Journal of Intellectual Property Studies
Vol. VI (2), July 2022, pp. 67-82

THE POTENTIAL ROLE OF 3D PRINTING TECHNOLOGY IN ENABLING LOCAL ENTREPRENEURSHIP: TO WHAT EXTENT PATENT LAW POSES A BARRIER

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Abstract

3D printing or additive manufacturing allows the rapid conversion of information from pre-designed digital 3D models or computer-aided design ["CAD"] files into physical objects through the continual addition of layers of material. This approach is in contrast with conventional manufacturing processes in which physical shapes emerge either by removing material, as in machining, or changing the shape of a set volume of material. This modern method of manufacturing does away with the time-consuming and costly tooling and machining requirements. The cost of failure is low in 3D printing and it allows flexibility in manufacturing. It is cost-effective in many other ways because there is no need of warehousing or far-off transportation. The advancements in 3D printing technology offer a new hope to the less privileged and under-resourced people with brilliant entrepreneurial ideas. With advances in material science and affordable availability of portable 3D printers, this disruptive technology is rapidly maturing to a level to support local entrepreneurship. This study undertakes an analysis of the potential of 3D printing in enabling local entrepreneurship and actual or potential challenges posed by patent laws. Part I of this paper evaluates the unique benefits of this revolutionary technology with a key focus on harnessing the potential of 3D printing in enabling local entrepreneurship. Part II examines to what extent patent exclusive rights possibly become a hurdle in using the full potential of 3D printing technology.

I. INTRODUCTION

The term 3D printing is used to describe 'any process of creating a physical object through the continual addition of layers of material – in contrast with conventional manufacturing processes in which physical shapes emerge either by removing material, as in machining, or changing the shape of a set volume of material, as in injection moulding of plastics or casting of metals.'[1] 3D printing is a revolutionary technology because of its enabling role in turning ideas into tangible objects. As noted by the former President of United States of America, Barack Obama, in his 2013

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[1] KLAUS SCHWAB & NICHOLAS DAVIS, SHAPING THE FOURTH INDUSTRIAL REVOLUTION (2018). [hereinafter 'Davis'].

State of the Union Address, 3D printing technology has 'the potential to revolutionize the way we make almost everything.'[2]

The advancement in 3D printing technology offers a new hope to the less fortunate people who have brilliant entrepreneurial ideas but do not have adequate resources. With advances in material science and affordable availability of portable 3D printers, this progressive technology is rapidly maturing to a level to support local entrepreneurship. This unique method of manufacturing is well-suited to help creative individuals harness their entrepreneurial potential. Entrepreneurial activity is defined as 'enterprising human action in pursuit of the generation of value through the creation or expansion of economic activity, by identifying and exploring new products, processes or markets.'[3] 3D printing, which enables on-demand manufacturing of customized or personalized products in a timely and risk-free manner, is uniquely well positioned to support new business ideas. 3D printing service bureaus and online markets further add to an enabling ecosystem for entrepreneurship based on digital fabrication.

This study undertakes an analysis of the potential of 3D printing in enabling local entrepreneurship and actual or potential challenges posed by patent laws. This analysis, with respect to practical and legal aspects, draws upon a wide range of sources including statutes, peer-reviewed publications, blogs, quotations from stakeholders, media reports, and real-world examples. Part II of this paper evaluates the unique benefits of this revolutionary technology with a key focus on harnessing the potential of 3D printing in enabling local entrepreneurship. Part III examines to what extent patent exclusive rights possibly become a hurdle in using the full potential of 3D printing.

Although there are some significant jurisdictional differences, the discussion in this study, with limited scope, is confined to the patent laws in the European Union (EU). It aims to answer the following legal questions: What is patent infringement liability of entrepreneurs who use 3D printing as a business strategy? What is patent infringement liability of intermediaries storing and distributing CAD files? What is liability of physical suppliers of 3D printers and filaments/ printing material? What is liability of 3D printing service bureaus? What defenses are available to all these potential infringers of patent rights? These legal questions are important in determining the future of 3D printing as an enabler of local entrepreneurship. This study will help policymakers at national

[2] Office of the Press Secretary, *Remarks by the President in the State of the Union Address*, THE WHITEHOUSE PRESIDENT BARACK OBAMA (Feb. 12, 2013), https://obamawhitehouse.archives.gov/the-press-office/2013/02/12/remarks-president-state-union-address.

[3] Marie Lavoie & James L. Addis, *Harnessing the potential of additive manufacturing technologies: Challenges and opportunities for entrepreneurial strategies*, 2 INT'L J. INNOVATION STUD. 123–36 (2018) [hereinafter 'Lavoie & Addis'].

and international levels by contributing to the debate over intellectual property and the scope of 3D printing in enhancing social and economic welfare of communities across the globe.

II. THE UNIQUE BENEFITS OF 3D PRINTING FOR ENTREPRENEURS

Because of its several disruptive features, the concept of 3D printing has initiated an entrepreneurial "maker" movement giving masses the opportunity to build something from ground zero.[4] This section evaluates the unique benefits of this revolutionary technology with a key focus on harnessing the potential of 3D printing in enabling local entrepreneurship.

A. Cost-Effectiveness

With the help of 3D printing, the complexities in manufacturing are exponentially reduced. If we are using traditional methods of manufacturing, the cost is higher if the shape of an object is complicated. On the other hand, if we are using 3D printing technology, manufacturing complex objects costs almost the same as manufacturing simple objects[5] It is hard to make complex products by using traditional manufacturing techniques because multiple parts need to be made and assembled. It is impossible to produce some very complex geometries through traditional methods. Traditional manufacturing technologies are efficient when we are dealing with simple curves and straight lines[6] Computer-aided designing has enhanced our capability to think beyond traditional geometry. 3D printing allows us to not only imagine but also build complex and innovative mathematical forms.[7]

3D printing enables fabrication of 'customized products with complex shapes according to customer preferences'[8] at little or no additional cost. Nearly any geometry can be produced as 'there are no limitations in the digital representation of real-world objects, at least conceptually.'[9] The freedom of designing and manufacturing assembly-free complex and innovative objects cost-effectively opens up new and exciting possibilities for entrepreneurship. Moreover, complex shapes can be produced using less material, because of additive processes, as compared to

[4] LUCAS S. OSBORN, 3D PRINTING AND INTELLECTUAL PROPERTY (2020) [hereinafter 'OSBORN'].
[5] Hod Lipson & Melba Kurman, *The Ten Principles of 3D Printing*, BIG THINK, https://bigthink.com/experts-corner/the-ten-principles-of-3d-printing (*last visited Nov. 23, 2020*).
[6] Matthew Connell et al., *Out of Hand: Materialising the Digital*, GREEN MAGAZINE, https://greenmagazine.com.au/out-of-hand/ (*last visited Nov. 24, 2020*).
[7] *Id.*
[8] Aamer Nazir et al., *The rise of 3D Printing entangled with smart computer aided design during COVID-19 era*, 60 J. MANUFACTURING SYS. 774 (2020).
[9] Lavoie & Addis, *supra* note 3.

traditional methods of manufacturing.[10] This method does not waste materials because 'instead of starting with a solid block of material and cutting it down to a shape, an object is built by adding one layer of material at a time.'[11] Self-assembled complex objects can be fabricated in one build by using this method, which reduces cost by cutting out manufacturing steps, labour, and machinery.[12]

The cost of prototyping is a significant factor in determining the cost of bringing a product to market.[13] 3D printing is important for entrepreneurs because prospects for acquiring outside funding and making early sales increase if the costs of prototyping is reduced.[14] 3D printing also reduces the time and effort involved in prototyping. When using a traditional manufacturing method, expertise in manufacturing engineering and a large-knowledge base is required in terms of analysing the geometry of the design and planning the tools and processes accordingly. On the other hand, when using a 3D printing method, time and effort is saved because you just need to know about the different printing materials, and understand the basic mechanisms of 3D printing methods. There is no need of expertise in manufacturing engineering or a large knowledge-base.[15]

3D printing technology enables start-ups to get off the ground sooner, without incurring prohibitively high costs. Building prototypes is cheaper and easier with 3D printing tools. It is possible not only to increase the number of iterations but also to decrease the time between iterations.[16] Without this technology, prototyping is both expensive and time-consuming. It may take weeks to complete if the design is complicated.[17]

B. Low Infrastructural Needs

3D printing can be an enabler of a fundamental shift in how products are designed, manufactured and distributed. To become a manufacturer, one does not need to own a factory or start a company. Anyone having creative ideas and access to digital manufacturing tools and skills can potentially become a manufacturer. This technology substantially reduces financial barriers to market entry. Low-cost entry is possible for individuals or start-ups that understand 3D printing

[10] Laxitha Mundhra, *From Face Shields to Ventilators and Nasal Swabs, 3D Printing is changing the Medical Scenario,* CIOL (Apr. 8, 2020), ciol.com/face-shields-ventilators-nasal-swab-3d-printing-changing-medical-scenario/) [hereinafter 'Mundhra'].
[11] Lesley M. Cano, *Basics of 3D Modeling and Printing*, *in* 3D PRINTING: A POWERFUL NEW CURRICULUM TOOL FOR YOUR SCHOOL LIBRARY (2015) [hereinafter 'Cano'].
[12] R WARNIER et al., PRINTING THINGS. VISIONS AND ESSENTIALS FOR 3D PRINTING (2014).
[13] Eric Joseph Van Holm, *Makerspaces and Contributions to Entrepreneurship*, 195 PROCEDIA - SOC. BEHAV. SCI. 24–31 (2015) [hereinafter 'Holm'].
[14] *Id.*
[15] Ho Nam Chan et al., *Point-of-care testing: Applications of 3D printing*, 17 LAB CHIP 2713 (2017).
[16] DALE DOUGHERTY, FREE TO MAKE: HOW THE MAKER MOVEMENT IS CHANGING OUR SCHOOLS, OUR JOBS, AND OUR MINDS (2016).
[17] OSBORN, *supra* note 4.

and the market and have access to the right equipment. Objects can be designed by using freely available and easy to learn open-source 3D modelling software tools, like Tinkercad.[18] Creating design drawings without this technology is a cumbersome process. As noted by Lucas Osborn, "individuals might have needed to hire a draftsperson to create technical drawings. They also would have needed to take those drawings to a manufacturing intermediary who would facilitate prototype construction."[19]

Scanning is another way to procure designs (of the existing objects). 3D scanners and certain smartphone applications make it possible to get a digital 3D photocopy of an object. The digitized object can be 3D printed as it is or modifications can be made in the digital file before printing a tangible object. Some websites like Thingiverse, GrabCAD, and YouMagine offer a plethora of accessible digital designs. These can be downloaded free of cost or at low cost. [20]

After content creation, the next phase is production, for which one needs access to 3D printers. 3D printers are becoming increasingly affordable.[21] A wide range of sources are used for producing filaments (printing material) for 3D printers. The price varies depending on the base material. The price of a filament is generally not exorbitant. According to a 2018 study, "a kilogram of 1.75 mm ABS filament reel costs around $30 on Amazon."[22] Variety is free because roughly the same technological infrastructure can be used to fabricate diverse objects that may substantially differ in shape or design.[23]

One does not require warehousing because there is no need to keep stock of intangible objects. Digitized objects can be delivered or distributed virtually without requiring additional infrastructural or transportation costs. The digitized files can be downloaded from the comfort of one's desktop and 3D printed into physical goods. In case of meeting the demand for already printed physical objects, there is no need to produce products in huge quantities. Products can be 3D printed and shipped or mailed as per demand. The costs and risks[24] are substantially reduced

[18] Mundhra, *supra* note 10.
[19] OSBORN, *supra* note 4.
[20] Dana Mahr & Sascha Dickel, *Rethinking intellectual property rights and commons-based peer production in times of crisis: The case of COVID-19 and 3D printed medical devices*, 15 J. INTELL. PROP. L. PRAC. 711–717 (2020) [hereinafter 'Mahr and Dickel'].
[21] Shardha Rajam & Adya Jha, *3D Printing – An Analysis of Liabilities and Potential Benefits Within the Indian Legal Framework,* 11 NUJS L. REV. 361 (2018); Simon Bradshaw, Adrian Bowyer & Patrick Haufe, *The Intellectual Property Implications Of Low-Cost 3D Printing*, 7 SCRIPTED 5 (2020).
[22] Bruno Borralho Gobbato, *Setting Up Your Own Home 3D Printing "Plant" in* 3D PRINTING IN ORTHOPAEDIC SURGERY 195–208 (2018) [hereinafter 'Bruno Borralho Gobbato'].
[23] Mahr & Dickel, *supra* note 20.
[24] Thomas Birtchnell & William Hoyle, *The 3D4D Challenge*, *in* 3D PRINTING FOR DEVELOPMENT IN THE GLOBAL SOUTH (2014) [hereinafter 'Birtchnell and Hoyle'].

as a number of logistical requirements and external factors become irrelevant in the supply chain management.

Low infrastructural needs for 3D printing contribute to the development of more user innovations and the creation of new enterprises by attracting more people into product design and development.[25] Many innovative individuals may actually become entrepreneurs if they find that there is a market for their creative user solutions.[26] Such accidental entrepreneurship is not hypothetical. There are many instances where lead users primarily developed products to solve their own problems before realizing that the product resulting from their innovative problem-solving can have a potential market. So, many firms are started based on innovative solutions to personal problems.[27]

C. Personalized and On-Demand Manufacturing

3D printing can be an enabler of new consumer centric business models. With 3D printing tools, 'design changes can be made quickly and easily with little or no additional cost.'[28] Mass customization is feasible with 3D printing because 'each item is created individually, rather than from a single mould, each can be made slightly differently at almost no extra cost.'[29] Convenient and cost-effective customization in 3D manufacturing increases the role of consumers in shaping the demand for unique and personalized products. Users can also choose base materials for 3D printing as per their individual preferences.[30]

New features can be added to the existing designs by iterating the CAD files according to any specific demands of individual consumers.[31] This personalized component distinguishes 3D printing from other manufacturing techniques. Other manufacturing methods 'require significant investment for the research, development, and production of tools, after which the design is pretty much locked.'[32] The ability to develop and deliver customised and personalized products via 3D printing offers a great value to entrepreneurs as they can build their business around such products. Xiaowei Xu and others rightly noted that:

[25] Holm, *supra* note 13.
[26] *Id.* 24.
[27] Holm, *supra* note 13.
[28] Cano, *supra* note 11.
[29] Lavoie & Addis, *supra* note 3.
[30] Xiaowei Xu et al., *Research on 3D printing service model for innovation, entrepreneurship, and universal applications*, 2020 J. ENG. 466 (2020) [hereinafter 'Xu et al.'].
[31] DOUGHERTY, *supra* note 16.
[32] Tobias Mueller et al., *Eight Weeks Later — The Unprecedented Rise of 3D Printing during the COVID-19 Pandemic — A Case Study , Lessons Learned , and Implications on the Future of Global Decentralized Manufacturing*, 10 APPL. SCI. 4135 (2020).

"With the improvement of people's material living standards, consumers' user needs tend to be personalised, and more and more people are pursuing personalised customisation. The characteristics of 3D printing technology make it can meet the needs of consumers infinitely."[33]

The availability of digital fabrication tools can have a transformational impact as these tools 'allow the physical world to be more mouldable, and therefore, more similar to the digital one.'[34] As the design is available in the digital form, modifications and adjustments can be made depending on what is working well and what improvements can be made. It allows entrepreneurs freedom to imagine things that do not exist but may be useful if such imagination is conveniently reduced to tangible objects. 3D printing, therefore, has an empowering role in making the world a better place.

On-demand manufacturing is possible with 3D printing because manufacturers do not have to worry about the minimum order or economies of scale. As set up costs and efforts are negligible, making a single object is as financially and practically viable as making a thousand objects. Neil Gershenfeld rightly noted that 3D printing process is capable of 'producing products for a market of one person.'[35] This unique feature offers a huge advantage to entrepreneurs or small start-ups as traditional methods of manufacturing that involve complex processes like moulding, forming, casting, and machining or subtractive methods are prohibitively costly and cumbersome for low-volume production.[36]

Traditional methods do not support on-demand manufacturing because the per piece production cost will be too high to afford if there is no economy of scale.[37] Because of large upfront costs in terms of tooling and customized labour, manufacturing by using traditional methods is a risky proposition. It is hard to determine how many copies of the product need to be manufactured because market demand cannot be foreseen with any precision. There is an issue of sunk cost resulting from unsold or unused products. 3D printing avoids upfront costs as well as irretrievable sunk costs because products can be manufactured on a need basis according to the demand.[38]

D. An Enabling Ecosystem

Using a 3D printer is not as simple as a click of a button. One needs to learn the required technical skills to make proper use of 3D printing tools. It is important to understand how materials interact

[33] Xu et al., *supra* note 30.
[34] Holm, *supra* note 13.
[35] Neil Gershenfeld, *How to make almost anything-The Digital Fabrication Revolution*, 91 FOREIGN AFF. 43 (2012).
[36] ROSA MARIA BALLARDINI ET AL., 3D PRINTING, INTELLECTUAL PROPERTY AND INNOVATION: INSIGHTS FROM LAW AND TECHNOLOGY 90 (Wolters Kluwer, 2017).
[37] Mostapha Tarfaoui et al., *Materials 3D Printing to Support the Shortage in Personal Protective Equipment Caused by COVID-19 Pandemic*, 13 MATERIALS (BASEL)(2020).
[38] OSBORN, *supra* note 4.

with a 3D printer. It is also important to know the design software and acquire CAD modelling skills to design objects. Similarly, the idea of scanning physical objects and 3D printing digitized objects may seem simplistic, but "the scanned models generally require a lot of tweaking before they can be used to print objects."[39] Acquiring new technical skills has become relatively simpler for entrepreneurs because of the availability of wide-ranging tutorials on the internet which address almost every detail and every problem that one might face in using 3D printing tools.[40]

There are hundreds of makerspaces around the globe.[41] Fab labs or makerspaces primarily empower people to create by enhancing access to tools for producing new products. Makerspaces 'commonly hold over $100,000 (USD) in equipment, a cost that would be prohibitive for an individual but is manageable when spread throughout the membership.'[42] More importantly, these spaces are 'designed to accommodate creative people and entrepreneurs who are trying to break the barrier of isolation and find a pleasant work environment that favours the development of partnerships.'[43] Makerspaces and Fab labs 'not only provide access to equipment and materials, but also to the expertise of the mentors and the internal/external network that comes with working in such facilities.'[44] Members from diverse backgrounds share their knowledge, skills, and ideas with peers to create a conducive and supportive environment for creativity and innovation.[45] Some makerspaces, like TechShop,[46] also play a role in building capacities by offering classes to help familiarise the members with the technical skills required.[47]

The enabling ecosystem for 3D printing includes viable mechanisms to reduce the start-up costs for entrepreneurs. Access to 3D printers can be possible without actually buying one. There are a variety of 3D printing service providers that print and deliver objects.[48] Many of these service centres are available on the internet, making it convenient for users to upload designs, get an

[39] Bruno Borralho Gobbato, *supra* note 22.
[40] 3D Now, *The Ultimate Beginner's Guide to 3D Printing – Part 1,* YOUTUBE (Mar. 11, 2017), https://www.youtube.com/watch?v=3LBTkLsjHGQ; *Tutorials*, SHAPEWAYS, https://support.shapeways.com/hc/en-us/categories/360001855814-Tutorials.
[41] HACKERSPACE, https://hackerspaces.org (last visited 16 June 2022).
[42] Holm, *supra* note 13.
[43] R Mitoula et al., *Co-working spaces in Greece after Covid 19 era*, ONLINE SYMP. CIRC. ECON. SUSTAIN. 2012–13 (2020).
[44] Rigoberto C. Advincula et al., *Additive manufacturing for COVID-19: devices, materials, prospects, and challenges*, 10 MRS COMM. 413 (2020).
[45] Holm, *supra* note 13.
[46] Alan Gershenfeld & Joel Cutcher Neil Gershenfeld, DESIGNING REALITY: HOW TO SURVIVE AND THRIVE IN THE THIRD DIGITAL REVOLUTION (2017); MARK R. HATCH, THE MAKER REVOLUTION: BUILDING A FUTURE ON CREATIVITY AND INNOVATION IN AN EXPONENTIAL WORLD (2017).
[47] TAKE CLASSES, https://web.archive.org/web/20171012125351/http://www.techshop.ws/take_classes.html.
[48] Bruno Borralho Gobbato, *supra* note 22; *See* more Josef Drexl, Anselm Kamperman Sanders & Nari Lee, *Intellectual property rights and open innovation in 3D printing: a different form of exclusivity*, *in* THE INNOVATION SOCIETY AND INTELLECTUAL PROPERTY 231–60 (2019).

instant quote, and get the printed objects shipped.[49] More familiar examples include Shapeways,[50] Voodoo Manufacturing,[51] and 3DHubs.[52] These online services charge fee for printing digital designs submitted to them and shipping the objects to the given address.[53] Potential manufacturers, who do not have financial capacity to have their own infrastructure, can use these services to deliver items to their clients. It is, therefore, possible to launch businesses without shouldering the costs of infrastructure.

Market access and having knowledge about the available markets are key factors in the potential growth of any enterprise.[54] Market access and awareness should not be a concern for entrepreneurs who leverage unique capabilities of 3D printing. All they need is a browser and an internet connection to sell their products through online marketplaces like Shapeways.[55] They can make their designs available for sale directly from Shapeways. They have an option to set their own shop up in the virtual space through signing up to Shapeways and start accepting and fulfilling orders from across the globe without expensive investments in marketing their products to the global audience.[56]

III. LIABILITY OF STAKEHOLDERS UNDER PATENT LAW

The advancements in 3D printing tools and their affordable availability bring new challenges for the patent law system because of the very realistic possibility of large-scale patent infringement. Anyone who has access to a 3D printer can be a potential manufacturer. The digital design files are easily accessible on the Internet and allow for a product to be replicated. 3D scanning applications are available on the smart phones. A combination of these tools provides a functional ecosystem to digitize and fabricate patent-protected objects without approval.

The advent of 3D printing benefits the society in general and entrepreneurs in particular, however, it raises serious concerns with regard to the commercial interests of patent holders and other stakeholders in the traditional manufacturing and supply chain model. Conventionally, before products become available to consumers either at bricks-and-mortar retail outlets or online stores,

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[49] Birtchnell and Hoyle, *supra* note 24.
[50] SHAPEWAYS, https://www.shapeways.com.
[51] VOODO, https://www.voodoomfg.com.
[52] HUBS, https://www.3dhubs.com; Hubs, *3D Hubs – focus on creating great products,* YOUTUBE (Dec. 9, 2020), https://www.youtube.com/watch?v=QOhG35sUMKs.
[53] Kelsey Wilbanks, *The Challenges of 3D Printing to the Repair-Reconstruction Doctrine in Patent Law*, 20 GEO. MASON L. REV. 1147 (2013) [hereinafter 'Wilbanks'].
[54] Marsha A. Tongel, *The feminine paradigm of entrepreneurship in the informal economy in* ENTREPRENEURSHIP IN THE INFORMAL ECONOMY 177–91 (2013).
[55] SHAPEWAYS MARKETPLACE, https://www.shapeways.com/marketplace.
[56] SHAPEWAYS, https://www.shapeways.com/business/e-commerce-integrations/; HATCH, *supra* note 46.

they are manufactured in large factories and then shipped to different countries across the globe.[57] Because of distributed manufacturing, empowered by 3D printing tools, manufacturers may lose extensive control over the products they make and sell. Likewise, patent holders (and other right holders) may lose control of their intellectual property because of the possibility of widespread unlawful and unlicensed violation of their exclusive rights. This section examines the threats posed by 3D printing to patent law and how patent exclusive rights can become a hurdle in using the full potential of 3D printing to support local entrepreneurship. Because of its limited scope, this section does not cover the other forms of intellectual property like copyright and trademark.

A. Liability of Direct Infringers

Direct patent infringement 'arises when someone, without authorization makes, uses, sells, offers to sell, or imports the patented invention.'[58] Infringing activity undermines the commercial interests of patent holders because 'each printed copy of an invention is a lost potential sale to the patent holder.'[59] 3D printing of patent-protected objects for entrepreneurial purposes will not be covered under private non-commercial use exception provided in the EU and many other jurisdictions.[60] Liability for direct infringement is regardless of an infringer's knowledge of the underlying patent or intention to infringe upon the patentee's rights.

3D printing tools foster direct patent infringement by making it possible to digitize physical products and share replicable digital designs on virtual platforms for download and direct print or manipulation via software tools. Imitation is also possible if one uses a computer drafting program to create a digital file of a product from scratch after studying it carefully.[61] Large-scale infringing activity can be possible at individual levels because '3D printing allows consumers to independently use a creation process that was once cost-prohibitive and limited to high-investment manufacturing plants.'[62]

A lot of direct patent infringement, via digital fabrication tools, takes place behind the curtain. Patent holders find it hard to enforce their exclusive rights because they are generally unaware of any infringement taking place in the privacy of someone's home or garage or within a small-scale business. Such unidentifiable infringing activity is hard to control because patent holders cannot stop something from happening if they cannot see it happening.

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[57] Maya M Eckstein, *Let's look closer at 3D printing and IP issues*, INSIDE COUNSEL (Feb. 09, 2016) [hereinafter 'Eckstein'].
[58] Rosa Maria Ballardini, Marcus Norrgård & Timo Minssen, *Enforcing patents in the era of 3D printing*, 10 J. INTELL. PROP. L. PRAC. 850 (2015) [hereinafter 'Ballardini, Norrgård, and Minssen'].
[59] Shardha Rajam & Adya Jha, *supra* note 21.
[60] The Patents Act 1977, c. 37, §60(5)(a)(UK).
[61] OSBORN, *supra* note 4.
[62] Wilbanks, *supra* note 53.

It is possible to learn who is printing what, but it is both overwhelming in scale and technologically difficult.[63] It might be both difficult and expensive to track direct infringement at individual level. This is particularly challenging because CAD files can be distributed uncontrollably over the Internet.[64] Tracking and suing countless individual infringers is an unattractive and inefficient business strategy because individuals generally have limited resources to pay monetary damages.[65] It defeats one of the main purposes of the lawsuit if individuals or small businesses are unable to pay for damages.[66] Such fruitless lawsuits may also expose the right holder to the public ire and reputational harm.[67]

Patent law still potentially poses a barrier to some extent because a certain amount of infringing activity via 3D printing may be identifiable and actionable when start-ups grow and become known. Entrepreneurs cannot simply disregard their liability under patent law presuming that their infringing activity will remain anonymous. Some patent holders will inevitably discover online postings of items infringing their patents. They may sue individuals or small businesses for infringing reconstruction if they are too strict about the enforcement of their patent rights.[68]

B. Liability of Intermediaries Storing and Distributing CAD Files

Making CAD files available online, to enable distributed manufacturing away from control of the right holder, may have legal implications because the accessible files can be modified via software tools and 3D printed without right holder's approval. Holding CAD file sharing platforms or services, like Thingiverse, liable for indirect infringement may seem an attractive option to right holders because the alternate approach of suing direct infringers is costly and cumbersome.[69] Patent holders, under most patent laws, can sue any centralized facilitators for indirect infringement who provide means to enable infringement of their patent.

In the EU, under Art. 26(1) of the European Community Patent Convention 1989 (CPC), third parties or intermediaries can be held liable for indirect infringement if they, 'supply or offer to supply within the territories of the Contracting States a person, other than a party entitled to exploit the patented invention, with means, relating to an essential element of that invention, for putting

[63] OSBORN, *supra* note 4.
[64] Ballardini, Norrgård, and Minssen, *supra* note 58.
[65] Stefan Bechtold, *3D Printing, Intellectual Property and Innovation Policy*, 47 IIC INT. REV. INTELL. PROP. COMPETITION L. 517–36 (2016) [hereinafter 'Bechtold'].
[66] Lucas S. Osborn, *Primer on Intellectual Property Law*, *in* 3D *Printing and Intellectual Property* 42–59 (2019); *See* more Lucas S. Osborn, *Patents – Direct Infringement, Individual Infringement, and "Digital" Infringement*, *in* 3D PRINTING AND INTELLECTUAL PROPERTY 82–103 (2020) [hereinafter 'Osborn'].
[67] Id.
[68] Wilbanks, *supra* note 55.
[69] Bechtold, *supra* note 65.

it into effect therein, when the third party knows, or it is obvious in the circumstances, that these means are suitable and intended for putting that invention into effect.'[70]

It is unclear whether CAD files qualify as a 'means' for the purpose of indirect infringement. Some scholars see CAD files as 'a powerful tool that, in a world of ubiquitous 3D printers, renders the possessor of the file just as satisfied as if he [or she] possessed the physical object itself.'[71] Despite being a powerful tool, CAD files may not qualify as 'means' in the legal sense. In the absence of a clear definition, it remains questionable what constitutes 'means.' Historically, there has been an emphasis on the physical or tangible nature of means, which excludes abstract instructions, plans, or drawings from the definition of this term.[72] CAD files, being purely digital entities, are neither physical nor tangible.[73]

It is important to consider whether the CAD file is related to an essential element of the invention. It is a very fundamental concept in patent law that 'one only infringes what is claimed in the patent. It does not matter what the inventor thinks the invention is, or what is described in the patent's other text – the patent claims govern whether someone infringes or not.'[74] The CAD file or digital version of the invention is generally not mentioned in the patent claims. In almost every case, 'a patent holder has a patent only on the physical device, not a digital version of it.'[75] The CAD file is merely a blueprint or a set of technical instructions which is 'neither part of nor embedded in the physical device.'[76] The digital representation of the object continues to exist independently even after the physical object is printed out.[77]

It is also important to consider whether the supplied means are suitable and intended to exploit the invention. It is a requirement under Art. 26(1) of the CPC 'that these means are suitable and intended for putting that invention into effect.'[78] Access to the CAD file does not necessarily enable one to wrongfully put the invention into effect. As noted by Rosa Maria Ballardini and

[70] Council of Europe, *Agreement relating to Community patents - Done at Luxembourg, 15 December 1989.*, 30/12/1989 89/695/EEC, OFF. J. L 401 (1989), https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:41989A0695%2801%29:EN:HTML [hereinafter 'Europe'].
[71] Timothy R. Holbrook & Lucas S. Osborn, *Digital Patent Infringement in an Era of 3D Printing*, 48 UC DAVIS L. REV. 1319 (2015).
[72] Ballardini, Norrgård, and Minssen, *supra* note 58.
[73] *Id.*
[74] Osborn, *supra* note 66.
[75] Lucas Osborn, *3D Printing as Indirect Patent Infringement Amid COVID-19*, LAW 360 (Mar. 20, 2020), https://www.law360.com/articles/1255547/3d-printing-as-indirect-patent-infringement-amid-covid-19.
[76] Ballardini, Norrgård, and Minssen, *supra* note 58.
[77] *Id.*
[78] Europe, *supra* note 70.

others, 'the accurate materialization of the physical object from the digital CAD file is not a simple click of a button but implies considerable technical expertise.'[79]

Knowledge and specific intent are also important because liability for indirect infringement arises, under Art. 26(1) of the CPC, 'when the third party knows, or it is obvious in the circumstances, that these means are suitable and intended for putting that invention into effect.'[80] In the context of 3D printing, knowledge refers to whether the digital file's supplier knew or 'whether it would have been obvious from the circumstances, that such a CAD file would be intended to be used in an infringing way by the person downloading that file.'[81] This highly subjective element makes it extremely difficult to prove indirect infringement in a court of law. Knowledge and specific intent are hard to prove in court litigation because 'one must prove knowledge of the specific patent at issue, not merely knowledge that the 3D printed product may be covered by various patents.'[82] As noted by Lucas Osborn:

"Indirect infringement is analogous to aiding and abetting a crime. It is more difficult to prove than direct infringement because the law typically requires the rights holder to prove that the indirect infringer knew of the IP [intellectual property] right and, in some sense, understood that there was infringement. In other words, innocent indirect infringement, even on a massive scale, is not actionable in most cases."[83]

In most jurisdictions, the court will also consider whether or not a recipient of a CAD file actually 3D printed the digital file.[84] Patent holders may find it extremely difficult to prove such infringing activity, especially if it is performed from the privacy of one's home. As patent laws are territorial in nature, complex questions may arise if the infringing activity takes place outside the country of protection or the granting jurisdiction.[85] Such a situation, resulting from cross-border transmission of digital data, is very much possible because the CAD files are shared across the globe over the Internet.[86] Realistically, the option of suing CAD file sharing intermediaries for indirect infringement is not as attractive as it may appear before undertaking detailed analysis of its practical and legal implications.

[79] Ballardini, Norrgård, and Minssen, *supra* note 58.
[80] Europe, *supra* note 70.
[81] Ballardini, Norrgård, and Minssen, *supra* note 58.
[82] Eckstein, *supra* note 57.
[83] Osborn, *supra* note 66.
[84] Osborn, *supra* note 75.
[85] Rosa Maria Ballardini et al., *3D Printing, Intellectual Property and Innovation: Insights from Law and Technology* (Wolters Kluwer, 2017) 70.
[86] Davis, *supra* note 1.

C. Liability of Physical Suppliers of Printers and Cartridges

Another approach to control infringing activity may be to 'target the problem further up the chain' by suing the manufacturers and/or suppliers of 3D printers and cartridges.[87] In order to be able to 3D print a digital file, access to a 3D printer and printing materials is a basic requirement. A broader range of infringing activity cannot be possible without an intermediary role of these actors. As a business strategy, it is profitable to sue such actors as they are likely to have financial resources to pay monetary damages.

Liability of suppliers of printers and cartridges will depend on the specific facts of each individual case. Infringement is not inevitable from the use of a 3D printer as 'a printer could be used entirely legitimately, for example by a designer to print his own design.'[88] 3D printers are generic machines. They are not designed or intended to print infringing items. They 'print whatever the CAD file tells them to print, including staple products.'[89] It is important to note here that staple commercial products are exempted from indirect infringement under Art. 26(2) of the CPC.[90] Actions against suppliers of printers and cartridges may also fail 'through lack of the required knowledge and intention.'[91] These actors have no obligation to possess knowledge of underlying patents. They are less likely to know if a particular product is patented because searching for patents and interpreting patent claims are highly specialized tasks which require significant legal knowledge.[92] These actors cannot be expected to bear this additional burden in the absence of any binding obligation to do so.

It would be an absurd idea to hold different actors liable for indirect infringement. It is not in the public interest to broaden the scope of liability without limits. As noted by Lucas Osborn:

> *'The hallmark of indirect infringement is assisting others in infringing. 'Assistance' could theoretically encompass a potentially large amount of activity. Anyone who sells a 3D printer has in one sense assisted a buyer who printed an infringing article. So too has the 3D printing 'ink' maker, the electricity provider that helped power the 3D printer, and the shipping company that transported the 3D printer from the manufacturer.'*[93]

The public interest may be undermined, and technological development may be hampered if liability is imposed on a broad range of actors for infringing use of technologies, that have

[87] Iona Silverman, *Optimising protection: IP rights in 3D printing*, 38 EUR. INTEL. PROP. REV. 5–10 (2016).
[88] *Id.*
[89] Ballardini, Norrgård, and Minssen, *supra* note 58.
[90] Europe, *supra* note 70.
[91] Ballardini, Norrgård, and Minssen, *supra* note 58.
[92] OSBORN, *supra* note 4.
[93] *Id.*

clear non-infringing uses, especially if such actors have no means to control the infringing activity.[94]

D. Liability of 3D Printing Service Bureaus

3D printing service bureaus are commercial facilities that own 3D printing tools and provide printing services at a certain cost.[95] If a 3D printing service bureau prints an infringing item on demand, it may be held liable for direct infringement. 'Making' the patented object is an exclusive right of the patent holder. 3D printing service bureaus directly infringe upon this exclusive right by actually printing out the tangible object. In case of primary liability claims, the patent holder does not need to prove that the 3D printing service bureau knew that the printing job would violate the patent holder's rights. As these service providers charge fee and do not print privately, the exception of private non-commercial use is unlikely to apply to them.[96]

Society may lose the benefit of 3D printing service bureaus if providers of this valuable service are pushed out of the business because of exposure to patent infringement suits and excessive costs of patent litigation. In order to retain this service for society's benefit, 'the law should provide a safe harbor framework … [to] insulate 3D print shops from liability for printing when they did not know – and, perhaps, had no reason to know – that the items were patented.'[97]

Even if 3D print shops or service bureaus struggle to continue their business model because of strict liability under patent law, it should be a concern only for those entrepreneurs who cannot afford to buy their own 3D printers and rely on these services to fulfil their orders. Not as many entrepreneurs will be impacted if such services go out of business in a worst-case scenario. The costs of 3D printers and printing materials are already affordable and are further dropping over time.

IV. CONCLUSION

3D printing is a disruptive enabling or empowering technology. This unique method of manufacturing is well-suited to help creative individuals harness their entrepreneurial potentials. 3D printing offers many benefits to entrepreneurs in terms of expanding the scope of possibilities and lowering the costs of market entry. It opens up new exciting possibilities because of its potential for personalized and on-demand manufacturing. With low infrastructural needs and a

[94] *Id.*
[95] Ballardini et al., *supra* note 36, at 183.
[96] OSBORN, *supra* note 4.
[97] *Id.*

growing enabling ecosystem, this technology enables start-ups to get off the ground quickly without incurring prohibitively high costs.

The patent law system is not well-equipped to deal with the challenges posed by 3D printing. Large-scale patent infringement can be possible because protected products can be replicated by using digital design files either created with the help of 3D scanning applications or accessed on the Internet. What is particularly concerning for patent holders is that a lot of patent infringement, via digital fabrication tools, happens away from control. It is hard for patent owners to know who is printing what. Even if they develop tools to track infringement, suing countless individual infringers is an unattractive and inefficient business strategy because individuals generally have limited resources to pay monetary damages.[98]

It can be foreseen that there will be calls for new legislation that provides broader protection to safeguard commercial interests of patent owners. Patent holders will seek more legal tools to control the creation and dissemination of digital files. While reforming patent laws and policies, it is important to ensure that enforcement of patent laws and policies does not prevent entrepreneurs from making full use of the unique capabilities of 3D printing. The primary objective must be to make this revolutionary technology available to society. As argued by Rosa Maria Ballardini and others, 'from a policy perspective, it may be important to try to develop legal tools that would exempt these suppliers [of the CAD files and 3D printing services] from liability in order for 3D printing technology to be diffused.'[99] Stringent patent laws and costly patent litigation should not be allowed to harm the growth potential of 3D printing technology.

Funding

Australian Research Council Discovery Project 'Inventing the Future: Intellectual Property and 3D Printing' (Project ID: DP170100758).

Declaration of competing interest

No competing interests.

[98] Bechtold, *supra* note 65.
[99] Ballardini et al., *supra* note 36, at 183.