Insights from an emerging maker economy. *Interaction Design and Architecture(s), 30*(1), 75—94.

Wu, D., Greer, M. J., Rosen, D. W., & Schaefer, D. (2013). Cloud manufacturing: Strategic vision and state-of-the-art. *Journal of Manufacturing Systems, 32*(4), 564—579.

Xu, X. (2012). From cloud computing to cloud manufacturing. *Robotics and Computer Integrated Manufacturing, 28*(1), 75—86.

Yin, R. K. (2013). *Case study research: Design and methods*. Thousand Oaks, CA: Sage Publications.

Zervas, G., Proserpio, D., & Byers, J. W. (in press). The rise of the sharing economy: Estimating the impact of Airbnb on the hotel industry. *Journal of Marketing Research*.