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3D Printing and the Law

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Abstract

Heralded as the "third industrial revolution" (Markillie, 2012), the rise of 3D printing has attracted both anticipation and controversy in recent years. While many look forward to the era of mass customisation where products are free of tariffs and shipping costs, others are wary of its potential to undermine our legal framework. The cost of 3D printers first fell below US$10,000 in 2007 (3D Printing Industry, 2016). As the price continues to fall, there grows an unprecedented capacity for 3D printing to empower individuals, especially those who are otherwise unable to obtain certain products due to high costs or governmental control, in a decentralized economy. 3D printing therefore challenges archaic Laws based on a different economic model: industrial production. Despite its capacity to transform our legal landscape, disproportionately few academic analyses have been dedicated to exploring the legal implications of 3D printing. This paper will explore the intersection between 3D printing, Intellectual Property, Gun Laws, and Product Safety and Privacy, before concluding with a proposal to amend the Law.

Introduction

With every rise of a new technology comes a head-on confrontation with existing legal frameworks across the globe. In particular, the 3D Printing revolution in recent years, emboldened by its sheer magnitude, has profound implications on multiple facets of the Law. 2.3 million 3D printers are predicted to be shipped globally in 2018, a 23-fold increase in the span of four years (McCaskill, 2014). This proliferation is accompanied by an estimated loss of US$100 billion worth of intellectual property (Stamford, 2014). Many of these printers are already capable of printing products ranging from pasta (Halterman, 2014) and pharmaceutical drugs (Norman et al., 2016) to firearms (Ghost Gunner, 2016), organs (Geall, 2016), and even other 3D printers (RepRap, 2016). This phenomenon not only tests the Law to its limits, but also challenges the effectiveness of cross-jurisdictional Law enforcement.

3D printing challenges archaic Laws based on the long-established economic model of industrial production—by opening up the possibility for domestic production within a decentralized economy. This new economy is difficult to govern and emphasizes customization rather than replication (a criterion for IP infringement). Despite its

capacity to transform our legal landscape, disproportionately few academic analyses have been dedicated to exploring the legal implications of 3D printing. This paper aims first to provide some background on 3D printing, then to examine the applicability of Laws to Intellectual Property, Gun Laws, Product Safety, and Privacy, before concluding with a proposal to amend our Laws.

Background of 3D printing

3D printing is traditionally a colloquial term for "additive manufacturing." The process was first patented in 1977 by inventor Wyn Kelly Swainson, under the description "method, apparatus and product in which a three-dimensional figure is formed in situ in a medium having two active components by causing two radiation beams to intersect in the media" (Swainson, 1977). In short, a beam of light traces the shape of the product and solidifies liquid plastic along its way, building the product up layer by layer—hence, "additive manufacturing." The commercialization of this process was started by Chuck Hull, who developed the stereolithographic file format to digitize the process by which UV light is used to solidify photopolymers (Hull, 2014). Hull then co-founded the company 3D Systems in 1987 (3D Printing Industry, 2016) to provide this service.

Nowadays, a range of printing processes is available, such as Direct Ink Writing for ceramic materials (Lewis et al., 2006), Laminated Object Manufacturing for paper, foil and plastic film (Sculpteo, 2016), and Electron-beam Melting for metals. Within this range, there are three major types of 3D printing technologies: Extrusion, Resin and Powder. Extrusion is the most traditional type and works by melting a plastic filament and depositing the liquid on a platform, layer by layer. Resin uses laser beams to cure a liquid, photosensitive resin to form the product, as seen in stereolithography technology. Powder also uses laser beams, in this case to sinter a powdered material to form a solid, and it is most commonly used in Selective Laser Sintering technology (Aniwaa, 2016). A new technology called "Continuous Liquid Interface" was published in Science 2015, which allowed 3D products to be printed within minutes, not hours (Tumbleston et al., 2015). This technology is anticipated to become a fourth major type of printing processes, further expanding the scope of its potential to disrupt our legal framework.

The appeal of 3D printing lies in its ability to reduce material costs. For instance, in typical manufacturing more than 90% of titanium used to manufacture an airplane is discarded. But thanks to the "additive manufacturing" process in which matters are added layer by layer instead of being carved out, 3D printers only require 10% of the material (All 3DP, 2016) to produce the airplane. More traditional processes, such as CNC machining, work by cutting away significant portion of the original plastic block, leading to high "scrap rates," i.e. huge amount of materials wasted. Another traditional process is injection moulding, where molten material is injected into a pre-designed cavity that later solidifies into the desired shape. It yields a lower scrap rate than CNC machining, but might lead to waste plastic

in the sprue, the runners, leaked materials and the gate locations (Creative Mechanisms, 2016). Such material surplus is only necessary for the production, not functioning of the product. In contrast, 3D printers present a more efficient alternative as they allow products to be 60% lighter (All 3DP, 2016) without compromising on their quality.

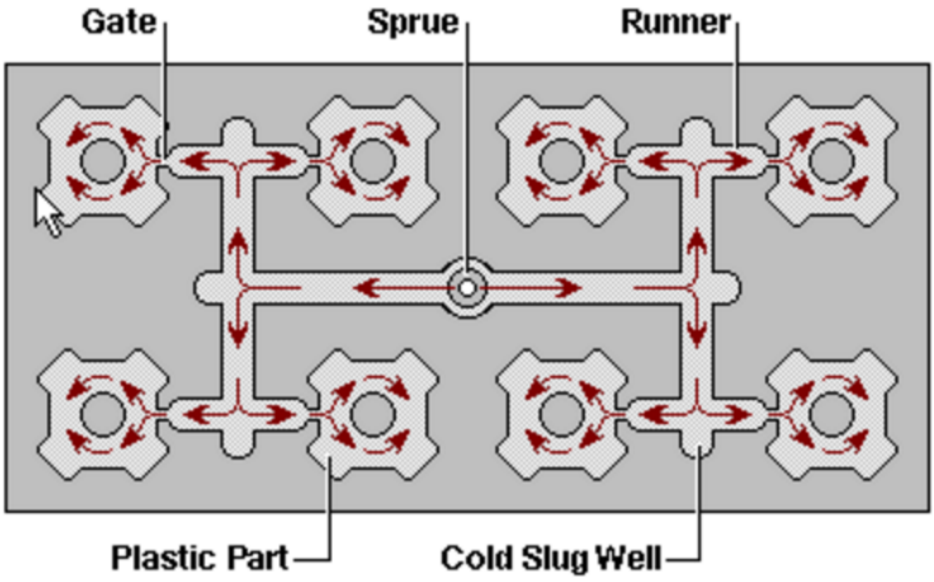

FIGURE 1: Creative Mechanisms—Injection Moulding.

3D printing remained very much an industrial technology until the launch of the RepRap project in 2005 by Dr. Adrian Bowyer (Bowyer, n.d.). It was the world's first open source platform, where all Computer-aided Design (CAD) files (the digital models for the printed products) were published under GNU General Public License (Ferdinand et al., 2016). RepRap attracted many programmers to change the CAD files as long as they re-shared their modifications. Through this project, one family can save up to US$2000 by printing 20 domestic products every year (Wittbrodt et al., 2013). The market, which used to worth less than $4 billion in 2014, has been estimated to reach $490 billion by 2025 (Keeney, 2016), transforming the average household family into manufacturers capable of infringing Intellectual Property and product safety guidelines without detection by law enforcement authorities. The democratization of 3D scanners by MakerBot in 2013 (Millstein, 2013), due to the lower prices it offered, was followed by new technology that enables smartphones to act as 3D scanners (ETH Zurich, 2016) that convert measurements of physical objects into digital files. That said, although democratization complicates the legal aspects of 3D printing by opening up concerns about privacy and surveillance, the range of products produced by domestic printers remains limited and has yet to truly create upheaval in the economy.

Intellectual Property

Intellectual Property Rights (IPRs) are monopolies given to institutions responsible for the creation of original and intangible assets. IPRs are assigned in the form of copyright, trademarks, design rights, trade secrets and patents. Their purpose is to spur innovation by outlawing "free riders" who copy creations for commercial benefit, and to generate income for owners to promote further innovation. A global convergence of IPRs was achieved through the merging of Berne Convention for the Protection of Literary and Artistic Works 1886 and the Paris Convention for the Protection of Industrial Property 1883 into the United International Bureaux for the Protection of Intellectual Property in 1893 (Encyclopaedia Britannica, 2016). Despite this convergence, IPRs have inconsistencies across various jurisdictions, which 3D printing has managed to expose. This paper will attempt to address the implications for Copyright, Designs and Patents brought by the advent of 3D printing.

Copyright

Copyright is a form of IPR and is automatically assigned to authors of creative works. The making of a 3D printed product depends on both the creation of the CAD file and the designing of the product. The applicability of copyright on each of these processes is explored below.

In the UK, a "computer programme; preparatory design material for a computer programme" (Copyright, Designs and Patents Act, 1988) is protected under the Copyright, Designs and Patents Act 1988. Although the Directive of the European Parliament recognised that "the development of computer programs requires the investment of considerable human, technical and financial resources" (Software Copyright Directive, 2009), many in the US are doubtful that CAD files could be considered in the same way. Unlike other computer programmes, CAD files are machine codes automatically translated from the on-screen drawing or laser-scanning of a design, and they are not readable by humans. The actual design undoubtedly involves human intellect, but the CAD file itself seems unable to satisfy this requirement. Computer programmes, on the other hand, exhibit creativity because the programmer manually writes the human-readable code and decides how it should be worded in order to carry out a task. If CAD files do not fall under "computer programme," they are most likely to be classified as "design documents and models," defined as "any record of a design, whether in the form of a drawing, a written description, a photograph, data stored in a computer or otherwise" under section 51. In this case, the Law states that "it is not an infringement of any copyright ... to make an article to the design or to copy an article made to the design" (Copyrights, Designs and Patents Act, 1988). Although people are not allowed to copy these files, they can 3D print those products without seeking permission from owners, so long as these products are not artistic works.

The debate is intensified by the advent of 3D scanners. The scanner creates a CAD file by scanning an object and automatically

converting its measurements into digital format. This process at first appears completely automated because the file itself is created without any "investment of considerable human, technical and financial resources" (EU Database Directive, 2005). In British Leyland Motor Corp v. Armstrong Patents Co 1986, the House of Lords ruled that Armstrong's reproduction of Leyland's exhaust pipes by "reverse engineering," or the construction of the product without creating the product itself, constituted "copying" (British Leyland Motor v. Armstrong Patents, 1986). The "reverse engineering" of a product scanned by a 3D scanner would seem to follow the same reasoning. However, by considering the world's first 3D body scanner mPORT, introduced into the market in 2015 (AFR, 2015), the similarities between 3D scans and photography become apparent. mPORT enables customers to scan and store their body measurements so that they can correctly size and personally customize their clothing. Similarly, a photographer often selects the best angle before taking a photo, "exhibit[ing] a degree of labour, skill or judgement" that attracts copyright. If we position a human inside the mPORT, a similar process is adopted. The concept of scanning a human body in such a way for such purposes is, furthermore, a unique and unprecedented invention, and should therefore be protected with copyright.

The applicability of copyright to the actual product's design is complicated by the nature of 3D printing—mass customization. It is difficult to enforce the Law when all it takes is a few modifications on a personal computer to evade copyright infringement. The requirements for "originality" is not defined in the Act but is clarified in University of London Press v. University Tutorial Press, where the criterion for 'original or inventive thought' was excluded because "copyright acts are not concerned with the originality of ideas, but with the expression of thought," requiring only that 'the work must not be copied from another work." It was established in this ruling that as long as the *expression* of thought originates from the author, there is no need for the thought itself to be original. It is possible to express an idea copied from someone else in a new way—this would not constitute an infringement to the original author's intellectual property rights. Applying this concept to 3D printing, expressing an existing 2D design using a CAD file, or even printing it out in 3D form, potentially falls under "expression of thought" and is therefore permitted under this interpretation of the Act. As a result, the original author would be disadvantaged (Peterson, 1916).

In recognition of this problem, the company Digital Forming devised a business model which could be used as a template for future Law-making. In 2008, the company developed the software tool "User co-design object" (UCODO), which is divided into two processes: "Original Design Object'"(ODO) and "Co-Design Objects" (CODO) (Assaonline, 2009). A case study is used on its website to illustrate how this works. First, professional designers working for Digital Forming designs the basic structure of a lamp under ODO. A customer is then allowed to alter the design under the criteria set by CODO, which places restrictions on how many modifications can be made so

that the lamp remains "functional, fit for use [and] aesthetically pleasing" (Digital Forming, 2009). Under CODO, the contribution of both the professional designer and the customer is recognised. The customer can then print his or her design using the 3D printers provided by Digital Forming, or sell the product to other buyers (given that the customer pays a license fee). This business model was granted government funding at the London Science Museum's Centenary Anniversary to further develop 'open 3D products' (Ashuach, 2010). By recognizing the distinction between ODO and CODO, the company is able to safeguard its own copyrights while reaping the benefits that personalized 3D printed products bring.

Unfortunately, current Laws surrounding both design files and 3D designs have yet to adapt to recent developments. Thingiverse is a US-based website launched in 2008 as a repository of open source design files (Baichtal, 2008). As an attempt to protect designers, Thingiverse is subjected to the requirements of the Digital Millennium Copyright Act, which issues takedown notices for files that are suspected to constitute copyright infringement (Digital Millennium, Copyright Act, 1998). In 2011, a file illustrating the Penrose tribar was issued a takedown notice for "copying" the same design uploaded in Shapeways (Coetzee, 2011), another online platform. Thingiverse had to remove this file from its site, but the legal reasoning behind this notice was unclear. The question of whether the design file or the design of the 3D Penrose tribar itself constituted copyright infringement was left unanswered. The 2D image of the Penrose tribar was first envisioned by Reutersvärd in 1934 and is now freely available in the public domain. Shapeways could not possibly have argued that the file on Thingiverse was a copy of its own because the image had already existed long before Shapeways has published it. Although Shapeways' file could be seen as the first 3D representation of the 2D design, the conversion from 2D to 3D did not involve major modifications to Reutersvärd's Penrose tribar design. Thingiverse's design file itself is also completely different from that of Shapeways' and therefore could not be seen as a copyright infringement.

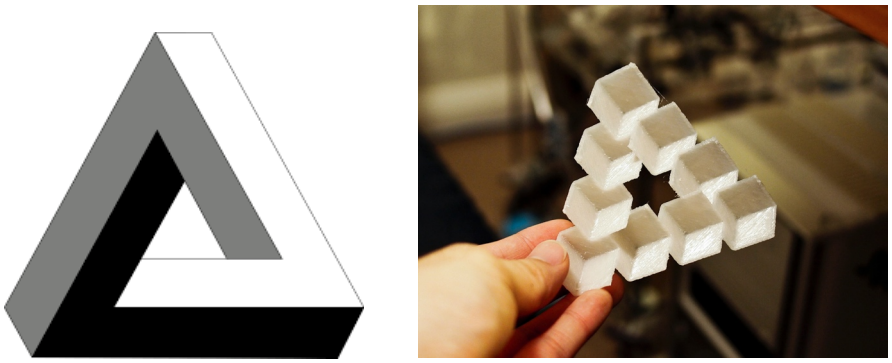

FIGURE 2: Left: Reutersvärd's 2D Penrose tribar; Right: Shapeways' 3D Penrose tribar.

That said, takedown notices can sometimes benefit copyright owners. Another notice was issued in 2013 for the sale of a 3D printed Iron Throne iPhone Dock produced by mstyle183 on nuproto.com. The notice states that the product "replicates the Iron Throne on the [Game of Thrones] series," and that it could "mislead consumers into believing that it is connected with the Series and that it originates with or is sponsored by the Home Box Office" (3Ders, 2013). Under UK Law, two criteria must be met in order to establish copyright infringement. First, *Interlego v. Tyco* asserts that the product must be copied from "an earlier work" because "copying, per se, however much skill or labour may be devoted to the process, cannot make an original work" (Oliver, 1988). Although much "skill and labour" is "devoted to the process" of creating the design file for the iPhone dock, it remains an exact replica of Game of Thrones' design. Secondly, it must not be created "privately and for purposes which are not commercial" (Copyright, Designs and Patents Act, 1988). The iPhone Dock was available for pre-order at $49.99 (3Ders, 2013) and therefore satisfies this second criterion. A clear case for copyright infringement is thus demonstrated. The takedown notice prevented mstyle183 from profiting from the intellectual creation of another, safeguarding the effectiveness of copyrights in this case.

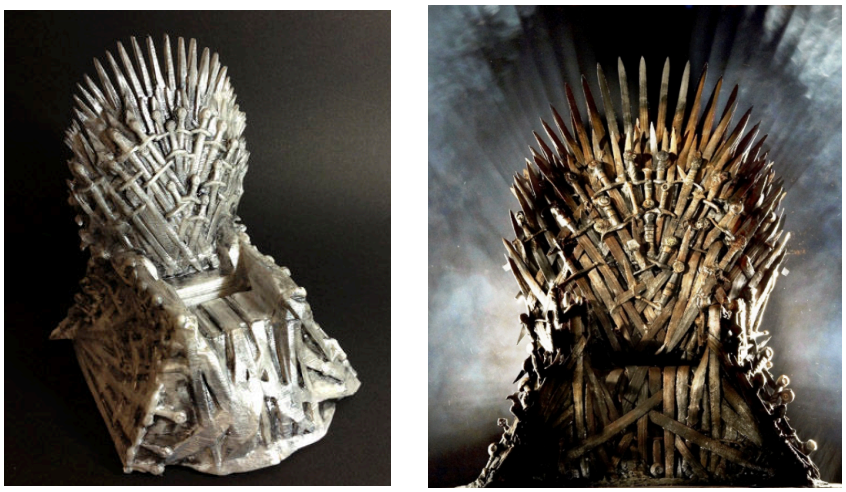

FIGURE 3: Left: mstyle183's 3D printed iPhone Dock; Right: Game of Thrones Iron Throne.

Design Rights

The Registered Designs Act 1949 protects the "appearance of the whole or a part of a product resulting from the features of, in particular, the lines, contours, colours, shape, texture or materials of the product or its ornamentation" (Registered Designs Act, 1949). Although the Act does not protect computer programs, it could be applied to the designs of 3D products. On the other hand, Unregistered Designs Rights are not monopoly rights, meaning infringements only take place when a physical object is produced from the design. Both registered

and unregistered rights consist of similar criteria, which could mean that many 3D printed products would not be protected. 3D printers are widely used for the production of small technical parts used in appliances. Section 1C of the Act asserts that "a right in a registered design shall not subsist in features of appearance of a product which are solely dictated by the product's technical function." If such products "have individual character," they could be considered as "component part of a complex product" if they "remain visible during normal use of the complex product." The decision in *Amp v. Utilux* clarifies that even if a specific design is chosen out of many other possibilities, all of which are capable of facilitating the function of the "complex product," it could still be excluded from Design Rights. This decision is based on the belief that these possibilities all consist of no creative component and only technical function. Problematically, this belief undermines the creative effort necessary to design functional parts. For instance, it requires a high level of skill to design an exhaust pipe. The original designer as well as the 3D designer should both be able to profit from their designs.

The judgment in *Karen Millen Fashions v. Dunnes Store* in June 2014 is particularly interesting in this context. Karen Millen accused Dunnes Store of copying its design for a shirt protected by Design Rights. Dunnes then appealed by claiming that Karen Millen's design had no "individual character" in the first place because it merely copied parts of other people's designs and assembled them to create this shirt. The Court of Justice of the European Union rejected Dunnes' claim by saying that the combination of all these "parts" gave the shirt a distinctive and 'individual character' which set it apart from all designs that inspired the creation of the shirt. Nowadays, we can easily design a 3D-printed product using software on a personal computer by "mashing up" various features. This process undoubtedly involves considerable creative input and thus, according to *the Karen Millen Fashions v. Dunnes Store* ruling, this process would be protected under Design Rights. That said, such protection could be undermined by Section 7A (2) which states that reproducing a design is legal if it is done "privately and for purposes which are not commercial" or "for experimental purposes." Because most 3D printed products could be exempted from this Act, original designers would be unlikely to profit much from their creations.

FIGURE 4: Left: Karen Millen design; Right: Dunnes copies under its 'Savida' Label.

Patents

Patents are non-automatic rights granted for the protection of novel ideas including mathematical or physical algorithms, ideas behind processes such as recipes, and ideas that control machines. The UK Patents Act 1977 outlines three criteria these ideas must fulfill in order to qualify for a patent issue: the invention "must be new," involve "an inventive step," and possess "industrial application." Although part I (2c) states that "a program for a computer" is not an "invention for the purpose of this Act," there have been more than 20,000 patents issued for computer programs by the European Patents Office as of 2002 (MacQueen, 2011). This inconsistency between EU and UK Laws was brought to the High Court multiple times where the UK Patent Office's rejection of patent applications was challenged by European decisions. Successful patentees are entitled to exclusive rights for up to 20 years under the Trade-Related Aspects of Intellectual Property Rights 1995. The advent of 3D printing, however, demonstrates the limitations of the UK Patents Act. Four features of the Act in particular seem at odds with the very essence of 3D printing.

First, unlike copyright, a person can infringe upon a patent without being aware of its existence. The definition of "infringement" most relevant to the 3D Printing technology is defined under Section 60 (2) as an action which "supplies or offers to supply in the United Kingdom a person other than a licensee or other person entitled to work the invention with any of the means, relating to an essential element of the invention." CAD files are undoubtedly "essential elements of the invention" of 3D printed products as printers cannot print anything without them. Therefore, if a CAD file is uploaded online, patents could be infringed. The use of "a product obtained directly by means

of that process" also constitutes infringement. The monitoring of patent infringement will become virtually impossible when almost all products are printed at home. As the spirit of collaboration lies at the heart of 3D printing, our current patents Law could lead to a surge in unintentional infringements that might remain undetected by Law enforcement authorities. Unlike other patented ideas that traditionally arise from independent research, the advancement of this technology relies on collaboration and teamwork, a phenomenon unrecognized under the current legal framework.

Second, the 1977 Act is territorially restricted. Section 60 (1) requires the infringement to be committed "in the United Kingdom in relation to the invention without the consent of the proprietor of the patent." The two companies comprising the duopoly of 3D CAD files market, Thingiverse and Shapeways, are both US-based companies. Nearly all CAD files are shared on either of these sites, meaning that the activities this Act tries to outlaw is being conducted on foreign land and thus beyond the scope of its influence.

Third, similar to the case of copyright, users can evade patents infringement by modifying CAD files. The ability to customize the product is central to the rise of 3D printing. However, the "tweaking" of patented products solely for repair is legal. This opens up gray areas under the Law—it is unclear whether people can legally "repair" a product so that it becomes customized according to the precise needs of the user, or whether they are only allowed to "repair" a product when it becomes worn-out to restore its original structure. Moreover, an infringement is given special considerations under the 1977 Patent Act if "it is done for experimental purposes." Whether experimenting with a personalized version of the product that best fits the user's needs falls under "experimental purposes" is another matter for further discussion.

Lastly, Patents Act provides an exception for actions that are "done privately and for purposes which are not commercial." The original intent of this clause was to grant as much freedom as possible to individuals without compromising on the profits earned by patent holders, on the basis that private consumption makes up an insignificant portion of the product market and cannot threaten the expansion of such markets sustained by patented ideas. 3D printers challenge this assumption; they restructure economic models by allowing households to act as manufacturers to satisfy their own consumption without needing to engage in any external commercial activities, thereby freeing themselves from patents infringement. While other patents are valued for their "usefulness" in industrial processes (because the Act requires the idea to be "capable of industrial application"), 3D printing is valued for its potential to replace them. All domestic 3D printing will fall under this exception and thus will avoid patents infringement while still limiting the expansion of product markets, the very outcome our Patent Act attempts to prevent.

Conclusion

UK's Copyright, Designs and Patents Act has served its purpose well

since its first implementation in 1988. Innovation has been encouraged and rewarded under the system, facilitating the technological advancement of our country and the competitiveness of our businesses. And yet, ironically, the world we currently live in, which was made possible by this Act, is now hampering the effectiveness of the Act itself. In recent years, the greatest creations are often made online where the enforcement of IP Laws is limited. These breakthroughs have created a more globalized platform where 3D printing flourishes by democratizing the customization of domestic products. Many branches of Intellectual Property under this Act have yet to keep up with the evolution of technology—activities that would normally be illegal are exempted from prosecution if conducted outside the UK or for private use. The US responded to this by issuing takedown notices that bypass the need to refer to current Laws. This sometimes resulted in the over-enforcement of the Law as seen in the case of the Penrose Triangle.

Product Safety

10% of counterfeit pharmaceuticals will be produced with 3D printers by 2019 (Basiliere, 2015), and the Law should intervene to minimise the damage caused by unsafe products (Basiliere, 2015). Arguably, monitoring the production of these products is even more important than protecting IPRs because of the human lives at stake. Law enforcement has traditionally been successful in controlling product production in a centralised economy, but the rise of the Dark Web, coupled with the household usage of 3D printers, poses new challenges to our legal system.

Firearms

The production of firearms is a relatively controversial aspect of 3D printing. In June 2012, a former Texas Law student, Cody Wilson, founded "Defense Distributed" on libertarian ideologies (Popescu, 2016). The company aimed to raise US$20,000 to develop a 3D printable gun (Matus, 2013). Although official donations were suspended early on, the target sum was met in September 2012 through Bitcoins donations (Del Castillo, 2013). The file for an AR-15 semi-automatic rifle titled "the Liberator" was published the following year and was downloaded over 100,000 times within two days. The US Department of State's Office of Defense Trade Controls Compliance immediately issued a takedown notice on the basis that the file violated the International Traffic in Arms Regulations. But by this time the open source platform "Fosscad" (Greenbery, 2014) has already attracted enthusiasts to print out "the Liberator." In response to this, Philadelphia became the first US city to outlaw the "use of a three-dimensional printer to create any firearm, or any piece or part thereof" in 2013. Yoshitomo Imura from Japan became the first person to be jailed for printing a 3D gun in 2014 (Krassenstein, 2014).

FIGURE 5: The Liberator.

As an experiment, two reporters working for Daily Mail 3D printed the "Liberator" using a £1,700 3D printer and attempted to carry it onboard a Eurostar train from London to Paris at St. Pancras International Station in 2013 (Murphy, 2013). Even though the gun was made of plastic, it was capable of firing a deadly 0.38-calibre bullet. In order to evade security checks, they dismantled the gun into three parts, which all successfully passed through the metal detectors because they contain no metal components. These weapons can be easily obtained by anyone who has access to a 3D printer, regardless of their criminal background or mental health status. Alarmingly, homemade firearms have already been used to commit crimes. For example, John Zawahri was banned from purchasing firearms due to his mental illness. In 2013, he assembled his own gun and murdered five people in Santa Monica (Engel, 2013). These incidents expose security risks in an age of terrorism. Defense Distributed sued the Department of State in 2015 for allegedly violating the First Amendment for free speech and the Second Amendment for the right to bear arms (Greenberg, 2015). Whether computer files can be categorised as "speech" is still unclear. The evident functionality of a file may not negate its "expressive" components. The Supreme Court previously ruled that "whatever the challenges of applying the Constitution to ever-advancing technology, the basic principles of freedom of speech and the press, like the First Amendment's command, do not vary when a new and different medium for communication appears" (Scalia, 2011). As the company was founded on libertarian ideologies, the publication of the "Liberator" CAD file could be seen as an expression of the political ideals Wilson and his donors endorse. This right is accompanied by the 'right to receive information and ideas' (Stanley v. Georgia, 1969). The banning of the CAD file would therefore violate the rights of the public as well as of Wilson himself.

Regarding the second amendment, the Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF) ruled on the 23rd September 2016 that "an individual may generally make a firearm for personal use… [but] must be licensed by ATF." Indeed, the right to bear arms would be meaningless without the subsidiary right to manufacture them. The second amendment was constructed to allow citizens to effectively defend themselves. In the past, people did so by acquiring a gun with features that suited their needs, such as weight of the weapon and length of the barrel. 3D printing allows users to customise their own weapons to perfectly fit their preferences. This creates a more level playing field between those who are physically stronger and those who are less so. In particular, customised weapons allow disabled people to create firearms that they can easily operate. However, on 20th September 2016, the 5th Circuit Court of Appeals weighed the benefits of 3D printed weapons against the drawbacks and concluded in a 2-1 decision that:

> Ordinarily, of course, the protection of constitutional rights would be the highest public interest at issue in a case. That is not necessarily true here, however, because the State Department has asserted a very strong public interest in national defense and national security. Indeed, the State Department's stated interest in preventing foreign nationals—including all manner of enemies of this country—from obtaining technical data on how to produce weapons and weapon parts is not merely tangentially related to national defense and national security; it lies squarely within that interest. (Defense Distributed v. Department of State, 2016)

The Streisand effect suggests that the most effective way to publicise a piece of information on the Internet is to ban it. Despite the ruling, the dissemination of 3D gun files remains difficult to control. The Dark Web, which encrypts users' IP addresses so that they cannot be detected by Law enforcement authorities, provides the perfect place for these files to disseminate. Just as the number of downloads surged on Pirate Bay after the State Department took Wilson's gun file down from his website, people could turn to unregulated domains for more of this illegal information.

Products Liability

Products Liability is possibly the area of Law most relevant to the public. It holds institutions that take part in the creation and the selling of a defective product accountable for the injuries the product causes. Products such as mechanical parts, drugs, cells, food, and prosthetics can be printed and sold. Consumers in the UK are protected by both the 1985 EU Product Liability Directive and the 1987 UK Consumer Protection Act. In a 3D printing scenario, however, the line between manufacturers and the consumers is blurred. A 3D printed product involves the contribution of many different parties, such as the designer, the CAD file writer, the printer, the seller, the person who customised it, the person who assembled the parts, etc. Sometimes the customer himself completes all these procedures. This prospect can be daunting for a customer who wishes to recover damages for a defective product.

Due to the lack of case studies in this area, I have invented the following scenario to illustrate the applicability of Product Liability Laws on defective 3D printed products. A designs a skateboard and asks B to create a CAD file for A's design. B tweaks the design slightly and sells it to C. C buys the new design and prints it out in a 3D printing shop owned by D, who buys 3D printers manufactured by M. The employee working at the shop, E, decides to assemble the parts of the printed design for C, but forgets to insert an extra iron screw. C sells this skateboard to F, who is slightly heavier than the weight limit set by A and who injures himself when the wheel where the extra screw should have been inserted comes off. Whom, if anyone, can F sue?

A: The 1987 Act requires A to supply the product "with a view to profit" to be liable. A is not involved in any of the commercial dealings above and therefore is exempted from liabilities. The structure of the end product is also first modified by B, then altered by the way the 3D printer prints. Moreover, A cannot reasonably foresee that his design will be modified, and he therefore is not required to ensure that the design still functions well after slight modification.

B: B is not the original designer of the product and makes insignificant changes to its structure, so it is difficult to argue that his modifications lead to the injury. It is also unclear whether it is sufficient for B to ensure that the product can withstand a user who weighs exactly as much as the original weight limit. The Act also does not specify that B must give instructions on where to insert iron nails. Moreover, "product" is defined as "any goods or electricity" (Consumer Protection Act, 1987) and usually does not apply to intangible assets, such as CAD files.

C: C is an occasional 3D printing hobbyist who does not print and sell products as a living. Therefore, the action is not "in the course of a business of that person" (Consumer Protection Act, 1987) defined in the 1987 Act.

D: D only provides access to 3D printers, and his business only involves the use of his printers. He is not involved in deciding whether these 3D products should be sold. As he plays no part in the use of these products, he cannot be held liable. F's best case for suing D is to prove that he failed to maintain and repair his 3D printers.

M: In order to sue M, F must prove that the 3D printer was defective when it left M's factory and that this defect was the cause of his injury. As the 3D printer has already been in use for several years with no major accidents and has probably printed dozens of other skateboards, it is unlikely that F can sue M.

E: Just like A, C, and D, E is not directly involved in any commercial activities in the selling of the skateboard. He is under no obligation to assemble the parts, and therefore no obligation to *finish* assembling the parts. He is also given no instructions on where to insert iron nails and therefore tries to assemble the parts to the best of his abilities. He does not guarantee C that the skateboard was complete.

Even if F was not overweight, the wheel would have come off and injured somebody. It is difficult to argue that by being slightly

overweight, F should be responsible for his own injury. As seen from the above, it is difficult to sue anyone under the current Acts. The Law needs to recognise intangible products and small-scale 3D printing before it can fully protect consumers' interests.

Fortunately, the application of 3D printed products so far has not led to any liability claims. Instead, these products have saved lives. For instance, functional veins can now be printed using patients' own cells by the BioPrinter owned by Organovo Corporation (Liggett, 2010), and 3D printed vertebrae were successfully implanted in 2015, saving the life of a cancer patient (Reynolds, 2016). The US Food and Drug Administration recognises the value of 3D printing in medicine and approved the first 3D printed drug, Spritam, in August 2015 (Murphy, 2015). The Federal Food, Drug, and Cosmetic Act also allows unapproved medical devices, such as 3D printed ones, to be used in an emergency. In 2012, several newborns were saved by 3D printed bioresorbable airways that obtained emergency clearance from FDA (Ventola, 2014), which also approved a 3D printed Titanium Bone Tether Plate in 2015 (MedShape, 2015). It is predicted that by 2019, 10% of people living in developed countries will have 3D-printed body implants, constituting 35% of surgical procedures (Basiliere, 2015). Whether the Law should loosen its control over unapproved medical devices must be addressed.

FIGURE 6: World's first 3D printed vertebrae implanted in 2015.

Legal disputes surrounding 3D printed products could arise in the near future. The ruling in Winter v. G.P. Putnam's Sons may be a good indicator of how our Law would react to these disputes. In this case, two readers of the Encyclopaedia of Mushrooms were poisoned by mushrooms that were described as "edible" in the encyclopaedia. The

two readers sued the encyclopaedia for being a "defective product," but the court ruled that the information in the book, not the book itself, was defective. Intangible assets such as the contents of the book cannot, under the current Law, be sued under product liability. If the same reasoning were adopted for 3D printing, customers who domestically print 3D products would not be protected as the CAD file they rely on for the printing is a strictly intangible asset. Traditionally, the manufacturer would be responsible for damages caused by the products, but 3D printing allows customers to act as manufacturers themselves. Neither are they unable to sue the person who designs a defective item because designs and CAD files are intangible assets.

Conclusion

While 3D printing has brought medical breakthroughs, it could also threaten our safety. Attempts to prohibit the distribution of gun files on the Internet would be challenged. As guns can now be printed with plastic, they could evade security checks by metal detectors. The creation of the "Liberator" not only tests the effectiveness of law enforcement but also challenges the US Constitution. Moreover, the creation of dangerous and defective 3D printed products is currently difficult to curtail, as the UK Consumer Protection Act does not recognise intangible products and small-scale commercial activities. The first 3D printed product liability claim will likely work against the interests of the consumer, discouraging the use of 3D printed products and disrupting the flow of innovation. 3D printed products ought to be held to the same safety standards as factory manufactured ones, and consumers should be able to recover damages for any defective products. A new legal framework is therefore required.

Data Privacy

3D printers' ability to personalise products, such as organs, often requires biometric data. The UK Data Protection Act 1998 categorises such data as "sensitive personal data," which includes information about one's "racial and ethnic origin," "physical or mental health," and "sexual life." Alongside existing pervasive technology such as the collection of genome data for research and DNA samples of innocent bystanders for crime scene investigations, the advent of 3D body scanning creates another platform where institutions can obtain intimate data from individuals. Our Laws must address to what extent data collected by 3D printers and scanners should be used for commercial or research purposes.

Medical Applications

Organovo Corporation successfully produced the world's first human liver in 2013 for drug testing use (PR Newswire, 2013). In 2015, beauty brand L'Oreal partnered with Organovo to 3D print human skin for testing cosmetics (King, 2015). The use of human tissues to test medical treatments is on the rise, and more CAD files of organs containing information about genetic defects are being created every day. By printing out an exact replica of the organ, doctors can predict

the success rate of an operation or a drug. CAD files, however, contain "sensitive data" about a person's health. It might not be possible to obtain consent from an unconscious patient before replicating his or her organ. Without consent, doctors may be unable to decide whether to perform a particular operation or prescribe a specific drug.

It is also unclear whether consent is required to print out CAD files for research. By printing a copy of someone's diseased organ, scientists can test medications. 3D scanning coupled with 3D printing also allows aspiring surgeons to practice operating on organs. However, patients might be uncomfortable knowing that replicas of their hearts are being sliced open. Their right to privacy might also be infringed. If CAD files about their "physical health" are disclosed to third parties, patients might face discrimination in employment. Companies could exploit their poor health for profits by targeting advertisements, a far from inconceivable consequence in light of the accusations that gambling industry have been harvesting information on income, debt, age and sex from "data houses" to target their online advertisements. (Busby, 2017) Companies could even group all patients with the same disease by their "racial or ethnic origins," and if a certain race is found to be susceptible to a specific impairment, that race could face social discrimination in being adopted, or entering into relationships and marriages. Racial origins could even become a factor in insurance costs.

Other Commercial Applications

The adult toy business thrived under the advent of 3D scanners because of the privacy and personalisation that 3D scanning offers. 3D printed sex toy retailer SexShop3D was launched in 2014, and in 2016 the company released their first customisable product, the Pocket [Ladypart]. Customers hoping to order customized sex toys based on their own individual anatomies first choose the colour of their skin tone, upload a 3D scan of the shape of their genitals, then either buy the CAD file to print at home or have the company 3D print for US$70 (Grunewald, 2016). This biometric data falls under "sensitive information," which describes a person's "sexual life," but the company can use the data collected as a reference when designing its next product. SexShop3D could categorize information according to racial background and find out the preferences of each group, just as Facebook currently allows advertisers to exclude audience of a specific "Ethnic Affinities," including African Americans, Asian Americans and Hispanics (Angwin and Parris, 2016). Even if the data is anonymised, information about the sexual preferences and genital sizes of a particular race should fall under "sensitive personal data." The dissemination of this information will have implications for human rights and privacy.

Similarly, 3D scanning is used to scan bodies in the fashion industry in Australia. In March 2014, the company mPORT introduced the world's first 3D body scanning booth, mPOD (Collins, 2014). The company is now partnered with Westfield and aims to set up mPODs in every centre for its 60,000+ members (MPort, 2016). The mPODs

produce a naked avatar by using infrared light to scan and record 200,000 points of reference around the customer's body, after the customer has removed all of his or her clothes except undergarments. The service provided by mPORT is divided into two features: myFASHION and myHEALTH. myFASHION sends the naked avatars to other clothing brands for size recommendations and even orders custom-made clothing. myHEALTH tracks users' BMI, fat composition and hip-to-waist ratio. This information is classified as biometric data and falls under "personal sensitive information."

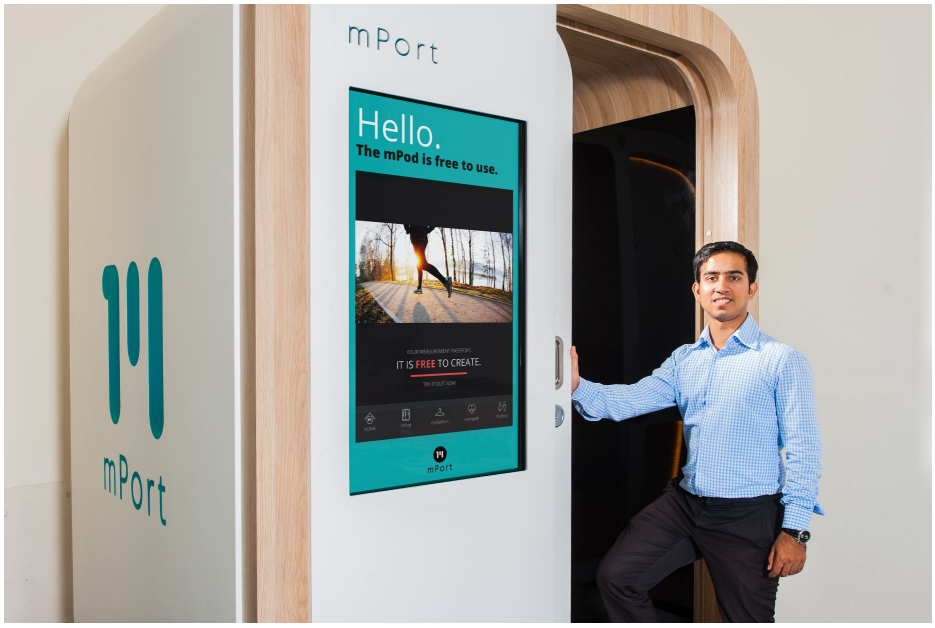

FIGURE 7: Dipra Ray, CEO, co-founder and Managing Director of mPORT.

Such application of 3D technology raises privacy concerns. The FAQ page of mPORT declares that "general data may be used for research purposes, but only namelessly to ensure anonymity." The company is the one to decide what "research purposes" may encompass, leading to a lack of transparency in its conduct. Its privacy policy also allows mPORT to collect "information required for mPORT's functions and activities" from sources such as "social media and similar websites." The wording in the privacy policy is ambiguous, allowing much leeway for mPORT to decide how "personal sensitive information" should be handled. They could send body measurements to fashion brands so that these brands could target their advertisement to people with a specific body shape. This scenario borders on discrimination. Moreover, the collected information could be analysed to form predictions about the user's race and socio-economic status for "research purposes." Fortunately, mPORT's Australian users are protected by the Australian Privacy Principles and the new and tightened Privacy Act 2014. But these Acts only recognize data about "an identified, or reasonably identifiable, individual." If the data

collected by mPORT is anonymized, it will not be subjected to strict regulations.

If 3D body scanning reaches UK markets, users will be protected by similar Laws. Under Article 7 of the EU Data Protection Directive, these "personal sensitive data" could be collected for "legitimate interests." This guideline lacks clarity, thereby creating legal loopholes for businesses to exploit for their own gains. This problem is particularly difficult to resolve even if Laws are enforced because fines against businesses are often set at too low a rate. Indeed, personal privacy is not very well protected in the UK. The UK owns the world's largest DNA database of 3.6 million entries collected from crime scenes (Johnston, 2006) and the largest number of CCTVs in public areas—a total of four million, or one for every eleven citizens (Barrett, 2013). The European Court of Human Rights recognizes the danger of the UK owning such a large DNA database and states that unless the data is stored "in accordance with the law and is necessary in a democratic society," it will infringe upon privacy rights under Article 8 of the European Convention on Human Rights. With the advent of 3D scanning, Bentham's Panopticon doesn't seem so much of a dystopian fiction after all.

Conclusion

Due to the customizable nature of 3D technologies, the data collected from 3D printers and scanners is increasingly intimate. Technology is becoming increasingly pervasive technology as it is used to identify individuals by their physical features, such as DNA samples, CCTV cameras, and fingerprints. It is of paramount importance that "sensitive personal data" be used not for exploitation but for genuinely "legitimate" reasons like medical care and law enforcement. If the data is leaked, discrimination may result. Given the apparent lack of clarity of our Data Protection Act, the current Law does not govern the expansion of privacy intrusion.

Proposal to Amend the Law

There have been incremental developments in our legislation to accommodate the challenges 3D printers present, but the evolution of this technology still outpaces that of the Law. The legal implications of 3D printing are vast, threatening intellectual property rights, public safety, and privacy. The implementation of a new legal framework is a matter of great urgency. That said, the Law can never solve all the problems posed by technology – for example, despite Internet regulations, the Dark Web emerged as a haven for illegal activities away from governmental control. But it is inevitable that criminals will always exist, no matter how faultless a legal system is. The following proposal seeks to minimize, not eradicate, the negative effects brought by the advent of 3D printing.

Enforcing Intellectual Property Laws that were written for a centralized and industrial economy is an uphill battle in the world of 3D printing. The value of this technology lies in its capacity to customize goods, rendering most products ineligible for infringement

claims. If the contribution to these products is split fairly evenly between various designers, we must recognize "joint authorship" under section 4 of the 1988 Act. But if customers are only allowed to tweak the designs within fixed parameters, without changing the overall character of the product, the original designer should remain as the sole owner of its IPR. The question of IPRs attribution for design files should also be addressed to facilitate innovation. CAD files are currently excluded from IP eligibility because it is "intangible;" the requirement for products to be "tangible" should be reformed to keep up with newer forms of creations. Whether these files are eligible for IPR must be evaluated according to their innovative elements. For instance, CAD files generated by 3D scanners are comparable to Google's Street View images, which are taken with customized panoramic lens every 2.5 seconds (Sparkes, 2014). The manual adjustments of camera settings, such as the angle and aperture, earned Google the copyright to these pictures despite the automation of photo taking. If the process of 3D scanning requires similar creative input, such as special lighting or manually locating the "points of reference," then the files should be entitled to IPRs. Takedown notices are currently issued only as a remedy for copyright infringement; these notices should be extended to other areas of IP Law for fuller protection. Territorial restrictions should also be removed from Patents Law to keep up with the increasingly globalised world, so that illegal activities occurring on US-based websites could be prosecuted by citizens who live in other countries but are still harmed by the activities.

The safety of consumers is undermined by the blurring of lines between manufacturers and consumers, which goes against the traditional framework of liability attribution. Historically, commercial manufacturers have almost always been held accountable for the injuries caused by defective products. Nowadays, domestic manufacturers who 3D print goods for themselves are not capable of inspecting their own products by conducting safety tests as commercial manufacturers often do. As copyright and patents holders are credited for their creation, they must also be held liable for any damages they cause. In a 3D printing scenario, the Law should therefore allow consumers to sue the designer instead of the manufacturer. Alternatively, as Berkowitz suggested, a new category for "micro-sellers" (Berkowitz, 2015) could be introduced. Domestic manufacturers who occasionally sell their products could be held liable, but a "fairness analysis" would be conducted to determine his blame. This analysis would take into account the manufacturer's experience in manufacturing, scale of business, ability to buy insurance, and good faith, so that 3D hobbyists would not bear the huge penalties intended for larger corporations. However, in order to address the cause of dangerous goods, designs of products should be subjected to the same safety standards as manufactured goods. When a seller sells the CAD file of a particular product, its printed, physical form must be approved by government safety regulations. The domestic 3D printing of safety products such as seat belts, helmets, airbags, and goggles should also

be outlawed so that these products' quality can be carefully monitored to prevent serious injuries. As for 3D printed firearms, there is a limit to how effective the Law can be at prohibiting the dissemination of 3D gun files on the Internet. New laws could compel 3D printers manufacturers to download software that detects and prevents 3D printing firearms. Although the rights to free speech and to bear arms are enshrined in the US Constitution, the Law must be prepared to prioritize the safety of the nation by compromising on such rights.

The greatest limitations of both IP and liability Laws are the exceptions given to non-commercial activities and their territorial restrictions. The democratization of 3D printers will allow most household products to be printed at home in the future—under current laws, this household production will not be eligible for IP and liability protection. Designers who invest effort into the creation of 3D printable products will not be able to benefit financially from their designs. Consumers will also be unable to sue designers for damages caused by hazardous designs. This exception for non-commercial activities should therefore be removed from the Law. Moreover, 3D printing activities often span across several jurisdictions—people from all over the world could participate in the designing, customization, manufacturing, or copying of one product. Governments must work together to devise international legal agreements so that Laws can be enforced across jurisdictions.

The Laws on data privacy are convoluted at best. As data becomes increasingly personal, it also increases in value. This provides great incentives for businesses to exploit the loopholes in our current legal framework so that they can profit from this data. First, the definition of "legitimate interests" under the Law should be clarified—for example, for medical care and law enforcement purposes only—so that the phrase does not allow businesses to exploit personal sensitive data for their own gains by declaring that it is in the company's "legitimate interest" to generate a profit. This change, however, might hamper their ability to target products towards specific groups of customers, thus repressing their profit gains—lawmakers therefore must be careful not to discourage research and development in technological firms. Second, the fines for a breach in data privacy should be raised in order to effectively deter firms from treating these fines as another form of investment costs. This fine increase also could discourage development, especially among infant industries and new technologies that face higher barriers to entry; again, lawmakers must be careful. Third, the company must clearly explain to consumers how it uses personal information before asking for consent, rather than embedding this information within pages of terms and conditions. Disclaimers should not be used and must not exempt businesses from any legal constraints on their use of personal data. Lastly, data should be completely anonymized. This requires not only names to be removed from the data, but also that sensitive information about a certain category of people and information such as race, socioeconomic class, and disabilities should only be used for medical research. However, the Law should not require consent from a patient

in an emergency before a doctor can 3D print body tissues, as long as the information collected is handled appropriately. The Laws on unapproved medical devices should also be loosened so that 3D printed medical devices can be used more widely for better healthcare.

It is therefore of paramount importance that a new legal framework be introduced. It is equally essential that new Laws not be so restrictive that they interfere with the growth of 3D printing technology. The balance of these two concerns will vary across jurisdictions, but lawmakers around the world should move toward a universal framework that will allow cross-borders criminal activities to be controlled.

Conclusion

The evolution of mankind has been shaped by a number of revolutions. In recent history, societies have been transformed by the industrial revolution in the 19th century, globalization in the 20th century, and the Internet age in the last two decades. Laws have evolved to accommodate the changes brought about by these events. Today, we are at the brink of another revolution. The advent of 3D printing has ushered in another era for the legal world, defying all economic norms upon which our Laws have been constructed.

The advent of 3D printing brilliantly demonstrates the multifaceted nature of the Law. This paper has explored the Law in relation to the 3D printing revolution, namely Intellectual Property, Gun Control, Product Liability, and Data Protection. The rise of the Internet has provided useful context for how these branches of Law might respond to the new "disruptive technology" of 3D printing (Zurcher, 2014). The music industry was particularly hard hit by this transformation, which enabled netizens to illegally download millions of soundtracks for free at the click of a mouse. Although the industry successfully took legal action against Napster, a file sharing site, in 2000, their attempt to halt the surge in piracy was largely futile. This forced the industry to adjust its business model, and many artists now rely on an average of US$0.007 per Spotify stream as the only alternative to having their music entirely pirated on other platforms. 3D Printing is the music piracy of our era, as discussed in this paper, which has largely focused on UK domestic Laws, though international cases, such as gun control in the US, also provide insight into the issues raised by 3D printing.

Discussions on IP are categorized into Copyrights, Designs and Patents. This paper raises the question of whether CAD files should be copyrightable, and makes the distinction between purely automated and skilled 3D scans. As 3D printing opens up the opportunity for mass customization, the Law should recognize co-designers by adopting the policy framework proposed by Digital Forming. The main issue with Design Rights is that they do not cover technical designs, undermining the creative input of designers who seek to constantly improve existing functional objects. As for patents, an exception for "private use" is permitted and only domestic infringements are prosecuted. These criteria stand in direct contradiction to the very

essence of 3D printing—to domesticate and globalize manufacturing by allowing the entire world to instantaneously share the same physical products.

Products safety is possibly the most critical area this paper examined, as it is responsible for safeguarding human lives from terrorist attacks and defective products. CAD files of functioning firearms are available for downloading and printing with just a £1,700 3D printer. Most disturbingly, these lethal weapons could be made out of plastic and evade metal detectors at security checks. If these firearms fall into violent hands, the deranged or the absent-minded, the security of the nation could be threatened. Although the problem of liability attribution is of less urgency, it perhaps resonates most with the majority of customers. Designers who benefit from intellectual property rights in recognition of their contribution should bear the responsibility for any damages caused by their designs.

The erosion of privacy and liberty is unfortunately not a novel concept in modern society. If sensitive data is poorly handled, discrimination may result. Ambiguous definitions must be eliminated from the Law so that institutions cannot take advantage of this ambiguity for profits. This paper's proposed amendments to our Law provide a solid foundation for the Law's evolution.

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