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Co-creation, commercialization and intellectual property - challenges with 3D printing

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ABSTRACT

3D printing (3DP) has high transformative potential as it is not only distinctive from other existing manufacturing techniques but also presents several previously unimaginable advantages. Its digital nature coupled with the availability of internet access offers the potential for radical decentralization of industrial production, as well as collaborative design of the artefacts produced. This important characteristic is advantageous not only to end users but also to commercial companies that are currently attempting to introduce this technique for manufacturing final products. One important advantage that companies could gain from this model is the possibility to engage in co-creation activities with the user community, and in this way benefiting from users' contributions.

This article begins by presenting a well-studied example of an industry that relies upon co-creation models, the software industry, in order to highlight the possible legal challenges with a particular focus on intellectual property rights. The paper then goes on to investigate the potential IP implications of co-creation for companies operating in industry fields that heavily rely (or are planning to heavily rely) upon 3DP technology. These questions are addressed from multiple perspectives based on theoretical argumentation and empirical research (in the form of case study research) with relevant stakeholders. The paper concludes with some recommendations as to how companies could possibly engage in co-creation with the user community in the field of 3DP.

Keywords: Intellectual property rights; IP management; 3D printing; co-creation; commercialization; open source licensing

1. INTRODUCTION

Additive manufacturing (AM), more colloquially known as 3D printing (3DP), is a method of producing physical objects from digital 3D-model data through a layer-upon-layer process. As a manufacturing technique, it is the opposite of subtractive manufacturing methods, such as machining, which typically involve astronomical up-front costs and are dominated by economies of scale (Gibson I et al., 2010). 3DP has high transformative potential as it is not only distinguished from other existing manufacturing techniques but also presents several previously unimaginable advantages [2]. Petrick and Simpson (2013) argue that 3DP processes represent a change from 'economies of scale' to 'economies of one', allowing a paradigm change towards mass-customization. Product cost per part in 3DP basically remains constant and allows fully customizable objects to be produced including highly complicated structures, as well as other advantages, such as manufacturing on demand and reduction of the environmental footprint of manufacturing activities.

Another disruptive element of this technology is its relation to digital artefacts. The 3DP process begins with a digital blueprint, i.e. the digital or virtual representation of a physical object (CAD file), that is created either by using modelling software or by 3D scanning an existing physical object. This digital element of 3DP easily allows and supports distributed 'customization' of products, empowering end users to start from a digital CAD file and tailor it in accordance with their needs and preferences. In addition, the digital element coupled with the availability of internet access offers perspectives of radical decentralization of industrial production, as well as design of the artefacts produced. Common printing examples include printing out individual toys, jewellery items, and specific spare parts for home appliances.

Considering these key advantages of 3DP technology, it does not come as a surprise that several online platforms connecting users [3] over the Internet have already emerged in different countries. For instance, platforms such as Cult3D [4], PinShape [5], Thingiverse [6] and Sculpteo [7] act as CAD file repositories, permitting internet users to access, download, modify, redistribute, and ultimately print out the physical objects digitally represented in the CAD.

This important characteristic is advantageous not only to end users but also to commercial companies. In fact, although 3DP has long been used only for prototyping (Bogue, 2013), the current trend is to attempt to introduce the technique for manufacturing final products. Indeed, one important advantage that companies could gain from the above-described configuration is the possibility to engage in co-creation activities with the user community, that way benefiting from users' contributions. In this article we refer to 'co-creation' in terms of companies co-creating with the users' community (Prahalad CK and Ramaswamy V, 2004). Specifically, we focus on situations where companies incorporate both open source licensed (e.g. produced by the users' community) and proprietary licensed products (e.g. produced internally by the company or licensed in from third parties) into the final proprietary licensed product they release to the market. In recent years the topic of 'co-creation' (as understood in this paper) has attracted the attention of the scholarly community, raising several managerial and theoretical issues (Söderberg J, 2013; Raasch C et al., 2009). Yet, to date, several questions related to the management and efficiency of this model of collaboration remain open. Among these uncertainties, issues related to intellectual property rights (IPRs) are of cornerstone importance.

This paper aims to shed light on the potential IP related challenges that manufacturing companies might face if intending to commercialise products by building upon digital CAD files downloaded from available open hardware repositories (or otherwise created by the user community). We begin by generally highlighting the advantages, as well as the IP related risks, associated with co-creation models for companies. We then present a well-studied example of an industry that relies upon co-creation models, namely the software industry, in order to highlight the possible IPR risks involved, as well as the coping mechanisms that that industry has implemented in order to navigate those risks and, this way, set the basis for a parallel discussion to the 3DP field. Also in the case of software, we focus on situations where companies incorporate both open source licensed and proprietary licensed code into the final proprietary software they release to the market. After this, the paper goes on to investigate the potential IP implications of these types of co-creation innovation models for companies operating in industry fields that heavily rely (or are planning to heavily rely) upon 3DP technology. In this part, the questions are addressed from multiple perspectives, based on theoretical argumentation and on empirical research (in the form of case study research) with relevant stakeholders. Based on the findings of the empirical analysis, the paper concludes with some recommendations as to how companies could possibly engage in co-creation with the user community in the field of 3DP, highlighting areas where future research is necessary.

Even though the challenges related to IPRs and 3DP are generally global and not limited to any specific jurisdiction, the law clearly applies and is interpreted differently based on national or regional rules. Here we will refer to IP laws and principles stemming from the European systems, whereas going into detail of possible different interpretations of European law at national level would not be relevant for the purpose of this study.

2. OPEN INNOVATION AND CO-CREATION

In recent years, discussions around open types of innovation models have increasingly gained the attention of academics and industries. Traditionally, research and development in firms has been a secret, closed, linear process that engages internal experts within company walls (Gassmann O, 2006). Increasingly, different R&D activities have been opened up and distributed. Users and other external stakeholders are increasingly involved in these industrial activities (Benkler Y, 2006). Opening up development processes paves the way for different involvement of external stakeholders (Chesbrough H, 2003), users (Von Hippel E, 2005) or crowds (Kleemann F et al., 2008; Kozinets R et al., 2008). Benkler Y (2006a) has even suggested that in some areas of production, self-organising commons-based peer production may disrupt traditional industries (i.e. parts of journalism and printing of encyclopaedias).

Traditional R&D-oriented companies will likely populate the business landscape for the foreseeable future and therefore ways that enable more open approaches that are still in conjunction with more traditional companies are in high demand. These more open development structures include, for example, open innovation, co-creation and co-production. 'Open innovation' means an open process where an idea or invention is translated into something useful and valuable. 'Co-creation' (of value) means taking the customer as an integral part of the value production process and has roots in the earlier notion of co-production (Vargo S et al., 2004). In traditional manufacturing consumers and producers are seen as separated entities, in order to guarantee manufacturing efficiency. However, currently practitioners and academics view production of value as a continuous goal, where division into production and consumption breaks down. The most relevant academic definition of co-creation for the purpose of this paper is the one according to which co-creation is '*the joint*

creation of value by the company and the customer, allowing the customer to co-construct the service experience to suit their context' (Prahalad CK and Ramaswamy V, 2004, p. 8). In traditional manufacturing consumers and producers are seen as separated entities, in order to guarantee manufacturing efficiency. However, currently practitioners and academics view production of value as a continuous goal, where division into production and consumption breaks down.

The underlying assumption is that taking customers closer to value production helps to better address customer needs, provides relevant perspectives and novel knowledge. This engagement requires an understanding of the different motivations users might have for participation. One lesson learned is that IPR arrangements (including licensing activities) have a role to play in these motivations: involved users expect to have some rights to the process and end-product of value produced.

Farrell and Shapiro (2004) argue that, traditionally, two separate schools of thought concern IPR strategies in general: 'incentives' type of strategy ('strong' IPR protection and enforcement strategy) and 'openness' types of strategy ('weak' IPR protection and enforcement strategy). Those who belong to the 'incentives' (or 'closed') school argue that creators are only likely to continue contributing in the future if they can capture sufficient value, so that strong IPR protection is necessary. When this strategy is chosen, Henkel and Baldwin (2009) conclude that the project can be divided into several parts, enabling contributors to participate in one portion of the project only. In this case, the different parts of the project will be protected by different IPRs.

In contrast, proponents of the 'openness' school argue that weaker IPR regimes stimulate creativity and innovation. In particular, artistic creators are intrinsically motivated to create and continue producing even in the absence of strong IPR protection. A large body of literature is available on this (e.g. Benkler Y, 2006b and Benkler Y, 2006c, and Hess and Ostrom, 2007)

Clearly, the types of model and IPR strategy work differently depending on the industrial field concerned. For example, in drug research and development the costs of closed-model research activities are covered via strong IP protection and sales of drug products over their full lifetime. It is important to note, however, that this modularity of IP is likely to increase the cost of design, will add legal costs, and may imply loss of performance. Areas such as the software industry, instead, rely on both 'closed' and 'open' innovation models, usually mixed together (including a form of 'co-creation'). In these types of 'mix' settings, managing IPRs is perhaps one of the major challenges for companies. Indeed, careful planning of IPR strategies is essential for any company that plans to engage in these types of co-creation.

In the following parts we investigate further how for-profit companies and open-source communities co-exist and co-create. We focus on models where companies commercialise under proprietary licenses products that are built upon combining open source and proprietary software products and we highlight risks and coping mechanisms in terms of IPRs.

3. THE SOFTWARE INDUSTRY AS AN EXAMPLE

As previously mentioned, the software industry is probably the most well-established example of an industry that partially relies upon co-creation types of model for commercial purposes. Nowadays commercial software companies include several elements of open source software [8] in their proprietary software, that way making open source software elements an issue to be considered as a part of forming a software company's innovation strategy.

3.1. FLOSS DEVELOPMENT MODEL

In software, the open source development model differs from the traditional 'closed' innovation type of model in several respects. From a development structure perspective, while the proprietary model favours a centralised, closed type of development with products fully 'built in-house', the open source model makes use of collaborative developing structures that extend beyond the boundaries of a single firm. As such, open source projects are controlled by a community of stakeholders and the software is usually developed by a group of self-organised collaborators.

Other major differences relate to the policy treatment of the software source code, as well as the relationship to IPRs and the licensing schemes used. In particular, while in proprietary models the developing firm usually owns and retains all the rights over the software it produces, in 'open' source models the licences include conditions that allow licensees to 'use' the code for several purposes. For example, FLOSS licences generally allow users to 'use, modify, distribute, and re-distribute' the original source code. [9] Each FLOSS licence is based on copyright law. Specifically, FLOSS licenses set the relationship between the copyright holder and the users. Notwithstanding these common characteristics, FLOSS licenses differ in several respects. One of the most important distinctions lies in the extent the license allows commercial exploitation, especially with respect to the possibility to combine the FLOSS code with proprietary code. For instance, the essential nature of the GNU General Public License (GPL), which is the most commonly used FLOSS license, is enshrined in a requirement called 'copyleft'. According to the GPL, if a piece of code that in whole or in part contains or is derived from a FLOSS code or any part thereof is distributed or published together with other (proprietary) software, the source code of the entire final product must be made available and licensed under the terms of the GPL. [10] In other words, if a company combines GPL software with its own developed proprietary software, the question comes down to whether or not the result is published 'as a whole work'. If the proprietary code that a company combines with the GPL code is apparent and recognizable as an independent and separate work, that code might be able to remain free of the GPL 'taint' (also called the 'contamination' risk or 'reciprocity' of FLOSS licences). On the other hand, copyleft-types of licenses are not uniform in this aspect. For example the Lesser General Public License (LGPL) [11] and the Mozilla Public License (MPL) [12] are more permissive than the GPL. Finally, licenses like the BSD license (and, generally, the so called 'academic' licenses) allow more commercial exploitation and more flexibility in combining open source with proprietary software (Välämäki M, 2005). It is important to keep all this in mind, because these differences might be crucial for firms attempting to commercialise under proprietary licenses products that are built incorporating FLOSS and proprietary licensed software.

In addition, open source has increasingly been used in hierarchical settings (so called OSS 2.0) in organizations (Fitzgerald B, 2006) where the actual source code may remain unlicensed (i.e.

protected by IPRs), may be provided with a proprietary licence or maybe used only internally. In these cases, the licence is not the primary tool regulating to use or distribution of the software. Currently, through the increasing use of tools such as GitHub and open source based cloud solutions, licences are eroded even more. According to the Open Source Initiative (OSI) definition, Open Source is "a development method for software that harnesses the power of distributed peer review and transparency of process"; in other words, it includes more than just the licence of the software (Välimäki M, 2005a).

3.2. CO-CREATING IN SOFTWARE: IPR CHALLENGES

Over the years the software industry has managed to develop a stable and sustainable innovation model via incorporating elements of the co-creation innovation model into their traditionally closed type of model. On that basis, one could argue that the coexistence of proprietary and open source software is nowadays essential for software companies and that situations where companies incorporate both open source and IP protected software into the final proprietary software they release to the market are relatively common. Due to the different and allegedly conflicting principles under which proprietary and open source software are based, however, the relationship within the two systems might not always be peaceful. As with every disruptive change in company business models, reaching this goal has in fact implied delving into several challenges to look for workable solutions. Among these difficulties, management of the IPRs involved in the model has been a major reason of discussion (Riis T, 2016).

As concluded by Ballardini (2012), the most relevant questions in these types of 'mixed' settings have been related to ownership of the resulting IPRs stemming from the co-creation processes, problems associated with the licensing schemes used (i.e., compatibility with the various licence terms at various levels, namely 1) among different FLOSS licences, 2) among different versions of the same FLOSS licences and 3) among open and closed licences), as well as issues related to the type of IP enforcement strategy to pursue in this context. Certainly, issues related to IP ownership and IP enforcement are strongly inter-correlated with each other. For instance, while identifying right holders may become difficult in the digital environment when digital goods are in parallel or subsequently co-created by several people, monitoring infringement and enforcing those IPRs becomes more challenging. Furthermore, the IP management of co-owned works (for copyright) or inventions (for patents) becomes especially problematic when the value of the respective individual contribution is hard to identify and to measure. To add wood to the fire, laws on co-ownership of IP in Europe are far from clear, as the level of harmonization of the rules among, for e.g., the EU Member States is still not mature (Gorbatyuk A et al., 2016).

At the same time, however, over the years the software industry has managed to develop a set of coping mechanisms to navigate these challenges. Among them, probably the most relevant are strategies developed in terms of compliance with the obligations imposed by the various types of licences a company incorporates into its business model. A first basic yet highly important step has been to build a solid design of the architecture and principles around the types of licence a company plans to incorporate, as well as perform some compliance and compatibility checks of licences included on a regular basis. This also includes monitoring the terms of the licences included in each FLOSS package before choosing them. Clearly, developing ways to deal with the 'copyleft' clause and the so called 'contamination' risk of FLOSS has also been an important point. Even though the safest option appears to be to avoid copyleft types of licences, companies have also developed strategies that have allowed them to also use copyleft licences. Among these, probably the strongest type of

strategy has been to rely upon the philosophy and the primary aim of the Free Software Foundation (FSF) and the FLOSS community: to promote the philosophy and ideas behind GPL and open source software. This goal can be achieved, for instance, by seeking compliance of source code distribution both in and out of courtrooms. Moreover, in terms of copyright ownership stemming from co-created works the most successful strategy in software content has been to fully re-write the code while keeping the same functions. Clearly, although this strategy has worked in avoiding possible copyright infringements, it is not necessarily working in case of patents on software. At the same time, though, the existing case law on the specific issue of FLOSS and patents is relatively limited, which might indicate that the legal risk of companies infringing patents when incorporating pieces of FLOSS code into their model is relatively low, for instance because with highly used FLOSS packages the community of users promptly detects possible patent claims (Ballardini RM, 2012)).

Overall, it can be argued that the software example represents a successful case where the stakeholders have managed to create a sustainable way of navigating most of the IPR related challenges stemming from 'mixed' open/closed models related to co-creation

4. CO-CREATING WITH 3D PRINTING

4.1. IMPORTANT GENERAL FACTORS

As previously explained, 3DP is a technology that allows manufacturing of physical objects starting from digital files. One of the most interesting characteristics of 3DP as a manufacturing method is that it allows expansion of the possibilities for people to participate in the planning and realization of objects [13]. This way, 3DP facilitates the creation of objects 'on demand', based on needs or feedback coming from possible final users of the product, allowing mass customization.

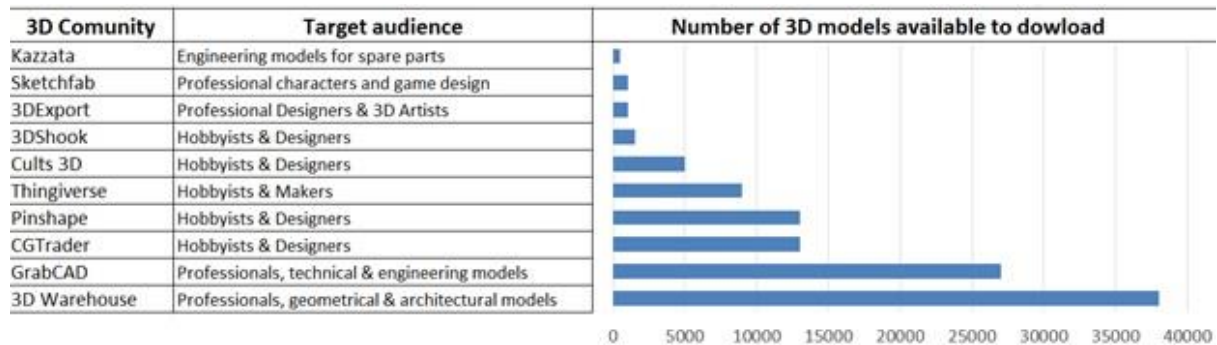
Under the existing regime of global competition, companies are under great pressure to offer not only standard products but also tailored applications (Tuominen K, 2013). The globalized economy is forcing businesses to become increasingly consumer-oriented and to target niches of the market that can be exploited profitably. In other words, 'customization', understood as to make or change something in accordance with the buyer's or user's needs, is increasingly becoming the rule of the game in global business strategy.

Although 3DP technology is far from reaching a suitable point of maturity (Flores Ituarte I. et al, 2015), as of today a strong interest in this technology already exists among the users. This is due partly to the hype surrounding the development of 3DP technology *per se* [14] and partly to the clearly great potential that this technology could bring about. Furthermore, even if users might at this point of time not yet be able to print out objects themselves at home, they can rely upon currently available 'printing centres' with a physical or digital address (e.g. Shapeways [15] or iMaterialize [16]) or even educational centers (e.g. schools, universities and libraries) (Eisenberg M, 2013).

Generally, to facilitate co-creation activities, open hardware repositories have lately been flourishing. Figure 1 presents a representative view of how different 3DP communities are currently offering CAD models. The offering seems to be fragmented and each platform tries to differentiate itself by targeting specific audiences. The underlying business model, CAD data licensing options (e.g. some allow only uploading of CAD files, some others also allow downloading and sharing of CADs) and pricing strategies differ from platform to platform. Other substantial differences exist in aspects such as the availability of CAD and target users

of these models. Despite a noticeable emergence of platforms offering CAD models for the engineering community, the biggest volume of CAD models offered is targeted at the community of hobbyist fabbers, designers and amateurs.

Figure 1- A compilation of 3D CAD repositories, their target audience and volume of CAD models (last visited 23.05.2016)



5. CO-CREATING AND COMMERCIALIZING WITH 3DP: THEORETICAL AND EMPIRICAL ANALYSIS

The advantages of 3DP in terms of customization, together with the fact that social media have clearly shown us that user interactivity is a powerful tool of success for several digital businesses (e.g., the videogame industry), all indicate that co-creation and 3DP will keep on growing in the not too distant future. Indeed, there is reason to believe that co-creation models in 3DP will play a key role in the development of commercial products, especially in those industry fields characterized by the need for personalised/tailor-made/customized items and where a strong bond exists between the item *per se* and the community of users. For instance, co-creation for final products in 3DP might work well in sectors such as orthopaedics and robotics (which are usually highly personalized items) and in areas very close to consumers, such as the merchandising and fashion industries. Indeed, in any potential industry field, the key question relates to what business models to implement in order to be able to commercialise and profit from such co-creation models. Even though answering this question might include several aspects, here we will focus primarily on law-related issues with focus on IPRs.

5.1 EMPIRICAL STUDY VIA CASE STUDY RESEARCH METHOD

An empirical study in the form of case study research (Yin R, 2008; Yin R, 2011; Stake R, 1995; Tellis W, 1997) was conducted. Case study analysis was chosen because an in-depth investigation was needed to provide a holistic understanding of the phenomenon. To this end, the case study relied upon qualitative analysis to uncover whether the type of co-creation innovation model we identified is efficient in the field of 3DP and what kind of specific problems it poses in practice. The theoretical focus of the study was the problem(s) encountered by commercial companies co-creating with the users' community in the 3DP business.

The subject of the study was exemplified by representative stakeholders operating in the field. A multiple case study was conducted because more than one case was available. The nature of the project and the type of research questions investigated justified an 'intrinsic' and 'collective' case study, that is a study where a group of cases or objects are studied.

5.1.1. SELECTION OF RESPONDENTS

We derived our empirical data from eleven expert interviews. To select the subjects of investigation, an information-oriented technique was used. The companies were chosen for their representativeness with respect to the overall purpose of the research objective of the study (i.e., they were 'key' cases) and to maximize what could be learned in the time available for the study. Respondents were chosen among stakeholders working in different areas of relevance. In particular, we chose representatives from the following clusters:

- 3DP-CAD services (i.e. companies providing 3DP and manufacturing services to third parties, as well as CAD modelling and design capabilities to solve their customer needs);
- 3DP-CAD repository users (i.e. companies using CAD repository services to assist their business activities at different stages of the product development process);
- 3DP-CAD platforms (i.e. companies that provide CAD data to possibly upload and/or download for 3DP activities, as well as related services for 3DP manufacturing);
- Legal experts (i.e. in-house legal counsellors and lawyers experts in IP law and 3DP).

These stakeholders were chosen because they represented a wide variety of backgrounds that helped us forming a clear picture of the issues. Key people working in the companies were experts well-informed of the research object.

The size of the companies and their geographical areas of operation were not regarded as important factors in the selection of cases. Table 1 shows detailed information on the interviews and respondents.

Table 1 - Company, Respondent, Date of interview, and Cluster

Company	Respondent and Position	Date and Duration of Interview (min)	Cluster
1	Company CEO, 3DP technology expert	3.11.2015 (33 min)	3DP - CAD Services
2	Company CEO, simulation tools developer and expert	10.11.2015 (43 min)	CAD repository user
3	Company Founder, VP Business Development, IP lawyer	25.11.2015 (44 min)	3DP - CAD platform & legal expert
4	Product Artist	30.11.2015 (37 min)	3DP - CAD repository user
5	#1 Company Director of manufacturing #2 Company in house designer #3 Company lawyer	2.12.2015 (24 min)	3DP - CAD repository user & legal expert
6	Company CEO, IP lawyer	2.12.2015 (32 min)	legal expert
7	Company CEO, business development	9.12.2015 (26 min)	3DP - CAD repository user
8	IP lawyer	16.12.2015 (42 min)	legal expert
9	Company co-founder, industrial designer	14.12.2015 (35 min)	3DP - CAD repository user
10	Company IP and general counsel	5.12.2015 (43 min)	3DP - CAD platform & legal expert
11	#1: Scientist, post-doctoral researcher #2: Scientist, PhD researcher	21.01.2016 (25 min)	3DP - CAD repository user

5.1.2 DEVELOPMENT OF SEMI-STRUCTURED INTERVIEW PROTOCOL

Interviews were conducted using a semi-structured interview protocol (for the full protocol, contact the [corresponding author](#)). The questions posed to the companies included:

- *general questions* on the relevance of co-creation innovation models in 3DP and on the business opportunities related to this model;
- *specific questions on potential risks and challenges* (especially from the standpoint of IPRs) of using co-creation as innovation models in 3DP;
- *specific questions on possible coping mechanisms* to navigate the challenges identified.

Interviews were the most important source of information for the study and followed a semi-structured format. Key respondents were asked to answer the research questions from the perspective of their company, but also and more importantly, based on their extensive knowledge of the field. The semi-structured nature of the protocol meant that the questions were taken as starting points to the discussion. Our motivation was to establish natural professional atmosphere to discuss relevant issues related to co-creation and 3DP. Instead of leading the respondents and in order to capture the voice of the respondents, we intervened for clarifications and follow-up questions. This resulted in discussions that went beyond the interview protocol. Respondents were free to propose solutions or provide insights into the subject matter, as well as to corroborate evidence obtained from other sources. Indeed, this interactive method expanded the depth of data gathered. It is worth noting that our interviews were not geared towards providing the most common views or statistical generalisations. Instead, we aimed to find a sufficient number of differing viewpoints in order to cover the related issues. As such, the case study aimed to generate new understandings, rather than answer one (or a few) specific question(s). The interviews resulted in a rich corpus of discussion data which then served as material for the in-depth data analyses and reflection back to the theory.

5.1.3 DATA ANALYSIS

The study used two different sources of evidence relevant for our study: documents and interviews. The documents used were case law, legislation, publicly available company policy in the fields of intellectual property and open source, and company websites.

We transcribed the interviews and used pattern-matching techniques based on identified groups of questions (general, challenges, and coping mechanisms) and on the selected clusters (CAD services, CAD platforms, CAD repository users and legal experts). A draft report was written based both on the documents consulted and on answers received during interviews. All participants in the study then reviewed their own interview transcript and the whole report to verify the accuracy of reporting their answers, as well as the overall conclusions and observations. This process enhanced the accuracy of the case study.

The anonymity of the subjects interviewed and their respective companies was necessary because some participants considered the topic both controversial and confidential. As a compromise, a cross-case analysis was composed instead of a single-case report. The case study report does not portray any single company but rather a synthesis of lessons learned from key experts. Accordingly, none of the cases are presented as a single case study. Instead, examples from the cases are discussed under each research topic section.

In the following part we first describe and analyse the results derived from the empirical study (5.2.1, 5.2.2, 5.2.3). In session 5.2.2., before presenting the empirical results, we discuss from a theoretical perspective some of the key issues related to the questions that we posed to the interviews. Subsequently (5.2.4), we proceed with developing some recommendations for IP strategy in order to navigate the challenges and boost the opportunities stemming from this type of co-creation model in 3DP.

5.2. FINDINGS FROM THE EMPIRICAL STUDY

Generally, the empirical study shows that the level of knowledge of the issues addressed in this research varied considerably among interviewees. Those who regularly operate in the legal profession (e.g. IP company counsels and IP lawyers) were clearly more aware of the potential implications for IPRs. At the same time, however, the interviews showed how most of the questions over how the law should apply to this field of technology remain open at this point of time. We also found a great degree of heterogeneity about the importance of the issues at stake, with some interviewees stressing certain issues and others emphasizing different matters. Broadly speaking, the results showed four major points of concern in terms of co-creation and 3DP in the context of commercialization of final products: two of these were law-related and referred to the legal status of CAD files and the unsuitability of currently available open source licences for CADs. The other two major reasons for concern were not related to IPRs, but rather to technical issues: the quality of open available CAD files and the shortcomings deriving from the fact that 3DP technology is not yet sufficiently mature to support a co-creation type of innovation model for final products. In addition, several other legal concerns were pointed out, although in a more scattered manner.

5.2.1. RELEVANCE AND IMPORTANCE OF CO-CREATION IN 3DP

Currently, co-creation in 3DP in general is at an early stage and it appears still confined to the marketing level (i.e. used to produce quickly multiple product variants and gather customer feedback in product development activities).[17] Even though companies in various industry sectors are clearly looking towards co-creating with 3DP open community for ultimately developing commercial products, they seem to be reluctant to take that further step at this stage. On the one hand, this is because 3DP technology *per se* is still in its early phases of adoption at the final product level and, on the other, because not enough successful co-creation models and projects have been developed in 3DP thus far. Indeed, this might well be a problem that will resolve itself once the technology reaches a sufficient point of maturity.[18] One respondent pointed out that another problem might be related to awareness of open source and co-creation in general. A frequent perception among companies is that open source and commercialization stand exactly in opposition to each other. The overall notion that there are many different flavours of open source with different licensing models and different legal ramifications is often not clear among corporations. According to respondents, this factor might impede co-creation models from appearing even on a more general level.[19]

In terms of relevance of the co-creation model according to industry sectors, only a few of the companies interviewed thought that co-creation will be equally relevant across all industries[20] and that open-source communities, in general, will play a key role in the future of 3DP.[21] Most respondents drew a clear distinction between the industrial type of 3DP applications, on the one hand, and the consumer side, on the other. Generally speaking, the emphasis was on how the consumer side is already moving towards this co-creation type of model, while the industrial side is still more protected. An important reason for this relates to

costs: R&D costs in industrial applications are often considerable, while at consumer level R&D is limited, the life cycle of products is short and the costs involved in production are relatively low. Clearly, the higher the costs companies have to put into R&D and production the more reluctant they are to expose their IP portfolios.[\[22\]](#) Another factor that was identified is associated with the increasing affordability of home printers: even though a big market will soon exist for home 3D printers, people will most probably be able to print out only 'low' value items if they want to keep the level of their investment low.[\[23\]](#) Not only is the quality of printers not sufficiently accurate to support manufacturing of high-value items (and according to most respondents this will continue to be the case), but also the cost of materials to be used for printing out such objects can be very considerable.

Increased competition between companies might also play an important role in companies' willingness to share: competition puts companies in a defensive situation in order to protect their own investments. This may push them towards applying a more proprietary type of strategy in respect to their most valuable CAD data, while only sharing old or valueless designs.[\[24\]](#) Co-creation might work better for those consumer-level products that are relatively simple and more 'technically' and 'functionally' oriented, rather than 'artistic' types of object, where designers might be more attached to models they have actually created.[\[25\]](#) Moreover, co-creation works better for companies that rely upon business models according to which their products are renewed relatively often (e.g. 'Disney-type' companies). For corporations that rely upon core products and brands [\[26\]](#) that do not change (at least not substantially) over the years (e.g. 'Moomin-type' companies) allowing co-creation on actual products might not work as well.

It was also pointed out that because the underlying idea with 3DP is that it enables "building things differently" from conventional manufacturing, in the sense that "you can build in value into the designs"[\[27\]](#), this in turn implies that designers are putting more work into creating their own designs. In some cases, designers may well put three to six months of their time into developing a new design. For these types of more complex, time-consuming design developments, co-creation might not work well. In contrast, co-creation might be highly relevant for simple objects, such as in the spare-parts market[\[28\]](#). Indeed, the digitalization of inventories and the possibility to manufacture spare parts on demand is one of the most promising applications of 3DP in industrial domains (Khajavi et al., 2014).

Respondents also highlighted how co-creation might end up short for those sectors and products where significant concerns exist about product liability. In these cases, allowing the whole community to tinker with products might be perceived as dangerous and at times unethical.[\[29\]](#)

Differences between 'traditional-type' companies and 'more progressive' ones were also pointed out. Indeed, engaging in co-creation by definition implies 'giving away' some control. This might not be perceived by many "older, bigger, more corporate" types of company as the correct strategy to implement [\[30\]](#). The reason is not only related to costs, but also to the way of conceiving business strategy by trying to pursue an aggressive and 'closed' type of IP strategy. [\[31\]](#) On the other hand, "younger, more innovative types of company, namely the 'Tesla-companies' of 3DP", might be willing to take this step forward towards doing business in a more open, co-creative type of framework. [\[32\]](#)

Among the greatest advantages of co-creation models and 3DP, time-saving was considered important by some respondents. [\[33\]](#) At the same time, however, it was highlighted that although "remixing CAD files" taken from third parties' files (e.g. from available open

hardware repositories) might be wise for 'beginners' who might not know how to create something in CAD, this might not be a good option for experienced designers. [34] At the same time, though, this trend might change in the future, due to technological developments especially on the software side, whereas today the need still remains for high quality CAD packages to repair models easily and smoothly. [35] Moreover, although co-creation in 3DP might appear a good business model, it does require a considerable amount of work for a company that needs to build its online presence but that is also doing 'community manager work' and keeping track of community building and co-creating activities. [36]

Among the factors that might influence the success or failure of co-creation for 3D printed commercial products, the presence and infrastructure of the open source community plays a major role. At the current stage, the 3DP open source community is scattered and fragmented. Thus, in order for the co-creation model to succeed, the need is to develop a solid community of developers that are willing and able to work together on common projects. Whether such a community will be created also depends on market opportunities and demand for products that can be realistically developed by an open group of designers. [37] For companies and brand owners it will be important, firstly, to understand the best known co-creation models in their field of industry and in which designers have a role and, secondly, to try to learn how to be agile players and able to use different kinds of community supporting design and 3DP.

At the current stage, it appears clear that several problems associated with co-creation of 3D printable products seem to relate to technical shortcomings of the technology *per se*. Looking towards the future, however, it seems that issues related to IP will become increasingly important. In fact, the confluence of developing 3DP technologies from several fronts at very high speed (e.g. scanning devices being inserted into mobile phones and apps, high quality 3D software for CAD, simple 3D rendering sets, penetration of 3D printers among consumers and improved printing technology) indicate that in the not too distant future consumers will be able to make their own versions of their favourite "stuff". One respondent pointed out that: "Once consumers are able to make user-generated content that spans not only from consumer collectible products, like toys or fashion and accessories, but also home goods and replacement parts, then brands and companies that put products on the market are going to be faced with the very same questions that the music industry was facing, especially in relation to enforcing their IPRs in that environment" [38]. The perception is that in this scenario the necessity for owners of IP to allow co-creation on a consumer level and, consequently, to find ways to be able to monetise this consumer interaction with IP will become increasingly important.

5.2.2. SPECIFIC FINDINGS - IPR RELATED ISSUES

A. Legal Nature of CAD files - Background

At the core of 3DP is the CAD file, which is the digital representation of the physical product. The classification within the IP system of CAD files is of paramount importance for the proper functioning of co-creation settings. Are CAD files protected by copyright (e.g. as 'works of art', 'software', or 'databases')? Are they protected by patents, trademarks, designs or something else? At the time of writing, no legislator or court in Europe or the USA has yet addressed this question, although some of these alternatives have been presented and discussed in the legal literature (e.g. Mendis D, 2012 and Elam V, 2016). Indeed, this is a question that should be carefully addressed considering the possible repercussions from the perspective of both IP laws (which piece of law should be the relevant one to apply?) and policies. For instance, IP mechanisms apply differently in relation to the type of innovation or

creation involved (e.g. copyright protects original and creative works, including literary, dramatic, musical and artistic works[39]; a *sui generis* type of protection mechanism, in addition to copyrights, might apply to databases in some jurisdictions[40]; patents protect inventions that are novel, inventive and industrially applicable, as far as they are sufficiently disclosed[41]; trademarks protect any sign capable of graphic representation by which consumers can identify the source of goods or services [42]; while industrial design protects original, ornamental and non-functional features of the whole or part of an industrial or handcrafted product resulting from features in the lines, contours, colours, shape, texture, and/or materials used[43]).

Again, from a policy perspective, it may appear questionable whether the legal nature of CAD should ever be addressed separately from the legal nature of the physical object the CAD represents. For e.g., previous examples like those coming from the music sector, have shown that in terms of copyright protection, usually the digital copy of the original work receives the same protection than the physical one (e.g. if the first created physical work meets the requirement of originality to attract copyright protection, then also the digital version of such work would pass the originality bar). However, if, for instance, we were to decide *a priori* that CAD files are always to be considered 'software' in the view of the law, not only a specific piece of law (i.e. the Software Copyright Directive) and the specific rules in there included would apply in terms of copyright protection, but also this might mean that the CAD file (i.e. a software work) would attract copyright protection almost automatically. For instance, both in the USA and in Europe, the threshold of 'originality' required for software is nowadays generally relatively low[44]. On the other hand, it could also be that the physical object that a CAD file (i.e. the software) represents would not attract copyright protection at all (e.g. because the object is not original or because it is a functional object). In such cases, the CAD file and the physical object it represents would be treated differently in the light of the law (namely: the first created physical object would not be copyrightable, while the digital copy of such object would be).

In the specific context of co-creation in 3DP the question of the legal nature of CAD files is especially relevant in assessing the suitability of currently available open source licences for CADs. In particular, the question is whether and to what extent those open source licences, that are generally based only on copyright, are suitable for licensing out 'things', such as CAD files, that, instead, might also be protected by other types of IP rights (e.g. design rights, patent rights, trademark rights). As such, the question of the nature of CAD files represents a prelude to the subsequent question about the suitability of open source licences

A.1. Legal Nature of CAD files - Empirical Analysis

The empirical study showed a general low awareness of the legal nature of CAD files. In terms of what type of IP a CAD file could attract, most respondents did not have any clear opinion. In terms of legal 'nature' of CAD, the results show that interviewees tend to consider it not only as 'software'. Usually, the perspective was that CAD files are partly 'software', but also partly 'something else', like a 'work of art'. None of the respondents associated CAD files with 'databases'. Some respondents considered that the question should be addressed from the standpoint of protection of the actual physical object. One respondent reported that: "Although from the technical point of view CAD files are 'software', the IPRs in a CAD file should be linked to the IPRs in the actual physical object that the CAD file represents". [45] Following this reasoning, a CAD file should be associated with a physical object: depending on when the design was created, for some products designers can have the CAD file as the master, while for other products the master is the physical object *per se*. This

notwithstanding, both the physical and the digital version of the master should be treated equally and considered as the same thing. [46]

At the same time, respondents stressed that thinking through the distinctions between those two elements, i.e. the digital part and the physical part, is clearly one of the most challenging current legal questions in 3DP. For instance, one uncertainty is how to treat and protect a digital file for a physical functional thing. Can the digital file of a functional screw or hinge (purely functional, thus not copyrightable) be protected by copyright? If so, what kind of control does that copyright interest (in the digital file) give over the physical thing? Indeed, the risk is to extend copyright protection to the functional domain, which is not only dangerous, but also runs against basic copyright policies. [47]

Another point was that even though several objects created via 3DP are either functional or not original (thus not copyrightable) or not novel and not inventive (thus not patentable), the visualisation of that design, such as the way that it is coloured or displayed, could be unique enough and communicative enough so that it could actually attract IPRs. How to layer those kinds of rights within any licensing structure is, however, not clear at this point of time. [48]

B. Feasibility of Currently Available Open Licences for CAD Files - Background

One of the cornerstone elements that supports the functioning of the co-creation innovation model is the licensing scheme, as seen in the case of software (Välimäki M, 2005b). Historically, open source software licences and the principles they embed also represent the basic starting point of co-creation in fields other than software. A clear example of the influence of FLOSS is the Creative Commons (CC) licence for creative and artistic types of works. That is why existing open hardware platforms and repositories that host CAD files rely primarily on FLOSS licenses or, alternatively, on CC licences. In some cases no specific open source licence is used, while repositories simply rely upon their own terms and conditions.

Although some ongoing projects aim at developing open hardware licences to address multiple layers of rights, including different IPRs related to content, software and materials (e.g. the TAPR Open Hardware Licence [49] and the CERN Open hardware licence [50]) these licensing schemes do not seem to be yet sufficiently developed, at least not from the perspective of 3DP and CAD files. At the same time, though, both FLOSS and CC licences may present several shortcomings when used to license IPRs associated with CAD files.

A major problem relates to the fact that most FLOSS licences and all CC licences are based on copyright. According to Murray J (2014), these types of licences are "legal documents allowing copyright (and in some cases database rights and rights similar to copyright) holders to permit certain uses of their works that would not otherwise be permitted by adhering to the terms of copyright law". In other words, most FLOSS and CC licences allow people to easily give permission to others to use their copyrighted creations ('works'). As a consequence, these licensing schemes are appropriate as far as the 'item' to be licensed is fully covered by copyright. Indeed, the unsuitability of these types of licences for CAD files appears particularly prevalent in the 3DP cycle step of translating a digital object into the physical realm. Unlike with code or simply digital content, with hardware the licensing process is in fact more complex. The unique fact that with 3DP digital and physical are bound together and that a digital CAD file all of a sudden becomes hardware poses a challenge to the licensing system that has never been faced before. FLOSS and CC licences were not written with this perception in mind and, as such, they might not be suitable to deal with this framework.

B.1. Feasibility of Currently Available Open Licences for CAD Files - Empirical Analysis

Interestingly, the issue related to licensing schemes sparked a variety of different opinions among respondents. Indeed, even though most respondents agreed that FLOSS and CC licences are not appropriate for CAD files, the reasons behind this and the degree of relevance of the issue seemed to differ.

First, it was pointed out that although it is almost certain that software code would attract copyright protection, the question is not so straightforward either with hardware or with CAD files. CAD files may not necessarily be covered by copyright especially because often the CAD files currently offered by platforms are digital representations of functional objects (i.e. not copyrightable) and, if we are to follow the theory according to which rights embedded in CAD files should be linked to rights in physical objects, then many of these CAD files should not include copyright rights. One respondent highlighted that, especially because so many things that are 3D printed right now are functional "people who are making their stuff available under a FLOSS or CC licence are setting an expectation for themselves that is potentially unrealistic about the kind of control they have over the file they are releasing into the world". [51] On the other hand, this is also setting up barriers, which may not be legally legitimate, to potential users remixing these CAD files. [52]

Only two respondents highlighted that although software code usually embeds copyright (and in some cases patents), no other IPRs are associated with it. In contrast, with hardware and CAD files several other IPRs might be involved, especially design rights and trademark rights. If these rights are present in a CAD file, then neither FLOSS nor CC licences would work properly. [53] It was pointed out that one shortcoming is that FLOSS and CC licences only allow licensing out certain IP rights, namely copyright (and in some cases patent rights), leaving out all other types of IPR. [54] From the perspective of a company seeking to commercialise a product that includes third parties' CAD files, these shortcomings may mean that an additional licence (for instance to acquire the design rights) might be needed. Even though a similar situation might be faced with software (i.e. associated with a piece of software might also be IPRs, such as patents, that are not licensed out via FLOSS licences) there is reason to believe that with CAD files clearance of IPRs other than copyright might be more complex. This is especially because while it might be relatively easy (or at least economically feasible) to re-write a piece of code and remove parts of the code that are infringing upon, for instance, a patent right, this 're-writing' or 're-designing' process might be more tricky in the case of digital objects and 3D designs. [55]

Finally, respondents highlighted that CC licences in particular are problematic for companies that want to commercialise products based on co-created CAD files, because most CC licences do not enable all kinds of uses (especially not for commercial purposes). [56]

Interestingly, however, the interviews also revealed that the challenge related to the fact that currently no suitable licence is available for co-creating in a world of 3DP might not be as great as initially perceived. On the one hand, this is a real challenge for those companies that own IPRs like patents, designs and trademarks, because no suitable open source licence is currently available. On the other, the risk is negligible if companies have no IP to license (for instance because, as mentioned, most objects reproducible via 3DP are unoriginal or functional, thus not copyrightable, or because companies have no other registered IPRs). It was pointed out that, if we compare 3DP with software the difference becomes clear: because in most probability a computer programme attracts copyright protection, copyright is a much bigger barrier in this field, where licences are needed in order to allow co-creation (copyright arises

almost by default). Quite the reverse: for most functional items no protection by default is available (with the exception of unregistered trademarks and designs), while protection usually arises only upon registration of certain IPRs. This way, it was pointed out that "it is less common for users to stumble into, for instance, 'patent licensing thickets' in the same way that they may stumble into 'copyright licensing thickets'". [57] This also means that the importance of licensing in this field might not be equally critical for every 3DP-related project in the same way that copyright licensing is critical to practically every software project.

Those respondents that highlighted the importance of developing new open source licences specifically tailored for 3DP pointed out some of the limitations that exist with the currently available FLOSS and CC licences, suggesting that if a new open source licence is to be developed then these shortcomings should be given special consideration. For instance, it was highlighted that 'copyleft' licences [58] in general, and the GPL [59] in particular, are typically quite restrictive in terms of combining proprietary and open source types of software ('contamination' of FLOSS licences). [60] Furthermore, GPL also includes specific patent clauses with the intent to prevent redistributors of a free program individually obtaining patent licences, in effect making the program proprietary. Incorporating code originally acquired under a GPL type of licence might dilute possibilities for ownership, commercialization and thus ultimately compromising the company's IPRs. This risk, instead, might not arise with other more flexible types of FLOSS licences like the BSD and so called 'academic licences' (Välämäki, 2005c). In these circumstances, it was pointed out that if a new open source 3DP-tailored licence is to be developed, it should be based on the principles of the more flexible types of FLOSS licences. In reality, the problem with 'contamination' risks embedded in the GPL might be even more challenging in the field of 3DP because it is both digital and physical: what if you use a small part under a 'copyleft' type of software licence and then you print the object that is described in that CAD file and incorporate it in bigger hardware, like a physical product? How does the 'copyleft' clause (thus the 'contamination' risk) affect the legal status of the product and the end product as a whole? Does it indeed 'contaminate' the end product? Is there a risk is that the physical end product may be forced 'open source'? [61]

It was also pointed out that even though it would be best to reduce the number of available open source licences for 3DP to just a few (experience from software has shown how having to deal with too many different licences might add complexity and uncertainty for a company seeking to commercialise a FLOSS licence code), the danger is that the parties will not accept the too few conditions offered by those licences and will therefore opt for a proprietary solution. [62]

Interestingly, not all respondents agreed on the need to develop new open source licences tailored for 3DP. In fact, even though it appeared clear that CC licences are not suitable for 3DP (because they are only suitable for creative works of art, thus copyright protected works), some traditional FLOSS licences may be suitable for 3DP as well. It was pointed out that, at least from the legal perspective, these open source licences apply to everything, to all types of IPRs and creations/inventions (i.e., not only to software). [63] According to this standpoint, there is thus no need to develop any new type of open source licence tailored only to 3DP because the legal principles embedded in several FLOSS licences are also proper for this technology.

Some other respondents also suggested that in order to allow co-creation in this field the solution should not only be sought on the side of new open source licences. Instead, a whole licensing scheme system that could also include, for example, open source types of licences

should be developed. One way to solve this issue is to develop a 'licensing foundation' that allows a brand or a company to obtain products that are authorised on the market, allowing consumers to tinker with these products without being considered as infringers. [64] In other words, what is needed is a platform that would allow a brand to make available to consumers certain properties that they own, while at the same time defining the bundle of licences. [65] A parallel can be drawn with the structure of successful platforms like Youtube or RightsFlow that ran digital licensing for music and video rights at scale by first collecting licences from music publishers and collective societies to allow users to remix videos and music, and then sharing with the right-owners the revenues collected from advertising or subscriptions to videos. According to some respondents, this should be the ultimate target for developing sustainable licensing structures in the 3DP field to allow co-creation, while trying at the outset to set some kind of market standard for a so-called '3DP licence' would not be so efficient. [66]

Finally, respondents also pointed out alternative solutions to licensing models. For instance, one respondent suggested that the question about licensing and 3DP should be seen from a broader perspective as a question about IP strategy and about how and how much companies want to keep control over their products: "IPRs are often too strong and on several occasions too much protection leads to less, rather than more, innovation". [67] On the other hand, 3DP technology is evolving at such a high speed that companies should rather explore protection mechanisms alternative to IPRs in order to be on the safe side. This is especially so in 3DP, where it is very difficult for brands to enforce their rights. Other mechanisms such as time to market and agile innovation models are business strategies that might work better in the field of 3DP (especially on the consumer side) than protection via IPRs. If so, then whether e.g. currently available open source licences are suitable is not such a relevant question in this area. [68]

Finally, some respondents had no clear idea on licensing matters in relation to IPR of CAD files. [69]

C. IPR Enforcement - Empirical Analysis

To our knowledge, at the time of writing no decision has been handed down by any court in Europe (or in the United States) on issues related to 3DP and IPRs. At the same time, however, the empirical study revealed that starting from 2013 disputes among parties have begun to arise in this field (even though they were settled before reaching a court). Generally speaking, most disputes involved Internet service providers (ISPs) and platforms offering CAD files, or printing services (e.g., service bureaus, printing shops and maker spaces). Additionally, producers and manufacturers of raw materials and filaments have been involved in private disputes. At this stage, most disputes have been focused on product liability issues, while IPR matters encompassed a smaller proportion of cases.

In terms of IPR disputes, the importance of issues related to the printing of spare parts by end users has clearly emerged. These disputes have thrown light on the fact that interpretation of several concepts in IP law, ranging from issues related to the application and scope of rights to the concept of several exceptions and limitations (e.g., private and non-commercial use, research and experimental use exception), as well as the applicability of traditional enforcement theories of IPRs (e.g. issues related to secondary liability) and liability of intermediaries are being challenged by the advent of 3DP. [70]

Some disputes have highlighted issues with IPRs and 3DP in general. On the specific theme of 3DP and co-creation, it was reported that the cases that have appeared thus far have

involved users 'offering' CAD files of allegedly protected items on their websites or on third party websites. Clearly, even in view of the private copy exception, 'offering' a protected item on a website is not allowed under copyright law in most European jurisdictions. Similar examples, such as the Super 8 movie case [71], the Warhammer case [72], the Penrose Triangle case [73], the Game of Thrones case [74] and the Super Bowl 'Shark' case [75], all cases involving users creating CAD models of allegedly protected works and sharing them via open hardware platforms, have already made the headlines all over the world. Indeed, these types of cases raise questions not only as to the extent and scope of IP protection of CAD models, but also to the aggressive use of 'cease and desist' letters and of 'takedown notices' as tools for enforcing IPRs.

Among the reasons why no court case has yet to appear and why people prefer to settle rather than meet in a courtroom, two points were highlighted: on the one hand, the newness of the technology and, on the other, the risks associated with asking non-technically trained judges to express their opinions on difficult, new, and technical matters like those at stake with 3DP. In addition, it was pointed out that the '3D printing world' is still small, most parties know each other and may prefer to find agreement and settle. [76]

One respondent argued that enforcing IPRs in the 3DP environment is not going to be a matter of concern for IP owners in developed countries, where laws are very well structured and enforced. [77] A parallel could be made with the culture of 'Shanzhai' in China [78], characterised by imitation and trademark infringements. The problems that brands will have in 3DP will be the same as those they have had due to the Chinese culture of 'Shanzhai', and in the same way brands will be able to contain the phenomena by using IP laws. For instance, the 'Shanzhai' phenomenon only takes place in China, while it is not allowed in Europe or in the US, where IP laws are strong and enforced. Similarly, brand owners will find suitable ways to enforce their rights in the 3DP area. This may imply some changes in traditional company business models but what is certain is that IP owners are not going to allow 'open source activities' to take over without them keeping careful control over their IPRs. [79]

5.2.3. SPECIFIC FINDINGS - NON-IPR RELATED ISSUES

In addition to the above mentioned legal challenges, respondents highlighted how at the current stage several problems still lay in the technology *per se*, as well as in the level of standardization in the field of 3DP. Even though the focus of this paper is mostly on IPR related matters, it is important at least to touch upon these additional problems, since they are essential in order to obtain a general picture of the topic of co-creation in this field of technology.

Technical Problems

All respondents highlighted the general problem that the current level of technological development in 3DP is still insufficiently mature to fully enable co-creation in many industry sectors. At the same time, most of them agreed that at the current stage it is possible to use this technology for manufacturing simple consumer-level types of product. Only one respondent was firmly convinced that 3DP solutions will never reach such a level as to be usable for anything other than prototyping and that better techniques than 3DP are available to create final products. [80] The same respondent also pointed out that this focus on forcing 3DP to be used in final products might even hide the real advantage of the technology, i.e. it allows companies to test and tinker with ideas. According to this opinion, the real contribution

of 3DP lies in its ability to assist in developing novel mechanisms and ideas, not in being used for final production. [81]

Among the most relevant technical problems identified in terms of co-creation is the often poor quality of CAD files available from open hardware repositories. Some respondents found the models available in several platforms to be of such bad quality that it is usually quicker either simply to create models from scratch or to buy some proprietary models. [82] Among the reasons for this it was highlighted that the community of developers' is still highly fragmented and not yet sufficiently mature to provide good quality CAD files for sharing. [83] At the same time, however, it was also pointed out that this situation will most likely change in the not too distant future because of the growing home-maker movement in 3DP and better CAD packages to fix the models are expected to enter the market shortly. [84]

It was also stressed that the problem with the CAD files available on open hardware repositories might not necessarily be related to their quality, but rather to the fact that users do not pay sufficient attention to the type of material and the type of machine that should be used to print out objects from those specific CAD files. For instance, sometimes objects are not meant to be printed with FDM printing machines (as used by most 'at-home-users'). Typically, FDM parts made with low cost printers have low printing reliability and a rough appearance, which gives a 'hobby, not ready for real use' perception to many users (Flores Ituarte I. et al., 2015). This problem might be especially felt with files hosted in Thingiverse, because Thingiverse is linked to Makerbot's printers, which are only FDM machines. At the same time, though, Thingiverse also hosts designs that should be printed by using other types of machines. Indeed, there is room for improvement here and for platforms to take pro-active approaches in communicating with their users on these types of issues. [85]

Related to this last item, a gap in the market on the side of available platforms was also identified: even though several platforms are now available, insufficient quality control of the merchandise is offered. This means that the collection hosted by these open hardware repositories is not curated in any way. [86] Considering the demand and need for agents and intermediaries to curate the works of designers, more sophisticated platforms are indeed something that is missing and that are now much needed. It was also pointed out that even though a venue exists for 'amateur makers' with 3DP, great market potential also exists for professional designers. Currently, the focus seems to be more on the 'amateur' side of 3DP, while not enough distinction is drawn between the two sides of 3DP designers. At the same time, however, it is clear that platforms should be developed not only to support 'amateur' movements, but also to support professional designers. One of the main reasons identified to justify the lack of 'professional' platforms at the moment was cost: 3DP for more desirable objects is expensive and it is difficult for customers to buy those objects online, without having seen them. As such, these professional platforms should be developed so that they would add to their services the chance for users to display actual printed items at exhibitions worldwide. A similar model was used by companies like Materialise and Freedom of Creation at the beginning, but currently this type of service is no longer available. [87]

Standardization

Another problem with 3DP and co-creation that became evident from the interviews relates to standardization. It was stressed that not only is the process of standardization very slow and still in its infancy with 3DP technology, but also *per se* the fact that a digital file exists that is intended to create its physical object at the end implies that the process should involve more

communication about the file. Standards for communicating the characteristics of CAD files (i.e. the way the object should be printed out, the type of printer, how many times the object can be printed, the materials that should be used, etc) are in need of development. Currently, no effective way is yet available for including all that information consistently in the communication of digital 3DP files. Indeed, the respondents considered this as one piece of the puzzle that needs to be solved in order to ensure that the physical product is what the designer or co-creator intended it to be. In other words, the files need to have enough information to perform manufacturing appropriately. [88]

5.2.4. POSSIBLE IP STRATEGIES TO ENABLE CO-CREATION

The empirical study shed light on several types of strategies that IP holders could implement in an attempt to engage in co-creation in the field of 3DP.

Co-Creating in a Structured Manner

The findings revealed that one possible strategy for allowing IP holders to enable co-creation in 3DP is to develop structural licensing deals with platforms. Similar examples can already be found in the toy and fashion industries. For instance, respondents pointed to the pilot case of SuperFanArt between the giant of the toy industry, Hasbro Inc., and the platform Shapeways that started in 2014 and recently concluded, represented the first attempt to create a bridge between 3DP and a major manufacturer in the toy industry. [89] Hasbro is the second largest toy manufacturer in the US (after Mattel) [90], managing some of the most popular gaming, like My Little Pony, Transformers and the Little Pet Shop. The SuperFanArt project aimed to open a new era in manufacturing, during which the way to conceive designing and producing objects is completely rethought in order to include ideas, wishes and feedback coming from the community of designers over the Internet. SuperFanArt allowed users of Shapeways to create their own fully-licensed versions of some of the pieces in the Hasbro portfolio and to commercialize them through Shapeways. The way that the SuperFanArt project worked was that individual artists and designers in the Shapeways community who were fans of My Little Pony applied as 'artists', they were cleared by Hasbro and obtained a licence accordingly. So, even though the path for licensing was easier, it was not a kind of 'blanket' community licence. [91] The first phase of this pilot project was restricted to five artists who created their version of famous figurines from the well-known 'My Little Pony' brand. Due to coverage of the initiative by the media the program was then extended to other Hasbro products, like Transformers, Dungeons & Dragons, Monopoly, Scrabble, DragonVale, and GI Joe. A similar project to SuperFanArt is currently ongoing with the iMaterialise platform and the company Adidas in a project called the Futurecraft 3D shoe, which is part of a larger project called the Futurecraft series. [92]

The interviews revealed that there is generally much interest (from the standpoint of both companies and of the user community) in these types of large-scale licensing models, where brands are able to engage with certain members of the design community, legitimise them and, that way, create a large group of designers who are doing R&D and merchandising for the company in a novel way and bringing new and fresh ideas in house. Indeed, this model, if properly constructed, may also lead to significant licensing revenues for rights holders. At the same time, because this is not the traditional way to do business for most (large) rights holders, it remains unclear how the 'rules of the game' should be built in order to boost opportunities, while minimizing the IPRs related risks. The SuperFanArt type of licensing deal, for instance, is one such type of deal, but more models need to be developed to accommodate the different needs of other companies. Some respondents were also not sure

whether engaging in these developing models would be a valid option for their business at all, as they rather saw it as a possible distortion of their brands. [93] For instance, the importance was stressed for some types of company of being 'loyal to their customers' and keeping their brand integrity by sticking to the overall traditions and stories on which the brand was originally built.

A pilot model tested by one of the respondents [94] was based on a close deal with one online platform for offering for sale some classic products that were no longer protected by IPRs. This pilot project was aimed at testing the ground and seeing whether deals of this kind could work. As such, however, the project did not engage with the user community because it did not imply any possibility for customers to co-create. The 3D files of the products were just hosted on the platform and consumers could order them as a 3D printed item (physical product only). The idea was more for marketing purposes and to show that the company was engaging in some business activities that other brands had not yet been doing, thus also allowing possibilities to renovate or renew the brand. So far, however, that project has not shown itself to be successful. The company thought that the main reason was because both business and consumers are not yet sufficiently mature and prepared to embrace these types of model.

The "You-Tube" Model

One respondent especially highlighted the importance of right holders engaging in projects that aim at finding ways to legally monetize user-generated content that would typically be seen as illegal. [95] The respondent himself was engaged in one such project that, in similar ways to YouTube, aims to offer IP recognition and IP licensing services to brands that will allow content creators and online marketplaces to easily enable the monetization of user-created products. In other words, a system of scalable licensing agreements that allow anyone to use protected IP to create and sell products online. According to one respondent, this is the only way to avoid situations similar to the 'copyright disaster' that occurred with the entertainment industry due to the advent of P2P file-sharing technology and thus avoid expensive and inefficient lawsuits. Vice versa, engaging with their community of fans via relying upon 'micro-licensing' options that allow monetary returns to brands from user-generated content created by the community appears to be the only feasible way to survive in a world of ubiquitous 3D printers. This model certainly provides a useful alternative for many types of co-creation models and in several industry fields, especially in those areas that are more consumer-related.

On this model, open questions remain as to whether it will be feasible to create a sufficiently stable and sizeable community to support such types of user-generated content activity (for a more thorough investigation on this, see Dan Hunter et al, 2012), on the one hand, and whether this model might function for more industrial-type creations, on the other [96].

First (Fully) Open then (Partly) Closed

Another workable model that arose is based on a strategy according to which companies would first engage in co-creation with the users (e.g. allowing them to think through and engage in R&D activities), that way developing some solid product line and, subsequently, close down part of this open line of developed products. Open source solutions should be kept on the market in order to keep getting ideas and inputs from the community. [97] Especially in some fields of industry, like orthopaedics, which suffers from lack of affordable and effective commercially available solutions, this model may work well.

From a licensing perspective, an instrument that could enable such activity could be a system of double-licensing. This model has been used successfully by other companies for instance in the software field (Välimäki M, 2003). The dual licensing model that has been used in software mixed together proprietary and open source mechanisms and offered the same product under both a traditional proprietary licence and an open source licence. Technically, only one core product exists, but two licences are used: one for free distribution and use, and the other for proprietary distribution. With dual licensing anyone can download the product (software or CAD file) for free and redistribute it, just so long as the redistributed product is licensed under a FLOSS licence. The second licence removes the open source licence restrictions and allows purchasers to distribute it and integrate it with proprietary products. This second option obviously targets companies planning to customize the product for commercial purposes. Thus, both licences allow developers to customize the product and redistribute it as part of a larger product. If the larger product is released as open source, no licence needs to be purchased. If the product is distributed in proprietary form, it requires a commercial licence.

It is well known that the dual licensing system includes two major and interconnected legal risks: on the one hand, the danger is that the FLOSS licence can dilute ownership and even eliminate the possibility of a dual licence, while, on the other, projects with multiple designers can have conflicting IP claims. Certainly, the ability to license a product with terms other than open source requires full ownership of rights to the product. Thus, no hidden liabilities should remain in the form of code contributions from unknown third parties. As explained above, if in the case of software these problems can be partly circumvented by re-writing the code fully, with CAD files, such an exercise might not be as simple. In that case, other solutions should be developed to clear the rights. One respondent suggested that one way to deal with this issue might imply building on the double licensing strategy in the commercialization of the product, but instead of having the same product licensed under two different sets of terms, provide two different products that, although they are essentially the same, imply different technical complexity and 3DP techniques in order to be replicated. The more complex technical solution could feedback from the co-creation process of the simple solution. A relatively simple solution to replicate could be provided under an open licence, that way allowing the community to co-create and develop on the basis of that new solution, while a more complex solution based on sophisticated technology and 3DP techniques could benefit from this process and become the commercial product. [98]

Selling Authorised CAD files and DRMs

An important strategy that companies could implement in order to enabling co-creation would be to make available on the market authorized CAD blueprints of their products under certain conditions. IP owners could start selling authorised CAD blueprints of their products, in a similar way to selling music in MP3 in online stores. Additional services could also be included for those customers purchasing these authorised blueprints, such as customer support, repairs and future updates. The advantages for consumers would range from being able to modify the blueprints (under certain conditions), as well as reduced need to worry about viruses, reduced defective CAD files (compared for instance to those CAD files available under online platforms) and reasonable prices. Indeed, the challenge from a company perspective is how to find a proper balance between enabling co-creation via providing authorised 3D blueprints while being able to monetise from IPR ownership.

Generally, however, in terms of taking this type of strategy on board, the empirical study showed fragmented results. Although all respondents agreed that selling authorised CAD

files of their products could be an instrument to allow co-creation, some respondents thought that it would be too difficult to keep control while it would over-expose them to copying. [99] This position was especially embraced by companies that did not have a strong IP portfolio or any specific IPR strategy implemented, so that they felt especially vulnerable, even though they clearly saw the merit in this type of innovation model.

Other, more established companies considered that selling authorised CAD models of their products is a good option, but that the market is not yet sufficiently mature for this type of business. [100] Notwithstanding, it was highlighted that with the prospect of future developments it is advisable for companies (especially those operating in consumer markets) to start preparing by already creating CAD models of their products in advance.

The importance of digital rights management (DRM) to allow keeping control over CAD files was also pointed out. However, even though the importance of DRM for files emerged, respondents did not seem to be aware of any such solution currently available in the market, so that they did not seem to know precisely what possible coping mechanism could be adopted.

Trade Mark Protection

The empirical study also revealed the possible key role of trademark protection to enable co-creation in 3DP. It was pointed out that one way would be to include a trademark-related provision in all IP licences, waiving the possibility for licensees to trademark anything that is created (or co-created) based on one of the company's models or products. [101] For instance, one respondent said that "We work with some video game providers that are wildly popular around the world. We help creating some 3D-printable products for them, they license us the rights to the character from a video game and then we make products. In all of those licenses, there is a provision specifically about trademarks that says that we, as the licensee, have no ability to trademark anything that we create. Thus, by contract, are agreeing not to trademark these things ourselves, and that they basically hold the exclusive ability to go register the trademark for anything that they have licensed (to us)".

Another option that was pointed out is to base the licensing agreement on trademark protection of the CAD files. [102] Indeed, with 3DP it is possible that even though a company already holds trademarks on the physical products, protection should be extended to different trademark categories such as computer files and computerised programmes [103]. Extending trademark protection to other categories might be especially important at the present time, because, as explained earlier, the legal nature of CAD files remains an open question.

One respondent also pointed towards a recent initiative by the Open Source Hardware Association called the 'Open Source Hardware Certification Mark' program [104]. The idea behind this initiative is to create a system based on certification, so not depending on any open source licence linked to the CAD file, for open hardware in general. Upon meeting certain requirements, a certificate is issued under the form of a trademark logo to be placed on the goods, in order for the company to be able to communicate to the market that 'they are open'. [105] This system could also work well for 3DP.

6. CONCLUSIONS AND FURTHER RESEARCH

The study showed that in some segments of the 3DP ecosystem, engaging in co-creation with the user community might not only lead to substantial profits, but it might also be the only feasible way for companies to keep up in the market and keep hold of their IP rights in a world of ubiquitous 3D printers. Indeed, a model of this kind appears to work better for simple, close-to-consumer types of application (e.g. the entertainment, gadgets and simple spare parts markets) rather than complex, industrial areas (e.g. the medical or automotive industries). The study also revealed that companies operating in markets where co-creation is likely to take over will soon need to take pro-active approaches towards enabling adaptation of their business models to this technological disruption.

Indeed, one of the biggest challenges for companies in reaching this goal lies in developing sustainable and effective IPR strategies. The research revealed that the most urgent questions in terms of IPRs relate to defining the legal nature of CAD files, the feasibility of currently available licensing schemes for CADs, as well as issues related to enforcement of IPRs in the 3DP environment. At the same time, the results clearly show that, at the time of writing, several problems, other than IP, also need to find proper answers. Among these, the most relevant were maturity of 3DP technology *per se*, fragmentation of the user community and technology standardization matters.

The study also shed light on some possible coping mechanisms that companies could implement in order to navigate the challenges (especially in terms of IPRs) associated with co-creation in 3DP, that way boosting the great opportunities envisaged. Among these, the most relevant were towards developing specific types of licensing scheme, especially: 1) via structured licence schemes developed together with IP owners, platforms and users; 2) by co-creating via the so-called "You-Tube model", i.e. in the context of specific user-generated content platforms that implement mixed licensing rules to enable co-creation; 3) via double licensing types of model; or 4) via selling licensed CAD files of companies' products. The study also indicated a possible increase in the importance of using trademarks and certificate programmes based on trademark laws as strategic tools in the context of co-creating in 3DP.

Notwithstanding these important findings on possible IP strategies, the study also shed light on the need for future research on several fronts. First, the study mostly pointed towards the consumer-side perspective of 3DP. The reason for this can likely be justified by the fact that currently available technology already allows reproduction of simple, consumer-level types of item via consumers' 3D printers, while in terms of more complex, functional items the technology is not yet sufficiently mature. However, one should not derive from this the assumption that no market potential will arise from the industrial side. Instead, our approach allowed us to set a precedent for when the technology will develop sufficiently to also allow the functional, more complex, industrial side of 3DP. For instance, by selling licensed CAD files for digital inventories and spare parts applications or by entering in the co-creation model during product development activities. This notwithstanding, more research is required to investigate these issues from the industrial standpoint.

Second, the study also revealed that, compared to the software field, in 3DP stronger barriers might arise in terms of creating a sufficiently strong community of 'designers', as referred to amateurs and hobbyists fabber/consumers -pro-sumers. On the one hand, further research is needed in order to better investigate and develop workable ways for companies to be agile players in the context of the currently highly fragmented designer community. On the other hand, however, it can also be argued that because it might be more difficult for communities

and users to 'take over' and establish themselves in the 3DP ecosystem, there could also be more room for brands to impede co-creation from ever taking place in this area. Indeed, if brands were successful in preventing co-creation in 3DP, the danger is that this could potentially be the crashing point of 3DP in final products. Certainly this point also stresses the importance of further research in this area.

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<https://cults3d.com/>

<http://www.alai.org/en/>

<http://www.gnu.org/licenses/gpl-3.0.en.html>

<https://i.materialise.com/>

<http://imgur.com/x6gkbzB>

<http://www.materialise.com/cases/adidas-futurecraft-the-ultimate-3d-printed-personalized-shoe>

<http://www.ohwr.org/projects/cernohl/wiki>

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<http://www.oshwa.org/>

<https://pinshape.com/>

<http://www.sculpteo.com/en/>

<http://www.shapeways.com/>

<http://www.shapeways.com/superfanart/mylittlepony>

<https://www.tapr.org/ohl.html>

<https://www.thingiverse.com/>

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[2] See, for example World Economic Forum report, 2016 at: <https://www.weforum.org/reports/world-economic-forum-annual-meeting-2016-mastering-the-fourth-industrial-revolution>.

[3] By 'users' we refer here to members of the community that are active producers of designs. As such, in this paper we will use the word 'users', 'designers', 'pro-sumers' and 'hobbyists' interchangeably.

[4] See <https://cults3d.com/>.

[5] See <https://pinshape.com/>.

[6] See <https://www.thingiverse.com/>.

[7] See <http://www.sculpteo.com/en/>.

[8] Free/Libre/Open Source Software. See also Ghosh, R. (2002). Free/Libre and Open Source Software:

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[9] The term 'open source license' describes several different licenses certified by the Open Source Initiative. See <http://www.opensource.org/>.

[10] See GNU Lesser General Public License, version 2, at <http://www.gnu.org/copyleft/lesser.html>, "Terms and Conditions for Copying, Distribution, and Modification", 2b).

[11] *Ibid*, GNU Lesser General Public License.

[12] See Mozilla Public License Version 1.1. at <http://www.mozilla.org/MPL/MPL-1.1.html>.

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[14] Wohlers, T (2015), Additive Manufacturing and 3D Printing State of the Industry.

[15] See <http://www.shapeways.com/>.

[16] See <https://i.materialise.com/>.

[17] Company 9.

[18] Company 10.

[19] Company 8.

[20] Company 3.

[21] Company 11.

[22] Company 2 and 8.

[23] Company 4.

[24] Company 2.

[25] Company 5.

[26] 'Brand' is in this paper used in accordance to the definition provided in, for e.g., Helen Lom, "Branding: How to Use Intellectual Property to Create Value for Your Business" (WIPO, 2014), i.e. not as a synonymous of trademark, but "in a wider sense for referring to a combination of tangible and intangible assets like trademark, design, logo, trade dress and the concept, image and reputation that those elements transmit with respect to specified products and/or services".

[27] Company 4.

[28] Company 6.

[29] Company 3.

[30] Company 8.

[31] Company 8.

[32] Company 8.

[33] Company 1 and Company 2.

[34] Company 9.

[35] Company 4.

[36] Company 1.

[37] Company 6 and 3.

[38] Company 3.

[39] See, for instance, Berne Convention for the Protection of Literary and Artistic Works (1886), Arts 2 and 4 and Directive 2001/29/EC of the European Parliament and of the Council of 22 May 2001 on the harmonization of certain aspects of copyright and related rights in the information society, (28) of the preamble.

[40] See, for instance, Directive 96/9/EC of the European Parliament and of the Council of 11 March 1996 on the legal protection of databases.

[41] See, for instance, Paris Convention for the Protection of Industrial Property (1883), Art. 4 and European Patent Convention (1973), Art. 52.

[42] See, for instance, Paris Convention (1883), Art. 6-7 and Directive (EU) 2015/2436 of the European Parliament and of the Council of 16 December 2015 to approximate the laws of the Member States relating to trade marks (Trademark Directive), Art. 2, and the Regulation (EU) No 2015/2424 of the European Parliament and the Council amending the Community trade mark regulation entered into force on 23 March 2016

[43] See, for instance, Paris Convention (1883), Art. 5, the Directive 98/71/EC of the European Parliament and of the Council of 13 October 1998 on the legal protection of designs, Art. 1, the Community Design Regulation (CDR) EC No 6/2002 and Community Design Implementing Regulation (CDIR) EC No 2245/2002.

[44] While in the USA such threshold has traditionally been quite low, in the EU, countries used to differ on the level of originality required for software works (for e.g. Germany required a high threshold, while the UK a much lower one). However, the harmonization process conducted by the Court of Justice of the European Union (CJEU) has led to a softening of the requirements that some of the Member States previously enforced. See *Infopaq International A/S v Danske Dagblades Forening* (C-5/08), Judgment of the Court (Fourth Chamber) of 16 July 2009; *Bezpečnostní softwarová asociace - Svaz softwarové ochrany v Ministerstvo kultury* (C-393/09), Judgment of the Court (Third Chamber) of 22 December 2010; *Football Association Premier League Ltd and Others v QC Leisure and Others* (C-403/08) and *Karen Murphy v Media Protection Services Ltd* (C-429/08), Judgment of the Court (Grand Chamber) of 4 October 2011; *Eva-Maria Painer v Standard VerlagsGmbH and Others* (C-145/10), Order of the Court (Third Chamber) of 7 March 2013; *Football Dataco Ltd and Others v Yahoo! UK Ltd and Others* (C-604/10), Judgment of the Court (Third Chamber) of 1 March 2012.

- [45] Company 5, respondent # 3.
- [46] Company 5, respondent # 2.
- [47] Company 10.
- [48] Company 3.
- [49] See <https://www.tapr.org/ohl.html>.
- [50] See <http://www.ohwr.org/projects/cernohl/wiki>.
- [51] Company 8 and 10.
- [52] Company 10.
- [53] Company 8 and 3.
- [54] Company 8 and 3.
- [55] Company 8 and 3.
- [56] Company 3.
- [57] Company 10.
- [58] Company 10.
- [59] See <http://www.gnu.org/licenses/gpl-3.0.en.html>.
- [60] Company 8.
- [61] Company 8.
- [62] Company 8.
- [63] Company 6.
- [64] Company 3.
- [65] Company 3.
- [66] Company 3 and 6.
- [67] Company 9.
- [68] Company 9.
- [69] Company 1, 2, 4, and 11.
- [70] Company 8.

[71] See Todd Blatt Blog, <http://toddblatt.blogspot.ch/2011/06/cease-and-desist.html> and <http://torrentfreak.com/paramount-cease-and-desist-targets-3d-printer-pirate-110628/>. See also H. Peter, "The Next Napster? Copyright Questions as 3D Printing Comes of Age", *ARSTECHNICA.COM* (6 April 2011), <http://arstechnica.com/tech-policy/2011/04/the-next-napster-copyright-questions-as-3d-printing-comes-of-age/>.

[72] Castle, "Warhammer at War: How Home 3D Printers Are Disrupting Miniature Games" (2013), *Tested.com*. Available at: <http://www.tested.com/art/makers/452866-how-home-3d-printers-are-disrupting-miniature-gaming/>.

[73] For more information on the case see B. Rideout, "Printing the Impossible Triangle: The Copyright Implications of Three-Dimensional Printing", 5 *J. Bus. Entrepreneurship & L* Issue 1 (2011). Available at: <http://digitalcommons.pepperdine.edu/cgi/viewcontent.cgi?article=1074&context=jbel>.

[74] See <http://imgur.com/x6gkbzB>.

[75] See M. Masnick, "There's Something Fishy With Katy Perry's Left Shark 3D Printing Takedown", (6 February 2015, *Techdirt*). Available at: <https://www.techdirt.com/articles/20150205/16305829921/katy-perry-claims-copyright-over-left-shark-issues-takedown-over-3d-printable-version.shtml>.

[76] Company 8.

[77] Company 6.

[78] Company 7.

[79] Company 6.

[80] Company 11.

[81] Company 11.

[82] Company 4.

[83] Company 7.

[84] Company 4.

[85] Company 1 and 9.

[86] Company 4.

[87] Company 4.

[88] Company 3.

[89] See <http://www.shapeways.com/superfanart/mylittlepony>.

[90] See [http://www.wikinvest.com/stock/Hasbro_\(HAS\)/Data/Income_Statement](http://www.wikinvest.com/stock/Hasbro_(HAS)/Data/Income_Statement).

[91] Company 10.

[92] See <http://www.materialise.com/cases/adidas-futurecraft-the-ultimate-3d-printed-personalized-shoe>.

[93] Company 5, respondent #1.

[94] Company 5.

[95] Company 3.

[96] For discussion on artistic works, see also <http://www.alai.org/en/>.

[97] Company 9 and 11.

[98] Company 11.

[99] Company 4.

[100] Company 5.

[101] Company 3.

[102] Company 5, respondent #3.

[103] See Nice Classification (trademarks), Goods, Class 090342-090372.

[104] See <http://www.oshwa.org/>.

[105] Company 10.