*xxxxJournal ofEngineering Research and Application www.ijera.com*
*ISSN : 2248-9622 Vol. 9,Issue 11 (Series -I) November 2019, pp01-09*

RESEARCH ARTICLE OPEN ACCESS

# The use and abuse of 3D printing - Towards a mobile business model framework

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**ABSTRACT:**The paper aim to clarify changes in user activities and behaviour across different types of actors following the development of 3D printers. It proposes a mobile business model and outlining the features of development for direct digital manufacturing.
The exploratory study show that the use of 3D printing a) lowers the knowledge and resource barriers for experimentation and entrepreneurial entry, b) increases product and concept prototyping in product development, c) provides a potential for business model innovation by expanding the boundaries of the firm upstream and downstream, and d) becomes a ticket for entrepreneurial entry.

Date of Submission: 27-10-2019 Date Of Acceptance: 15-11-2019

## I. INTRODUCTION

Additive manufacturing, commonly denoted 3D printing (3DP), is an emerging general purposetechnology that manufactures components by adding one layer of materials to another. 3DP uses 3 dimensionalcomputer aided design (CAD) files, which are created by scanning or constructed within a computer. By so doing, 3D printers close the circuit from the physical reality to the digital domain; while digitalization brought about robust representation and calculations of the physical reality, 3D printers allow for taking the digital representations and make a physical equivalent of the digital blueprint.

3D printing tends to be a slow process compared to mass manufacturing but fast compared to conventional construction of physical prototypes (mock-ups). This means 3DP is commonly used for prototyping new products but only to a limited extent during production. This is claimed to be changing as the ability to build tailor-made gadgets means it is increasingly used for production of high-end specialized components. In addition, over the last two decades 3DP has become much cheaper, allowing for private uses of low end printers.This suggests that 3DP will not only influence R&D and manufacturing across a huge array of applications but also create new markets.

More specifically, 3DP has been claimed to disrupt manufacturing, allowing firms to move from prototyping to full-scale end-part production and replacement part production in a one-step process. At the same time, 3DP may be hyped prematurely as suggested by several scholars as the use of 3D printers still is in its infancy (Sandström, 2016; Rehier et al, 2017). Currently, even though there are relevant exceptions the literature is full of claims but with limited empirical evidence (Mortara and Parisot, 2014). For example, there is a lack of studies of productivity of using 3DP across different manufacturing processes and how and to what extent the use of 3DP enables not just technological experimentation but also entrepreneurial action. This is a severe shortcoming as it is well known that general purpose technologies require "co-innovation" (Bresnahan and Trajtenberg, 1995) for the realization of productivity gains. In other words, technological, organizational and behavioural changes may need

to co-evolve for the potential of the new technologies to be realized.

Given the suggested potential paired with the limited impact, the question is in what ways 3DP affect manufacturing from a use perspective.We address this issue by analyzing changes in activities and behavior across different types of actors that are using 3D printers. By referring to use we address how consumers, entrepreneurs,andincumbents' entrepreneurial activities are affected when actors start using 3D printers. Portraying the actors as users is in line with von Hippel (2004) who defined users as firms or individual consumers that expect to benefit from using a product or a service. Empirically we draw on a consumer database from one of Sweden's largest seller of 3D printers. The insights from the database are complemented by illustrations from four different users of 3D printers. To analyze the data, let us recall that the 3D printer literature claims that 3DP will be a new industrial revolution. A new industrial revolution can be addressed by focusing on the removal of knowledge and resource barriers for experimentation, production and entrepreneurship, which increases an actors ability to search for innovative solutions. This is in line with the logic of the introduction of a new capital goods structure, i.e. a structured and complementary combination of production technologies, which lowers the resource and knowledge barriers to entry (see Lachmann, 1956; Saemundsson and Holmén, 2011). More precisely, the study draws on the frameworks of entrepreneurial behavior including the users as innovators (von Hippel, 2004), entrepreneurial action and the structure of capital goods (Loasby, 2007; Lachmann, 1956) and the emerging literature on business model innovation.

Section 2 outlines the technology of 3DP including the production chain, materials, applications and uses. Section 3 presents the method of the study and Section 4 the empirical illustrations. Section 5 discusses the findings from a user and entrepreneurial perspective while Section 6 presents the conclusions and an agenda for further research.

**The Technology And Use Of Additive Manufacturing**

3D printing technology is being used in a variety of applications, which basically fall into two broad categories: rapid prototyping and component manufacturing (Bouge, 2013).

During the 1990'ies equipment for 3D printing technology was expensive and rarely used for non-industrial applications. This has changed due to the emergence of low cost and easy to use 3D printers as exemplified by the RepRap (replicating rapid prototype)project in 2011 (Jones et al., 2011).

Rapid prototyping (RP) is used in product development referring to technologies which create physical prototypes from digital data allowing users to test prototypes before full scale manufacturing. Prototyping is an essential part of new product development (NPD) before a significant investment in tooling is made (Pham & Gault 1998). Prototyping shortens the product development cycle and saves cost in the prototyping stage (Muita et al., 2015).

Additive Manufacturing (AM), or 3D printing evolved from the first rapid prototyping processes capable of direct part production ofthree-dimensional objects by adding material layer by-layer based on a "digitally sliced"3D CAD model (Klahn et al., 2015).

Rapid tooling (RT) is besides RP and AM the third important field for 3D manufacturing broadly described as any mold-making process that can create tools as a final product based on the sliced 3D models.Direct tooling typically uses materials such as resins tools, metal powder, or ceramic powder (CERAM, 2013).

3D printing technology processes can be classified into the three different categories: powder based, liquid based or solid based, depending on the status of the material used to create the prototype, final product or tool (Levya et al., 2003).

**A Paradigm Shift In Manufacturing**

Starting from manual crafting with a very slow pace, humanity reached industrial revolution and mass production in the beginning of 20th century. Since the onset of the industrial revolution and mass production, manufacturing systems evolved to more lean ones able to produce economically smaller batch sizes allowing for mass- or individual customization.Figure 1 below based on Abel et al (2011), shows how the manufacturing paradigms have evolved with respect to the origin of design requirements (consumer, artisan, designer or many person), manufacturing strategy (workshop, Factory or local)as well as the types of end users (consumers, passive consumers, active consumers or "prosumers" - production by consumers, home printingCraft manufacturing was carried out by artisans in a workshop for the product consumers. In mass manufacturing product development is a separated task carried out by a designer (presented in violet color) and manufacturing is carried out in a factory with specialized factory workers.

**FIGURE 1. A COMPARISON OF MANUFACTURING PARADIGMS AND THEIR MAIN ACTORS**
(Source: Abel et al., 2011 modified by Chen et al., 2015).

| **Craft manufacturing** | **Mass manufacturing** | **Mass customization** | **Direct digital manufacturing** |
|---|---|---|---|
| Consumer and Artisan | Designer | Designer and consumer | Interaction between many people |
| Workshop | Factory | Factory | Local production |
| Variable products | Standarized products | Customized products | Personalized products |
| Consumer | Passive consumers | Active consumers | Prosumer |

Consumers can here select from standardized products. Mass customization is very similar to mass manufacturing, but the consumers have a selection of products with varied properties.Direct Digital Manufacturingoffers the possibility of personalized ”tailor made” products with various design values like material selection and aesthetics (Chen et al., 2015).

**User Based 3d Printing And Business Models**

3D printing technologiesoriginallyhad only industrial uses because of high costs.The decreased cost has lately put them within reach of SMEs and individual entrepreneurs. In the late 2000s, the cost of 3D printing began to be low enough (and quality high enough) to start directly manufacturing final products since “speed, quality, accuracy and material properties have developed to an extent that 3D Printed parts can be made for final use” (Gibson et al. 2010). More precisely, with home 3D printers now being available for less than $500, 3D printing is becoming a technology any business, small or large, can afford and create new 3D based business model opportunities.

Beyond being used by industry and companies, there is a growing trend of using 3D printing in direct consumer markets, home 3D printing is growing.Theclaimed effectis that the development of 3D Printing will lead to an increase in competition between the traditional mass production and mass customization industries and SMEs as well as individual entrepreneurs, and “prosumers”).Such an increase of competition has been made possible by the digitalization of product development and challenge current past revenue, pricing- and business models. 3D printing supportsthedevelopmentof business models and enables new and interesting tools for current and future business model innovation.3D technology and printing promote easier (quicker product development at lesser costs than before) changes of business focus for companies while it makes the same thing for the competition.This creates a possibility for SMEs to enter new industries, making niche markets attractive to large scale industry. The potential for 3D printing is the creation of a more dynamic market structure where old boundaries cease to exist when consumers and SME industry start to produce and niche markets become interesting for large manufacturers (Rayna and Striukova, 2016).

The topic of business model have also been highlighted in a special issue of Technological Forcasting& Social change (Ford et al, 2016), addressing the need to develop more knowledge of business development of 3DP. Knowledge gap that needs to be addressed relate to “…the emergence and diffusion of AM technologies, i.e. the challenge of integrating AM into existing industrial systems versus the challenges of applying AM to create new industrial systems; the strategies that should be adopted by existing firms and new entrants seeking to create and capture value from AM technologies; broad issues of business strategy and specific technical challenges.” (Ford et al, 2016, p. 158).

Bogers et al (2016) focus on how AM integration of the firm’s business activities can affect customer involvement, along with its implications on the organization of the value chain. They argue that AM provides a shift from manufacturing-centric business model to a consumer-centric business model that provides value based on customization and co-creation. Further, the shift towards consumer-centric business models can also lead to more decentralized supply chains. For example, online platforms can provide access to digital design files that allow the customer to download, personalise and manufacture the products and components. Many firms have already identified the benefits of AM for their business, but they lack knowledge of how to implement this technology. Additional knowledge along the whole product development chain is necessary to succeed in implementing this technology (Rehier et al, 2017).

Business models evolve over time and companies sometimes need to shift from one business model to another to meet market or financial opportunities (Willemstein et al., 2007), or to follow (or lead) technological shifts (Tongur and Engwall, 2014).The ability to diversify a firm’s business horizontally to existing or new markets is a key aspect of business model innovation (Giesen

et al., 2007). 3D printing technologies make lateral moves less financially less risky, because products can be manufactured on demand with minimal costs.3D printing technologies is suggested to enable companies to rapidly move upstream or downstream. Here, firms may focus on design and service.In contrast, design firms may decide to take manufacturing in their own hands. This also means that firms can more easily adapt the "length" of their business model by taking on more activities or by giving up some of them (Rayna and Striukova, 2016).

## II. METHOD

To categorize different uses of 3D printers a brainstorming session was held among the authors. The constructed model was later modified based on a literature review of 3D printers from a technological and business perspective. Asemi-structured interview guide was created based on the updated model.

The research took place in three steps; an investigation of a distributor's customer database, interviews with three firms and one advanced hobby user, and continued conversations with the distributor based on the findings during the interviews. To analyze who buyers and users of 3D-printers are one of the largest distributors of 3D-printers in Sweden was interviewed. The company started in 2006 and has a turnover about 40 million SEK, which is roughly equivalent to the sales of a 1000 3D printers per annum.[1]Three meetings and interviews with the CEO and a sales manager took place during 2016-2017. The interviews aimed to identify how the 3D-printer industry has developed, and who currently buys 3D printers.To explore the variety of customers and users while avoiding speculation the semi-structured interviews focused on the company's customer database, encompassing about 100 customers. The first interviewaimed to provide an understanding of the firms' development during a 10 year period, how the distribution business idea emerged and what the trends and shifts have been during the last ten years. Questions were asked about customers, such as their background, history, needs, applications and relations. To what extent the contents of the database is transferable to other nations or contexts is currently unknown. In particular, the database is likely to miss out the high-end and low-end of the market. However, we suggest that the database provides us with a relevant representation of much of the population of 3D printer users.

In the second step, three business representatives and one maker (hobby user) were chosen for interviews. They were chosen as they ex ante were considered to be active users of 3D printers and considered to be representative of a "typical" customer for a user category.[2] The distributor made the necessary arrangements before we contacted the firms or the maker for interviews. An interview guide was developed focusing on three phases; (1) what initiated the investment, e.g. purpose and goal, (2) how the 3D-printer was use and why, and (3) what the outcomes and effects were, e.g. products, services, markets, organization, or suppliers. The interviews were triangulated by observations on-site, which allowed to capturing the effects of the 3D printer. The onsite observations were essential as the respondents were not fully aware of the impact of the new technology.With this understandingin the third phase we went back to the distributor and discussed the different categories.

Based on discussion with the distributor and the four illustrative case studies, we identified four types of "typical" customers that have bought 3D printers during 2016.

## III. ILLUSTRATIONS

This section will first present the findings from the distributor's database followed by four illustrations, three of which are SMEs and one early adopter who is using the 3DP as a hobby.

A general finding from the discussing the distributor customer database and the case studies is that there recently has been shift towards smaller and cheaper 3D-printers. Today a 3D printer costs from 500 USD, which is ten to a hundred times cheaper than two decades ago. This development hasopened up for many new buyers and consequently users. The maker movement is considered to have started in earnest around five years ago, andis expanding rapidly. Before the shift towards cheap low end 3D printers, customers were mainly businesses where the purchase decisions had to be approved by top management. More recently the decisions to purchase and operate a 3D-printer are usually taken on a lower managerial level due to the much lower costs of investments.

The largest group of customers represents small firms interested in new ways of producing products, to test and develop new prototypes. This group of firms had previously been working together with a design firm for creating mockups, but now chose to expand the business and buy one or more 3D printers to move into in-house production. Another group includes hobby users,

[1] For confidentiality reasons the precise statistics from the database cannot be specified.

[2]The category of schools/universities was explicitly excluded.

commonly denoted makers, who buya 3D printer for home fabrication. They are often interested in technological development, experienced with design, scanning and printing. The database also shows a group of costumers that focused on educational purpose, that is primary school, universities etc.

Below follows a short illustration of typical firms and makers that has invested in 3D-printers.

**Alpha:**Alphawas founded 1994 and manufactures and distributes wireless hearing products for people with a hearing loss. The products are used by the customersintheir private life and during work, school, and other public environments. The firm invested in their first 3D printer in 2014to be able to print prototypes and test functions in-house. Until the purchase of the 3D printer a supplier had made prototypes for the firms, based on Alpha's drawings and ideas. By using the printer Alpha does this work in-house.A development engineer at Alpha said:

"It has previously been expensive to purchase 3D printers, but now it is economically feasible for us to make the investment. With the 3D-printer we now have, we can test simple prototypes regarding function and design. But for more advanced prototypes, e.g. "fair prototypes" with high demands on dimensions and surfaces, we still use a design firm."

The goal of the investment was also to make the prototyping more cost and time efficient.As the firm invested in a simple 3D printerwhich works as"plug and print", Alpha did not need to develop or acquire new competences.

After using the 3D-printer for a year, new areas have been developed which they did not account for when making the investment. For example, Alpha uses the printer to lower its manufacturing costs by printing special fixtures that is uses while assembling its products.

In summary, the use of the 3D printer has changed some of its activities and has changed the scope of the firms to some extent but this change is relatively minor compared to the logic of its business model.

**Beta:**Beta is a newly started company, managed by an entrepreneur with experience of modelling and 3D printing.The entrepreneur has a background as mechanical engineer. He developshigh-tech analytical solutions for quality control globally within the agricultural, food, pharmacy and chemical industries. He has designed analyticalinstruments for an international company in south of Sweden for over twenty years. He has always been interested in design, such as presenting 3D-models and making movies to visualise objects. He actively follows the maker movement, providing ideas and solutions but also making enquiries to the online maker community when needed.

The entrepreneur has specialised in the use of different materials, specifically rubber and how it can be extruded by 3D printers. His use of 3D printers for rubber extrusion started as a hobby, but he quickly developed new ideas and tasks for customers that needed prototypes across a range of materials. The entrepreneur decided to start his own business a few years ago as his former employer moved its facility abroad. Some of former employer's equipment was taken over by the entrepreneur, which made it easier for him to start to consult on an advanced level. The entrepreneur works with developing his own ideas, but to earn bread and better he consults for companies enabling them to develop new products/equipment by using 3D printers, from idea to launch of specific new products.

I'm working with what I'm best at, design and 3D printing. I work with consultant project together with different partners, but I also work with my own ideas. In the long run, I hope to launch my own products which I'm working on."

In summary, Beta has found a service-oriented entrepreneurial niche in 3DP and uses his own company resources to develop a new viable product and business model around 3DP.

**Gamma:**The business idea started with an accident about ten years ago, where the entrepreneur lost most of his limbs. Due to the accident, everyday life became much more difficult, including walking outdoors. The entrepreneur tried many prosthetic feet, but could not find any that were sufficiently good. The reason was that his handicap was so severe that the smallest hole or stone could make him lose his balance, despite a high level of physical fitness, which forced him to use a wheelchair.As part of his education to become a development engineer, the entrepreneur researched why balancing when using prostheticswas so difficult. He concluded that it was the restricted mobility in the prosthetic feet that was the main problem. With the goal to be able to be physically active outdoors without being dependent on a wheel chair, the entrepreneur started to develop foot prosthesesin partnership with orthopaedic technicians and universities. The development resulted in a prosthetic foot with a turning capacity, which moves like a human foot and adapts to the surface.

The next step in the process developmentfocused on the design of the foot prosthesis. The function is important, but also the design featuring different patterns, materials and colours targeting high-end users were found to be crucial. Different technologies were evaluated, and 3D printing was chosen based on the flexibility and

possibility to develop many different types of complexed prototypes. A team of students and researchers were presented with the task of developing designed accessories to go with the foot prosthesis. The use of 3D printers resulted in new unique patterns.

"We developed patterns that only were possible to produce with a 3D-printer, but it also made the production more cost efficient [compared to traditional manufacturing technologies]. Furthermore, 3D printing also makes it easier to customise the product, for example based on the person's length and personal acquires. The possibilities are endless, so it's more about coming up with a limited product specification relevant for the customer."

Drawings and models are produced by the team, and the final version is printed by a supplier who operates advanced 3D printers. This network of students, researchers and companies with knowledge of advanced 3Dprintingmade it easier for the entrepreneur to visualise and test new possibilities. The alternative way evaluated by the entrepreneur would have been to use traditional technology, e.g. design, build-deliver model, which would have resulted in high fixed costs and limited set of products.

Today Gamma develops and sellscustomer-adapted prostheses and accessories. The prostheses are developed in close collaboration with users and 3DP is an integrated technology in the company product development process.

**Delta:**Delta is a hobby maker of 3D printers who is working as a development engineer in a service firm in the industrial sector. Skills and services provided by the firm include project management, product development, automation, 3D modelling, animation and visualization. The hobby maker has been working at this firm for over fifteen years, addressing small to complex product development projects in different areas, from idea to launch. The hobby maker bought a 3D printer for home fabrication because he was curious about the technology and was interested in developing new ideas and skills about 3D printing.

"I'm very interested in new inventions and follow the technological development worldwide. Youknow the virtualworld, butyouwant to havesomethingphysicalto be abletorelate to and feel, and youalsowant it fast and to a lowcost. That is why I bought my own 3D printer. When I bought a 3D printer a few years ago you needed to put in a few hours to make it work. The quality wasn´t the best and few problems had to be solved before it worked. Today, you can just plug and print with no major skills about 3D-printers, and everything [such as documentation, user groups, and 3D models] is available on the Internet."

The hobby useof the 3D printer hasimproved his professional work over the years made, much because prototypes can be printed and tested at home.

"I really like my work, but I don't always find time at work to develop my ideas, so now I can do it at home."During the three years since he bought the 3D printer it has mainly been used to print things for private use, such as spare parts and personal needs. The hobby maker has also done some smaller projects, addressing problems and needs for friends.

"Having a 3D printer at home also makes me more creative. I start looking at my home with different eyes. Now I could print things with the exact dimensions and design I wanted. Friends of mine have seen what I have done and asked me if I could help them."

In summary, Delta has improved his professional skills due to his personal 3DP engagement and act as an "eye-opener" and mediator for his surrounding on possibilities with 3DP based entrepreneurship and home-printing.

## IV. DISCUSSION

The paper stated that 3D printers can be understood as a new general purpose technology but that huge changes in the level and nature of experimentation and search and entrepreneurship for its potential come to fruition. What can we say about changes in user activities and behavior across different types of actors following the introduction of 3D printers? Much of the 3DP literature claims that 3D printers lower the cognitive and resource barriers for experimentation, production and entrepreneurship. This can be understood from the logic of the introduction of a new capital goods structure, i.e. a structured and complementary combination of production technologies (see Lachmann, 1956; Saemundsson and Holmén, 2011). In line with the literature, the data clearly indicates that the resource barriers for experimentation have decreased if we just focus on the affordability of the printers. This is also readily apparent from the dramatic decreases in the cost and price of 3DP and the recent broadened scope of users as indicated by the customer database and the four illustrative case studies.

The findings from the distributor's customer database, indicatethat the largest customer segment want to modify their new product development processes by testing and developing new prototypes. This is in line with both the claim that knowledge barriers for experimentation will be lowered by the use of 3D printers. Still, while the database allows us to pinpoint that the lowering of knowledge barriers motivates the printer purchase;this data alone does

not demonstrate that this happens. However, the case studies allow us to investigate this further.While at an early stage Alpha has changed its firm boundaries by diversifying into new types of design, prototyping and manufacturing activities. Even if these changes are relatively small given the entire scope of Alpha's activities it indicates there knowledge barriers to production and experimentation have decreased. Beta has diversified into 3D printer and materials consulting based on prior knowledge in materials and instruments. For Beta, the knowledge barriers have been lower to experimenting and searching for new innovative products. If Beta will succeed with this search, it may be the ticket to entrepreneurial entry for a product-oriented 3DP-based company.For its current business model, the combination of the entrepreneur's prior knowledge of analysis tools and materials science combined with the purchase and use of 3D printers has been the necessary foundation. Gamma develops and sells customer-adapted prostheses and accessories. The prostheses are developed in close collaboration with users. The use of the 3D printers allowed him to experiment and identify new design features. Here it was the combination of the new technology and personal interest that allowed for experimentation to happen. This is a clear indication of lower knowledge barriers. For Delta, who is a technologically advanced hobby user, the combination of the lower knowledge and resource barriers to experimentation has both allowed him to create and test ideas, some of which he uses in his daily professional work and producing repair parts for friends and family. Delta indicates that there is an increased importance of user users as it is becoming easier for some users to get what they want by designing it for themselves. Delta is a good example of what von Hippel (2004) refers to as a user's low cost innovation niche. However, Delta is a specific caseas much of his personal use is applied in his daily job, showing that the distinction between hobby and professional usemay be blurred.

While the data clearly is line with the idea of lower barriers knowledge and resource barriers to experimentation and, to a lesser extent, production, it cannot say anything in terms of the productivity gains of the new technology or how important it is relative to the actors' activities. We suggest that the impact currently is relatively limited.

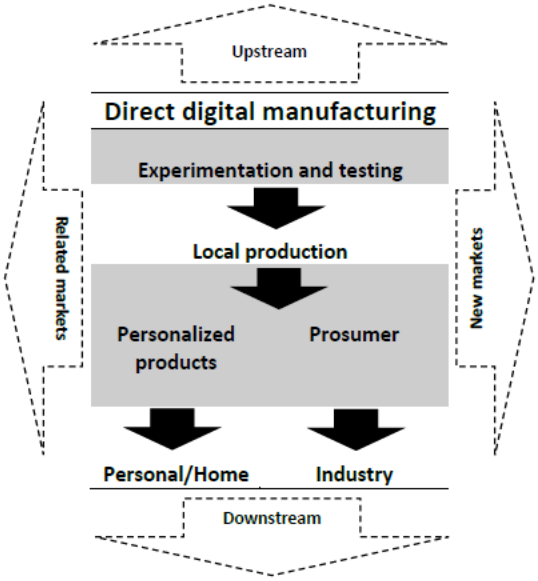
Does acquisition of 3D printers affect firms' business models and lead to business model innovation? The answer depends what we mean by a business model innovation and what type of actor we are talking about. Business model innovation can be understood as an innovation of a firm's business model but also the processes underlying a transformation from one to another business model. Alpha, Beta and Gamma are specific instances of 3DP using firms. The customer database has a large group of firms that previously were working together design firms for creating mockups, but now chose to expand the business and buy one or more 3D printers to move into in-house production. While Alpha is one such company, Beta is a consultant company that makes it easier for companies like Alpha to diversify into 3D printers. More specifically, Alpha, which is an established company,has expanded its boundaries by increasing the scope of internal activities following the purchase of a 3D printer. Alpha now make their own low-end prototypes and produces some of their own supplies. While this has changed some of their activities is has neither innovated their business model, nor transformed their innovative processes in a major way.

For entrepreneurs like Beta and Gamma the situation is different in that the use of 3D printers is a necessary for their existence, and at the same time addressing new possibilities regarding products and/or markets.If we understand a business model as an integrated logic or an activity system (Björkdahl and Holmén, 2013; Zott and Amit, 2011) it becomes clear that Beta's and Gamma's roles as a consultant and a specialized product company hinges on their mastery of 3DP. The Alpha, Beta and Gamma case studies indicate that there was not any need for acquiring additional knowledge. This is in line with e.g. Sachs et al. (1992) that the process of production is simplified, implying that in required knowledge of specific domains instead may be lowered instead.

## V. CONCLUSION

This paper has analyzed changes in activities and behavior across different types of actors that are using 3D printers.The empirical findings showed that the use of 3DPa) lowers the knowledge and resource barriers for experimentation and entrepreneurial entry, b) increases product and concept prototyping in product development, c) provides a potential for business model innovation by expanding the boundaries of the firm upstream and downstream, and d) becomes a ticket for entrepreneurial entry. Based on our results, the paper suggests that the potential of 3D printers alter user innovative activities is high but most of the potential is latent, see figure 2.

**FIGURE 2. TOWARDS A "MOBILE BUSINESS MODEL FOR DIRECT DIGITAL MANUFACTURING.**




Democratization of the product and service innovation due to low prices for high quality resources as discussed by von Hipper (2004) seems to be on display in this study. Firms and makers Alfa, Beta, Delta and Gamma demonstrate the use of inexpensive 3DP as effective innovation tools allowing firms as well as entrepreneurs and home manufacturing makers to improve skills and change boundaries. Delaying the spread of 3DP technologies within companies and education would for sure be an abuse of possibilities and a hinder for democratization of product and service innovation.

## IV. ACKNOWLEDGEMENT

The research has beenfinanced by Produktion2030 - a strategic innovation program supported by VINNOVA, Swedish Energy Agency and Formas, and The Knowledge Foundation in Sweden.

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