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CIPPM Centre for Intellectual Property Policy & Management

A Legal and Empirical Study of 3D Printing Online Platforms and an Analysis of User Behaviour

Research commissioned by the Intellectual Property Office, and carried out by:

Dinusha Mendis and Davide Secchi

Study I

March 2015

This is an independent report commissioned by the Intellectual Property Office (IPO). Findings and opinions are those of the researchers, not necessarily the views of the IPO or the Government.

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Dr. Dinusha Mendis is Associate Professor in Law and Co-Director of the Centre for Intellectual Property Policy and Management (CIPPM), Bournemouth University, UK
E-mail: dmendis@bournemouth.ac.uk

Dr. Davide Secchi is Senior Lecturer in Organisational Behaviour at Bournemouth University and from April 2015, Associate Professor in Organizational Cognition, Research Cluster for Cognition, Management, and Communication (COMAC), University of Southern Denmark, Slagelse
E-mail: dsecchi@bournemouth.ac.uk / secchi@sdu.dk

This is the first of a sequence of three reports on the intellectual property implications of 3D printing commissioned to evaluate policy options in relation to online platforms and selected business sectors.

Study I presents a legal and an empirical analysis of 3D printing online platforms; Study II offers an insight into the current status and impact of 3D printing within selected business sectors by employing a case study approach; the executive summary provides a summary of the findings of Studies I and II and provides conclusions and recommendations for Government, Intermediaries (online platforms) and Industry.

The commissioned project was led by Dr. Dinusha Mendis in collaboration with Dr. Davide Secchi and Dr. Phil Reeves.

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Any enquiries regarding this publication should be sent to:

The Intellectual Property Office
Concept House
Cardiff Road
Newport
NP10 8QQ

Tel: 0300 300 2000
Fax: 01633 817 777

e-mail: information@ipo.gov.uk

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INTRODUCTION

Additive Manufacturing or 3D printing as it is more commonly known, challenges all aspects of intellectual property laws. The ability to 'replicate' a physical object raises interesting issues about potential infringement. The rise of online platforms, which facilitates dissemination and sharing of object design files has given rise to further interesting questions about the intellectual property status of such design files and the activity/user behaviour on these online platforms.

In recognising these challenges, the Big Innovation Centre, in their 2012 Report '*Three Dimensional Policy: Why Britain needs a policy framework for 3D Printing*'[1] provided a number of recommendations including a recommendation to review the intellectual property implications of 3D printing[2].

However, there is limited literature and research addressing such issues and limited research on the legal and empirical implications of 3D printing. Whilst a number of academics[3],[4], have examined the implications for intellectual property law as a result of the recent proliferation of 3D printing, there is a lack of empirical evidence[5] to determine whether this emerging technology will have an impact on intellectual property laws.

1 Sissons A., & Spencer T., *Three Dimensional Policy: Why Britain needs a policy framework for 3D Printing'* (Big Innovation Centre; October 2012) Available at http://biginnovationcentre.com/Assets/Docs/Reports/3D%20printing%20paper_FINAL_15%20Oct.pdf

2 *Ibid*., see p. 33.

3 Bradshaw S., Bowyer A., & Haufe P., The Intellectual Property Implications of Low Cost 3DPrinting (April 2010) Vol. 7, Issue 1 *Script-ed* pp. 1-31; Mendis D., Clone Wars: Episode I – The Rise of 3D Printing and its Implications for Intellectual Property Law: Learning Lessons from the Past? [2013] 35(3) *European Intellectual Property Review* pp. 155-169; Mendis D., 3D Printing Enters the Fast Lane [2014] *Intellectual Property Magazine*, pp. 39-40; Mendis D., Clone Wars Episode II – The Next Generation: The Copyright Implications relating to 3D Printing and Computer-Aided Design (CAD) Files [2014] 6(2) *Law, Innovation and Technology* pp. 265-281; Li P., Mellor S., Griffin J., Waelde C., Hao L., & Everson R., Intellectual Property and 3D Printing: A Case Study on 3D Chocolate Printing [2014] 2 Journal of Intellectual Property Law and Practice, pp. 1-11.

4 Weinberg M., What's the Deal with Copyright and 3D Printing (2013) available at https://www.publicknowledge.org/news-blog/blogs/whats-the-deal-with-copyright-and-3d-printing ; Susson M., Watch the World "Burn": Copyright, Micropatent and the Emergence of 3D Printing [January 2013] Chapman University School of Law, Available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2253109 ; Simon M., When Copyright Can Kill: How 3D Printers Are Breaking the Barriers Between Intellectual Property and the Physical World (Spring 2013) 3(1) Pace. Intell. Prop. Sports and Entertainment Law Forum pp. 59-97; Available at http://digitalcommons.pace.edu/pipself/vol3/iss1/4/ ; Santoso S. M., Horne B. D., & Wicker S. B., Destroying by Creating: Exploring the Creative Destruction of 3D Printing Through Intellectual Property (2013). Available at http://www.truststc.org/education/reu/13/Papers/HorneB_Paper.pdf

5 Intellectual Property Office, 3D Printing: A Patent Overview (Newport: Intellectual Property Office; November 2013), p. 10. Available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/312699/informatics-3d-printing.pdf

Furthermore, none of the existing literature represents an overarching empirical and legal study into the multitude of online platforms dedicated to 3D printing. An article by Moilanen *et al*[6] provides an empirical study on the intellectual property implications arising from Thingiverse – one of the first online platforms to have emerged in the 3D printing field.

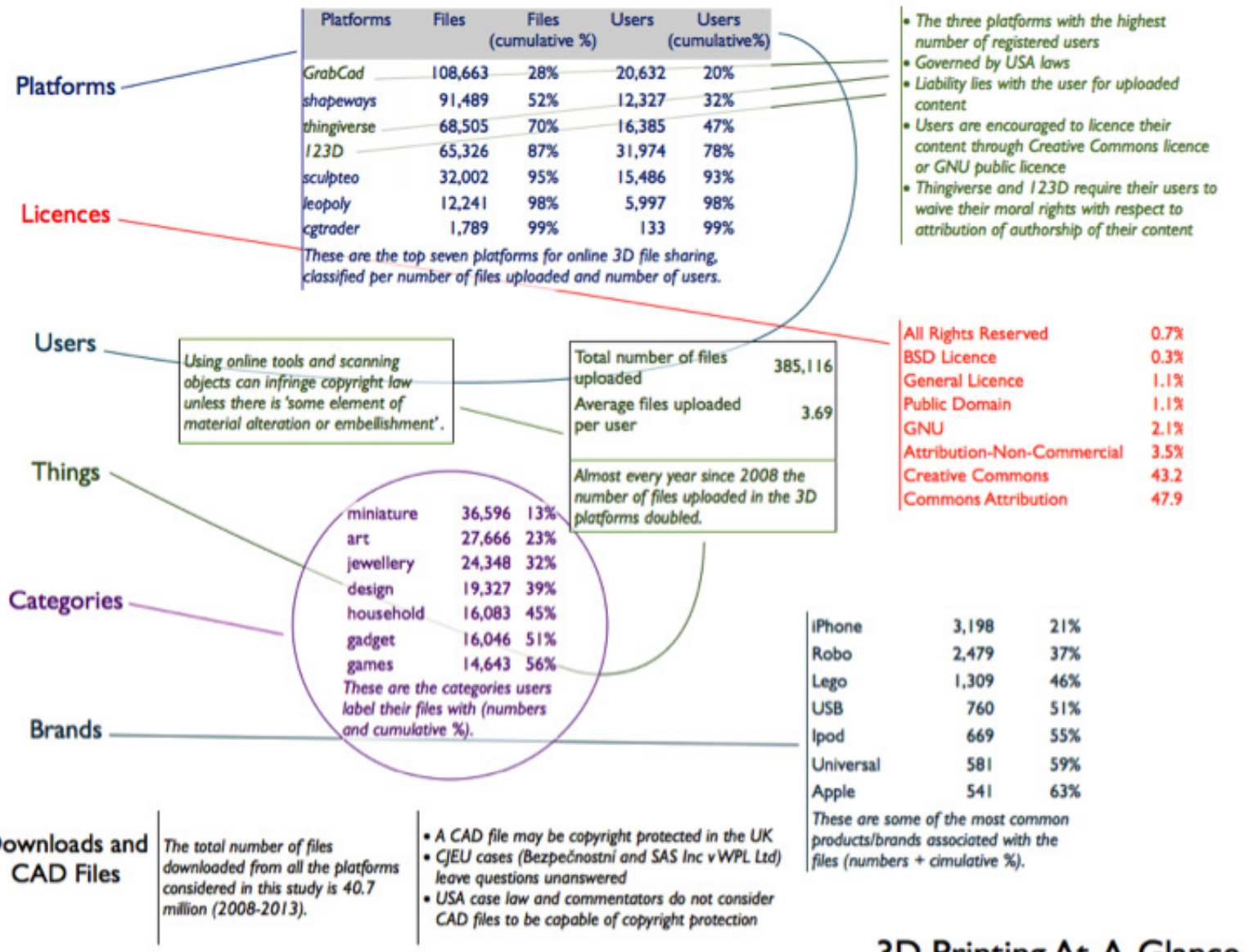
This Report goes beyond the research carried out by Moilanen *et al* by analysing data extracted from 17 online platforms dedicated to the sharing of 3D designs for 3D printing in order to understand how these platforms operate.

As such, this Report – which is Study I of a two-part Study[7] – fills a gap in the research relating to 3D printing. Applying a legal and empirical analysis, this Report aims to provide a clearer understanding of 'how' the sharing happens and assist in understanding the 'parameters' for sharing, e.g. terms and conditions, rules, regulations that apply, together with restrictions and bounds that apply to the user behaviour and file-sharing. As such, the current research attempts to evaluate the extent of this phenomenon amongst users and aims to explore and understand the activities carried out on online platforms. In doing so, the research examines the price, downloads, licences, type of physical objects, which are shared and the implications for intellectual property laws. In relation to the latter aspect of intellectual property laws, this Report focuses particularly on the copyright element for a number of reasons as explained below.

Study I is structured as follows. Section A of this Report will begin with a consideration of the copyright implications arising from the access and use of these online platforms. Thereafter, the discussion will provide an overview of the three online platforms dedicated to 3D printing – selected on the basis of being the platforms with the highest number of registered users before moving on to a consideration of the governing laws and choice of jurisdiction relating to these online platforms. The legal review will be followed by Section B which will set out an empirical overview of how the online platforms operate and will present new findings on the current status of 3D printing relating to online platforms. The Report will be concluded in Section C, by outlining the conclusions and recommendations drawn from the present research.

6 Moilanen J., Daly A., Lobato R., & Allen A., Cultures of Sharing in 3D Printing: What Can We Learn from the License Choices of *Thingiverse* Users? (2015) *Journal of Peer Production*, Available at SSRN http://ssrn.com/abstract=2440027

7 Study II of this project provides an insight into the current use and status of 3D Printing within businesses.


Platforms
Licences
Users
Things
Categories
Brands
Downloads and CAD Files
Platforms Files Files (cumulative %) Users Users (cumulative%)
GrabCad 108,663 28% 20,632 20%
shapeways 91,489 52% 12,327 32%
thingiverse 68,505 70% 16,385 47%
123D 65,326 87% 31,974 78%
sculpteo 32,002 95% 15,486 93%
leopoly 12,241 98% 5,997 98%
cgtrader 1,789 99% 133 99%
These are the top seven platforms for online 3D file sharing, classified per number of files uploaded and number of users.
• The three platforms with the highest number of registered users
• Governed by USA laws
• Liability lies with the user for uploaded content
• Users are encouraged to licence their content through Creative Commons licence or GNU public licence
• Thingiverse and 123D require their users to waive their moral rights with respect to attribution of authorship of their content
All Rights Reserved 0.7%
BSD Licence 0.3%
General Licence 1.1%
Public Domain 1.1%
GNU 2.1%
Attribution-Non-Commercial 3.5%
Creative Commons 43.2
Commons Attribution 47.9
Using online tools and scanning objects can infringe copyright law unless there is 'some element of material alteration or embellishment'.
Total number of files uploaded 385,116
Average files uploaded per user 3.69
Almost every year since 2008 the number of files uploaded in the 3D platforms doubled.
miniature 36,596 13%
art 27,666 23%
jewellery 24,348 32%
design 19,327 39%
household 16,083 45%
gadget 16,046 51%
games 14,643 56%
These are the categories users label their files with (numbers and cumulative %).
iPhone 3,198 21%
Robo 2,479 37%
Lego 1,309 46%
USB 760 51%
Ipod 669 55%
Universal 581 59%
Apple 541 63%
These are some of the most common products/brands associated with the files (numbers + cimulative %).
The total number of files downloaded from all the platforms considered in this study is 40.7 million (2008-2013).
• A CAD file may be copyright protected in the UK
• CJEU cases (Bezpečnostní and SAS Inc v WPL Ltd) leave questions unanswered
• USA case law and commentators do not consider CAD files to be capable of copyright protection
3D Printing At-A-Glance

SECTION A: LEGAL ANALYSIS

Introduction

> *The virtual world is a place of freedom where gravity is optional … The virtual world is easy to edit and revise. It's impossible to change the colour of the bark on a real tree, but simple to edit its image in a digital photograph[8] …It's just a matter of time until regular people will rip, mix and burn physical objects as effortlessly as they edit a digital photograph[9]... 3D printing opens up new frontiers. Manufacturing and business as usual will be disrupted as regular people gain access to power tools of design and production … Intellectual property law will be brought to its knees[10].*

A reading of the above quote acknowledges that 3D printing is expected to bring both challenges and opportunities. At the same time, Lipson and Kurman express their concern about 3D printing's ability to reproduce physical objects, especially when 'regular users' gain access to tools of design and production. This leads to their assertion that *"intellectual property law will be brought to its knees".*

However, at present, the position in relation to intellectual property laws remains unclear and studies, which combine legal and empirical research, are extremely limited in this area. The aim of this Report is to explore the implications, which arise in the 3D printing landscape through the access and use of online platforms which facilitate[11] the creation, dissemination and sharing of 3D object designs or Computer-Aided Design (CAD) files for download and printing.

For purposes of the research, data extracted from 17 online platforms[12] dedicated to the dissemination of 3D designs for 3D printing was analysed. From the data, the three platforms with the highest number of registered users were identified from the quantitative study[13], namely, (a) 123D[14]; (b) GrabCad[15]; and (c) Thingiverse[16]. Online platforms permit 'registered users' to upload, download, design, re-design or indeed purchase a 3D design or model if it also acts as a 'bureau service'[17]. It therefore implies that registered users are more engaged in the online activities of these platforms than those who simply visit and browse these sites. However where such activities lead to the infringement of Intellectual Property Rights, it raises a number of

8 Lipson H., & Kurman M., *Fabricated: The New World of 3D Printing* (Indiana: John Wiley & Sons, Inc.; 2013), pp. 13.

9 Lipson H., & Kurman M., *Fabricated: The New World of 3D Printing* (Indiana: John Wiley & Sons, Inc.; 2013), p. 10.

10 Lipson H., & Kurman M., *Fabricated: The New World of 3D Printing* (Indiana: John Wiley & Sons, Inc.; 2013), p. 7.

11 In the UK, under *Copyright, Designs and Patents Act* (CDPA 1988) the law prohibits the 'authorisation' of infringement. "Section 16(2) –. Copyright in a work is infringed by a person who without the licence of the copyright owner does, or *authorises another to do*, any of the acts restricted by the copyright" (emphasis added).

12 See *infra* p. 24.

13 See *infra* p. 31, Table 3 – 'Things and Users per Website'.

14 www.123dapp.com

15 www.grabcad.com

16 www.thingiverse.com

17 See, pp. 17-18.

questions and implications for intellectual property owners as well as users. The discussion below will consider issues arising from the operation and use of these online platforms, with particular focus on 123D, GrabCad and Thingiverse.

The discussion will, however, begin with a consideration of the implications for copyright law. Whilst 3D printing raises a variety of issues relating to IPRs, this part of the report will focus particularly on the implications for copyright law.

The rationale for focusing on copyright law is twofold. Firstly, an analysis of online platforms requires a deliberation of the legal status of 3D designs – CAD files –disseminated and shared on these platforms and from which a 3D printed product emerges. The sharing of these CAD files, raise questions relevant to copyright law. For example, can a CAD file be protected under copyright law? Does it qualify as a literary work?

Secondly, online tools (software) play a significant role amongst users in designing and re-designing 3D models. The transformation or modification of these 3D models raises interesting copyright issues such as – can 'modified' files lead to new derivative works under copyright law? In other words, where the file is modified – either by scanning or through the use of online tools – by other users what are the implications for copyright and in particular, originality?[18]

A consideration of these issues amongst others, which arise from the use of online platforms, requires an exploration of the implications for copyright law as discussed below. As such, the focus of this part of the research will remain specifically on online platforms and the implications for copyright law in view of the CAD files or design object files, which are shared on these online platforms.

Thereafter the Report will move on to a consideration of the regulation and operation of online platforms. To better understand how these online platforms operate, an analysis of the terms and conditions, terms of service and end user licenses – i.e. contractual provisions between the online platforms and end users – will be carried out from the perspective of the selected platforms. The aim of this discussion is to shed light on the Governing Laws and implications for users in view of the fact that the relevant online platforms are based in the USA. This raises questions: (1) relating to the implications for UK users and (2) the Governing Laws and Choice of Jurisdiction for all its users. The above questions have been addressed and answered bearing in mind its relevance to a UK audience.

Online Platforms and Copyright Implications

Every object produced by a 3D printer begins its design process with a CAD based digital object design file. "The object design file is similar to the architectural blueprints for a building or the sewing pattern for a dress – it is a digital 3D model which the printer uses to build the object using the specifications defined in the design"[19]. The interesting question to consider in

18 See *infra*, pp.12-15.

19 Santoso S. M., Horne B. D., & Wicker S. B., Destroying by Creating: Exploring the Creative Destruction of 3D Printing Through Intellectual Property *(2013).* Available at http://www.truststc.org/education/reu/13/Papers/HorneB_Paper.pdf

this regard is, how a user obtains a CAD design file. There are several ways in which these files can be accessed. (1) An individual creates and initiates an object design file (e.g. using CAD or similar software); (2) Modify an existing design; and/or (3) Scan the object.

Each of these options give rise to intellectual property implications and in the present context copyright implications – whether it is an original CAD file; one which has been modified or generated by scanning an object. However, before moving on to a consideration of these sections, the discussion will first, consider whether a CAD design file can be deemed a computer program within the meaning of the EU and UK legislation. Thereafter, the discussion will consider issues arising from the three scenarios mentioned above.

CAD Design Files and Computer Programs

In considering whether a CAD file falls within the definition of a computer program, it is first important to define a computer program. Writing a computer program involves the expression of an analysis of the functions to be performed as a set of algorithms (set out as a flowchart); followed by its restatement (by a programmer and/or by a computer) in computer language (the source code); and finally the translation by a computer running under a compiler program of the source code into a machine-readable language (object code)[20] which will result in a computer program at some stage[21].

In terms of its protection, the Recital of the EU Software Directive provides some guidance as follows:

> For the purpose of this Directive, the term "computer program" shall include programs in any form including those, which are incorporated into hardware. This term also includes preparatory design work leading to the development of a computer program provided that the nature of the preparatory work is such that a computer program can result from it at a later stage"[22].

An analysis of the above quote ascertains that "the protection is … bound to the program code and to the functions that enable the computer to perform its task. This in turn implies that there is no protection for elements without such functions (i.e. graphical user interface (GUI), or "mere data") and which are not reflected in the code (i.e. functionality in itself is not protected, since there could be a different code that may be able to produce the same function)"[23]. In other words, copyright protection will attach to the expression of the computer code and will not extend to the functionality of the software.

20 Waelde *et al*., *Contemporary Intellectual Property: Law and Policy* (Oxford: Oxford University Press; 2014) pp. 64-65.

21 *Ibid*.

22 *Directive 2009/24/EC Of The European Parliament And Of The Council of 23 April 2009 on the legal protection of computer programs, Recital* (7) (hereinafter Software Directive).

23 *SAS Institute Inc., v. World Programming Ltd*., (C-406/10) [2012] 3 CMLR 4. *See also* Guarda P., Looking for a Feasible Form of Software Protection: Copyright or Patent, Is that the Question? [2013] 35(8) *European Intellectual Property Review* pp.445 – 454 at p.447.

At the same time, Court of Justice of the European Union (CJEU) cases, notably, *Infopaq International A/S v. Danske Dagblades Forening*[24]; *Painer v. Standard Verlags GmbH*[25] and most recently *Football Dataco Ltd v. Yahoo! UK Ltd*[26] concluded that a "copyright work", should demonstrate the "own intellectual creation of its author" [27] in order to be original thereby placing the emphasis on the right form of authorial input as opposed to the category of copyright works.

Applying the Software Directive and cases such as *Infopaq*, the CJEU most recently considered the status of computer programs in *Bezpečnostní*[28] and *SAS Institute Inc., v. World Programming Ltd.,*[29]*. In Bezpečnostní*, CJEU stated, following the principles expressed in *Infopaq*[30] that notwithstanding the position under the *Software Directive*, the ordinary law of copyright could protect the graphic user interface (GUI) of a computer program[31]. In *SAS Institute Inc*., the CJEU concluded (unsurprisingly) that functionality, language and data file formats are not protected by copyright under the *Software Directive* since they do not constitute forms of expression. However, the Court suggested that the programming language and data file formats "might be protected, as works, by copyright under [the Copyright] Directive … if they are their author's own intellectual creation"[32] clearly drawing on the decision of *Bezpečnostní*[33].

However, its consideration in the UK High Court and Court of Appeal highlighted the issues with the CJEU decision. For example, the decision does not answer the question as to whether copyright protection might extend to underlying elements of the program, such as its programming languages and the format of data files, under the Copyright Directive. Lewison LJ in the Court of Appeal stated that the language used by the CJEU was at times, "disappointingly compressed, if not obscure"[34].

24 (C-5/08) [2010] FSR 20.

25 (C-145/10) [2012] ECDR 6 (ECJ (3rd Chamber).

26 (C-604/10) [2012] Bus. L.R. 1753.

27 Case C-5/08 *Infopaq Inernational A/S v. Danske Dagblades Forening* [2010] FSR 20. *See also*, Rahmatian A., Originality in UK Copyright Law: The Old "Skill and Labour" doctrine under pressure [2013] 44(1) *International Review of Intellectual Property and Competition Law*, pp. 4-34.

28 *Bezpečnostní Softwarová Asociace – Svaz Softwarové Ochrany v. Ministerstvo Kultury* (C-393/09) [2011] ECDR 3.

29 *SAS Institute Inc., v. World Programming Ltd*., (C-406/10) [2012] 3 CMLR 4.

30 *Infopaq International A/S v. Danske Dagblades Forening* Case C-5/08 [2010] FSR 20.

31 *Bezpečnostní Softwarová Asociace – Svaz Softwarové Ochrany v. Ministerstvo Kultury* (C-393/09) [2011] ECDR 3 at 35 and 38.

32 *SAS Institute Inc., v. World Programming Ltd*., (C-406/10) [2012] 3 CMLR 4, para. 39. The CJEU also stated that: "keywords, syntax, commands and combinations of commands, options, defaults, and iterations consisting of words, figures or mathematical concepts which, considered in isolation are not, as such, an intellectual creation of the author…It is only through the choice, sequence and combination…that the author may express his creativity in an original manner and achieve a result, namely the user manual for the program, which is an intellectual creation" (paras: 66-67).

33 *Bezpečnostní Softwarová Asociace – Svaz Softwarové Ochrany v. Ministerstvo Kultury* (C-393/09) [2011] ECDR 3 at 35 and 38. *See also*, Toft K., The case of SAS Institute Inc., v. World Programming Ltd [2014] 20(2) *Computer and Telecommunications Law Review*, pp. 59-62 at p. 60.

34 *SAS Institute Inc., v. World Programming Ltd*., [2013] EWCA Civ 1482 at [5].

According to Toft, the CJEU case law gives "developers the freedom to reproduce the functionality of software in the knowledge they cannot be pursued for copyright infringement … the same cannot be said for the initial software developer"[35].

As such, and drawing on the CJEU cases and their interpretation in UK Courts, the situation remains unclear at present.

In the UK, some guidance is provided by the *Copyright, Designs and Patents Act 1988* (as amended), which states that a computer program and its embedded data for example is recognised as a literary work under copyright law[36]. Applying the current law to the 3D printing context, it can be argued that a computer program encompasses an object design file or CAD file within its definition and is therefore capable of copyright protection as a literary work. Some support for this view can be found in *Autospin (Oil Seals) Ltd. v. Beehive Spinning*[37] where Laddie J makes reference, obiter dictum, to three-dimensional articles being designed by computers and states that "a literary work consisting of computer code represents the three dimensional article"[38].

In *Nova v. Mazooma Games Ltd.,*[39] Jacob LJ referring to the Software Directive implemented by the Copyright, Designs and Patents Act 1988 (as amended)[40] confirmed that for purposes of copyright, the program and its preparatory material are considered to be one component as opposed to two.

Can An Object Design File Be Copyright Protected?

Where creators involve themselves in the complete process of designing an 'original' 3D model or 3D design for downloading and printing, the intellectual property should rest with the user-creator[41]. This begs the question whether such CAD files are capable of being protected by copyright as a literary work.

Simon argues that even if it is determined that 3D design files are capable of being protected by copyright for example, issues arise when considering items such as food, living cells, and organs for which 3D printing is used[42]. He opines that copyright protection "cannot exist for …

35 Toft K., The case of SAS Institute Inc., v World Programming Ltd [2014] 20(2) *Computer and Telecommunications Law Review,* pp. 59-62 at p. 62.

36 Section 3(1)(b), (c) CDPA 1988.

37 *Autospin (Oil Seals) Ltd., v. Beehive Spinning* [1995] RPC 683.

38 *Autospin (Oil Seals) Ltd., v. Beehive Spinning* [1995] RPC 683 at 698.

39 [2007] RPC 25.

40 *Directive* 2009/24/EC *Of The European Parliament And Of The Council of 23 April 2009 on the legal protection of computer programs.*

41 For an account of the implications for UK intellectual property laws arising from 3D Printing, *see*, Mendis D., Clone Wars: Episode I – The Rise of 3D Printing and its Implications for Intellectual Property Law: Learning Lessons from the Past? [2013] 35(3) *European Intellectual Property Review* pp. 155-169.

42 Simon M., When Copyright Can Kill: How 3D Printers Are Breaking the Barriers Between "Intellectual Property and the Physical World (Spring 2013) 3(1) Pace. *Intell. Prop. Sports and Entertainment Law Forum* pp. 59-97. Available at http://digitalcommons.pace.edu/pipself/vol3/iss1/4/

scientific progress because that is protected solely by patent law"[43]. This view is further supported in the USA by Nimmer, who observes that the argument recipes are copyrightable "seems doubtful because the content of recipes are clearly dictated by functional considerations and therefore may be said to lack the required element of originality, even though the combination of ingredients contained in the recipes may be original in a non-copyright sense"[44]. US case law further lends support to this view. In *Oracle v. Google*, Judge William Alsup dismissed *Oracle's* copyright infringement claim against *Google* stating that there was no infringement by *Google* as "copyright law does not confer ownership over any and all ways to implement a function or specification, no matter how creative the copyrighted implementation or specification may be"[45].

Rideout approaches the argument from a different angle. He asserts that a CAD based digital object design file resembles computer software as opposed to stating that it is computer software.[46] Rideout reasons that CAD files will not be considered as copyrightable software in the USA:

> What differentiates 3D CAD files from other computer programs is that the 3D CAD files are basically just a triangular representation of a 3D object. The files themselves do not control how 3D printers operate … they merely serve as more of a blueprint for software to utilize[47].

As such, Rideout does not consider a 3D design file to be a literary work and states that a CAD file will more likely be considered under "pictorial, graphic, and sculptural works" including "technical drawings, diagrams and models"[48].

Interestingly, in the UK, such examples would fall under the category of artistic works[49].

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43 Simon M., When Copyright Can Kill: How 3D Printers Are Breaking the Barriers Between "Intellectual Property and the Physical World (Spring 2013) 3(1) Pace. *Intell. Prop. Sports and Entertainment Law Forum* pp. 59-97 at p. 71. Available at http://digitalcommons.pace.edu/pipself/vol3/iss1/4/

44 Nimmer M. B., & Nimmer D., *Nimmer on Copyright*, § 2.18[1] at 2-204.25-26 (May 1996). For further insight into copyright law, from a USA point of view, *see also Weinberg M., What's the Deal with Copyright and 3D Printing* (2013) available at https://www.publicknowledge.org/news-blog/blogs/whats-the-deal-with-copyright-and-3d-printing ; Weinberg M., *It Will be Awesome If They Don't Screw It Up: 3D Printing, Intellectual Property and the Fight Over the Next Great Disruptive Technology* (2010) available at https://www.publicknowledge.org/news-blog/blogs/it-will-be-awesome-if-they-dont-screw-it-up-3d-printing

45 *Oracle America Inc., v. Google Inc.,* 872 F. Supp. 2d 974 (2012) (D (US)). *See also*, Connor I., & Bhattacharya I., Copyright Protection of Software: A Convergence of US and European Jurisprudence? [2013] 18(2) *Communications Law*, pp. 45-48.

46 Rideout B., Printing the Impossible Triangle: The Copyright Implications of Three-Dimensional Printing [2011] 5(1), *Journal of Business Entrepreneurship & Law* pp. 161-180. Available at http://digitalcommons.pepperdine.edu/jbel/vol5/iss1/6

47 Rideout B., Printing the Impossible Triangle: The Copyright Implications of Three-Dimensional Printing [2011] 5(1), *Journal of Business Entrepreneurship & Law* pp. 161-180 at p. 168. Available at http://digitalcommons.pepperdine.edu/jbel/vol5/iss1/6

48 Rideout B., Printing the Impossible Triangle: The Copyright Implications of Three-Dimensional Printing [2011] 5(1), *Journal of Business Entrepreneurship & Law* pp. 161-180 at p. 168. Available at http://digitalcommons.pepperdine.edu/jbel/vol5/iss1/6

49 Section 4 *Copyright, Designs and Patents Act 1988*.

It is also interesting to consider whether 3D models, which come into being from a CAD file, infringe the artistic copyright of that object design file. The question can be considered from the perspective of making of a 3D copy of a 2D object and vice-versa[50]. A number of legal decisions in the UK have attempted to clarify artistic works and in particular the meaning of 'sculpture'[51] – which includes 3D works such as models, with *Lucasfilm v. Ainsworth*[52] being the most recent decision to attempt clarification. The case was illustrative of the point that a 3D object which comes into being from a design document or CAD file does not infringe copyright[53] if the CAD file or model embodying a design is used to create an object for anything other than an artistic work. In *Lucasfilm*, the Supreme Court, agreeing with the Court of Appeal's decision in 2009 held in favour of the defendant, Andrew Ainsworth, claiming that the *Star Wars* white helmets were 'utilitarian' as opposed to being a work of sculpture[54]. In other words, although the design document (i.e. a CAD file) carried artistic copyright, the object created from it, did not.

This case is reflective of the future challenges, which manufacturers of 3D objects will face in the UK. In accordance with the case it appears that copyright protection for a sculpture (or work of artistic craftsmanship) is limited to objects created principally for their artistic merit – i.e. the fine arts. However, cases such as *Infopaq*[55], mentioned above, arguably point to the fact that the category of copyright works is less important; rather the emphasis is on the right form of authorial input.

Derclaye states that the requirement for a work to be the intellectual creation of its author in order to be capable of copyright protection changes the current UK test of sufficient skill, judgement, labour and capital that still applies to all works except databases and computer programs[56]. This requirement may appear on the face of it a more onerous test when determining whether to confer copyright protection on 3D digital models of physical objects. However, subsequent case law illustrates that the test has been used successfully in protecting photographs, for example.

This was seen in the case of *Painer*[57] which held that portrait photographs attracted copyright protection. The Court stated that a portrait photograph could be protected by copyright if such a photograph "is an intellectual creation of the author reflecting his personality and expressing

50 Section 17(4) *Copyright, Designs, Patents Act* (CDPA) 1988 (as amended).

51 *Wham-O Manufacturing Co., v. Lincoln Industries Ltd* [1985] RPC 127 (CA of NZ); *Breville Europe Plc v. Thorn EMI Domestic Appliances Ltd*. [1995] *FSR 77; J & S Davis (Holdings) Ltd., v. Wright Health Group Ltd.* [1988] RPC 403; *George Hensher Ltd., v. Restawhile Upholstery (Lancs.) Ltd.* [1976] AC 64; *Lucasfilm Ltd. & Others v. Ainsworth and Another* [2011] 3 WLR 487.

52 *Lucasfilm Ltd. & Others v. Ainsworth and Another* [2011] 3 WLR 487.

53 This point was further established in *Mackie v. Behringer UK Ltd. & Ors* [1999] RPC 717. The Court held that a circuit diagram of a piece of electrical equipment was a design document according to the section 51 (CDPA 1988) definition and copyright could not be relied upon for the circuit diagram.

54 *Lucasfilm Ltd. & Others v. Ainsworth and Another* [2011] 3 WLR 487, para 44.

55 Case C-5/08 *Infopaq Inernational A/S v. Danske Dagblades Forening* [2009] ECR I-06569.

56 Derclaye E., *Infopaq International A/S v. Danske Dagbaldes Forening* (C-5/08): Wonderful or Worrisome? The Impact of the ECJ Ruling in *Infopaq* on UK Copyright Law [2010] 32(5) *European Intellectual Property Review* pp. 247-251 at p. 248.

57 *Painer v. Standard Verlags GmbH, Axel Springer AG, Süddeutsche Zeitung GmbH, Spiegel-Verlag Rudolf Augstein GmbH & Co. KG, Verlag M. DuMont Schauberg Expedition der Kölnischen Zeitung GmbH & Co. KG* [2012] ECDR 6 (hereinafter Painer).

his free and creative choice in the production of that photograph"[58]. Furthermore, "its protection is not inferior to that enjoyed by any other work, including photographic works"[59]. Applying the same reasoning to 3D digital models, it can be argued that there is no reason why such digital models should, as a rule, fail to meet the requirements.

In reflecting on the status of a CAD-based object design file, from the USA/UK perspective, it is clear that there is a lack of consistency and clarity in relation to its definition and its position under 'computer programs'.

Whilst USA commentators take the view that a CAD file is incapable of being protected as a literary work, the UK takes a more relaxed view suggesting that a computer program and its embedded data for example is recognised as a literary work under copyright law[60] thereby suggesting that a CAD design file could be copyright protected. However, the direction given by the CJEU in cases such as *Bezpečnostní* and SAS *Institute Inc*., and subsequent UK consideration of those cases raises more questions than answers. Simply, the situation in relation to the status of CAD files remains unclear at present.

However, to be protected as a copyright work, a CAD file will also have to demonstrate sufficient originality. Where a 3D digital model is not initiated by the creator, but instead is created from scanning an existing object or modifying an existing object found on an online platform, then meeting the originality criteria under copyright law will be challenging as discussed below.

Modifying An Object Design File: The Copyright Implications

Online platforms dedicated to the dissemination and sharing of 3D designs offer online tools (or "apps" as they are known) to users to create, edit, upload, download, remix and share 3D designs and all three online platforms emphasise that the users maintain ownership of and responsibility for their content. As such there is an expectation by the online platforms that any sharing, editing etc. carried out by users will be done in accordance with the relevant laws of the country. In the present context, the consideration will focus on whether the modification of design files made possible by online tools such as *Meshmixer, 123 Catch, MakerBotCustomizer*, and *Workbench*, for example, provided by 123D, Thingiverse and GrabdCad respectively[61], or through scanning infringes the copyright and originality of the existing CAD files.

'Originality' is not defined in the *Copyright, Designs and Patents Act (as amended)*. However, the meaning of 'originality' has been developed in a line of UK cases ranging from the *Graves' Case*[62] to *Interlego AG v. Tyco Industries Inc. and Others*,[63] *Antiquesportfolio.com Plc v. Rodney Fitch & Co. Ltd*.[64] and *Temple Island Collections Limited v. New English Teas Limited*[65].

58 *Painer* at para. 99.
59 *Painer* at para. 99.
60 Section 3(1)(b), (c) CDPA 1988.
61 See *infra,* pp. 15-18.
62 *Graves' Case* (1868-69) LR 4 QB 715.
63 *Interlego v. Tyco Industries Inc., and Others* [1988] RPC 343.
64 *Antiquesportfolio.com Plc v. Rodney Fitch & Co. Ltd*. [2001] FSR 23.
65 *Temple Island Collections Limited v. New English Teas Limited, Nicholas John Houghton* Case No. 1CL 70031 Patents County Court [2012] EWPCC 1.

As discussed in the preceding pages, in the EU, the originality test was defined in *Infopaq International A/S v. Danske Dagblades Forening*[66].

In the UK, Lord Oliver in *Interlego v. Tyco*, speaking about 'modified Lego designs' considers the transformation of physical objects by stating that in such circumstances, the copying should involve:

> … some element of material alteration or embellishment which suffices to make the totality of the work an original work ... even a relatively small alteration or addition qualitatively may, if material, suffice or convert that which was substantially copied from an earlier work into an original work... But copying, *per se*, however much skill or labour may be devoted to the process, cannot make an original work[67].

A reading of Lord Oliver's dictum implies that it is the extent of the change, which will qualify the work as an original work drawing a new copyright. Furthermore, the change should be 'material'. However, as Ong opines, it is important to note that the Privy Council's decision in *Interlego v. Tyco* was made in "response to a narrow factual context"[68]. In this case, the court refused to recognise copyright in the plaintiff's engineering drawings of its interlocking toy bricks, which had been re-drawn from earlier design drawings with a number of minor alterations. The decision was based on a very specific policy concern--that copyright law should not be used as a vehicle to create fresh intellectual property rights over commercial products after the expiry of patent and design rights, which had previously subsisted in the same subject matter[69].

This case suggests that where a 3D digital model faithfully reproduces a copyright work, like a sculpture for example, then the 3D digital model will not be sufficiently original to constitute a copyright work even where copyright in the original work has expired.

Scanning an Object Design File: The Copyright Implications

On the other hand, where an object design file or model is created from a scan or where the file has been transformed through the use of online tools, such a model will be capable of attracting copyright protection provided it can demonstrate "an element of material alteration or embellishment which suffices to make the totality of the work an original work"[70].

The quantitative study demonstrates that objects bearing the tag 'art' are one of the most popular items amongst the online community. This raises the question whether a scanned 3D digital model of an artistic work is capable of being protected by copyright. The first point to make is that scanning a work, which is in copyright constitutes copying[71] requiring permission to avoid infringement. However, the fact permission is required to scan the object and create the 3D digital model does not preclude the model from copyright protection. The performance score of Lalande's music in *Sawkins v. Hyperion Records*[72] were original works irrespective of

66 *Infopaq International A/S v. Danske Dagblades Forening Case* C-5/08 [2010] FSR 20. *Also see*, *supra*, p. 12.

67 *Interlego v. Tyco Industries Inc., and Others* [1988] RPC 343 at 371 *per* Lord Oliver.

68 *Interlego v. Tyco Industries Inc., and Others* [1988] RPC 343 at 365-366.

69 *See also*, Ong B., Originality from copying: fitting recreative works into the copyright universe [2010] (2) *Intellectual Property Quarterly* pp. 165-199.

70 *Interlego v. Tyco Industries Inc., and Others* [1988] RPC 343 para. 262H-263A.

71 *Infopaq International A/S v. Danske Dagbaldes Forening* (C-5/08) [2010] FSR 20 para. 24.

72 *Sawkins v. Hyperion Records Ltd.* [2005] EWCA Civ 565.

the fact they were derived from the original music in which copyright had expired. The performance score would still have been original if it had been created when Lalande's original music was still in copyright.

However, it is clear that where a work is 'copied' without authorisation it will constitute an infringement of copyright. As Bradshaw, Bowyer and Haufe point out "trafficking in copies of a manufacturers' official 3DPDFs (3D object design files) *(sic)* for spare parts would be illegitimate"[73]. This highlights the issues, which can surface from the sharing of 3D design files on online platforms, which can be modified numerous times by using online tools such as *Meshmixer, MakerBotDigitizer* (for purposes of scanning) for example.

This raises a further question about the status of scanned products arising from out-of-copyright works. In this regard, Ong supports the view that copyright can subsist in recreative works, which have been scanned from out-of-copyright works on the basis that skill and judgement has been exercised in the recreation of such works. He argues that copyright should not only 'incentivise' works, which are 'materially altered' from the pre-existing work. He states that it could be in the public interest for authors to make identical replicas of antecedent works which are of major cultural significance or extremely inaccessible or both.'[74]

This view is also supported by the cases of *Antiquesportfolio*[75] and *Painer*[76]. In *Antiquesportfolio* photographs of antiques were held to be copyright works taking into account the positioning of the object, the angle at which it is taken, the lighting and the focus which culminated in exhibiting particular qualities including the colour, features and details of the items. The court stated that such elements could all be matters of aesthetic or even commercial judgement, *albeit* in most cases at a very basic level[77] but sufficient to demonstrate a degree of skill for copyright to exist in the photographs[78]. A similar view was upheld in *Painer*.

Applying these cases to CAD based digital object design files, it could be argued that by making creative choices such as selecting particular views of the physical object when a 3D digital model is created through scanning an object is sufficient to make the 3D digital model an "intellectual creation of the author reflecting his personality and expressing his free and creative choice"[79] in its production.

On the other hand, considering this issue from the perspective of the current law, this could prove problematic in the 3D printing world. Whilst on the one hand scanning 3D digital models representing rare artefacts appears to attract copyright status, it is also clear that 3D digital models of works of artistic craftsmanship manufactured on an industrial scale (functional) will not, as reflected in *Interlego v. Tyco Industries Inc., and Others.* However, repeal of section 52

73 Bradshaw S., Bowyer A., & Haufe P., The Intellectual Property Implications of Low-Cost 3D Printing (April 2010) Vol. 7, Issue 1 *Script-ed* pp. 1-31 at p. 25.

74 Ong B., Originality from copying: fitting recreative works into the copyright universe [2010] (2) *Intellectual Property Quarterly* pp. 165-199 at p. 174.

75 *Antiquesportfolio.com Plc v. Rodney Fitch & Co. Ltd*. [2001] FSR 23.

76 *See* n. 57.

77 *Antiquesportfolio.com Plc v. Rodney Fitch & Co. Ltd*. [2001] FSR para. 36.

78 *Antiquesportfolio.com Plc v. Rodney Fitch & Co. Ltd.* [2001] FSR 23 para. 37.

79 *Painer* at para. 99.

of the *Copyright, Designs and Patents Act 1988* may change this current position in time to come[80].

As such, similar to the status of CAD files discussed above, the status of scanned products also remains unclear.

Li *et al* reflecting on their study into 3D printing chocolate[81] view it from a different angle. They reason that what is ultimately important is the basis of copyright, not the medium in which a product is being 3D printed[82]. In other words, if a 'substantial part' has been taken from another creator in designing a 3D model to be shared on online platforms, then "it makes no difference that a different medium is used (once the object has been scanned), or that the infringing work is derived indirectly from the original work, such as where an intermediary has given verbal instructions which are used by a third party to recreate the work"[83]. As Li *et al* go on to state, "it will continue to be an infringement if the size changes[84], dimensions are altered[85]; elements of the original work are left out or bits added[86]".

Having considered the copyright implications arising from online platforms, CAD files and modified or scanned objects the discussion will now turn to an analysis of the regulation of online platforms.

The Operation and Regulation of Online Platforms

The legal analysis is drawn from a consideration of three specific online platforms (123D, GrabCad and Thingiverse). These platforms were selected as they reflect the highest number of registered users in the 3D printing online community, as confirmed from the data in the empirical study[87]. Before considering their regulation, Governing Laws and what it means for UK users, a brief overview of the three platforms is set out below.

80 Repeal of section 52 of CDPA 1988 (as amended) - *'Effect of exploitation of design derived from artistic work' may change the current position in time to come*. See https://www.gov.uk/government/consultations/transitional-provisions-for-the-repeal-of-section-52-of-the-cdpa

81 See, ChocEdge at http://www.chocedge.com

82 Li P., Mellor S., Griffin J., Waelde C., Hao L., & Everson R., Intellectual Property and 3D Printing: A Case Study on 3D Chocolate Printing [2014] 2 *Journal of Intellectual Property Law and Practice*, pp. 1-11.

83 *Ibid*.

84 *Johnstone Safety Ltd v. Peter Cook* (Int.) Plc [1990] FSR 16; *Antiquesportfolio.com v. Rodney Fitch & Co Ltd.* [2001] FSR 345.

85 *Wham-O Manufacturing Co., v. Lincoln Industries Ltd.* [1985] RPC 127 (CA of NZ); *Johnstone Safety Ltd. v. Peter Cook* (Int.) Plc [1990] FSR 16 ('substantial part' cannot be defined by inches or measurement).

86 *Brooks v. Religious Tract Society* (1897) 45 WR 476.

87 See *infra* p. 31, Table 3 'Things and Users per Website'.

123D, GrabCad and Thingiverse: An Overview

Use of Online Tools ("apps")

All three platforms provide for online software tools or "apps" as they are known. *123D offers 123 Creature, 123 Sculpt*[88], *123D Catch, 123D Circuits, 123D Design, 123D Make, Meshmixer and Tinkercad* amongst others[89]. Each "app" provides a different function. Using these online tools, or apps, the user can create their own design or they can build, edit or customise other people's designs. The pages, which display a design on 123D also show "revisions", which are later versions of the design edited by other users. Icons inform the user how many times the design has been downloaded and how many times it has been remixed[90].

GrabCad's main focus is on an application known as *Workbench*.[91] *Workbench* is essentially a file sharing software available to registered users, which can be downloaded onto their desktops. It allows the user to upload, download, share, edit and manage 3D designs. The software is compatible with many different file types which facilitates the access, use and sharing of the files.

The online platform Thingiverse[92] is owned by MakerBot and was bought by Stratasys in 2013[93]. Thingiverse offers online tools such as *MakerBotCustomizer* which, as the name suggest, allows users to customise a design available on the Thingiverse website by using the tool[94]. MakerBot also provides for the MakerBot Digitizer scanner and makes available to users the *Makerware* tool for the Digitizer. The *Makerware* tool / app permits users to scan any product, upload to Thingiverse which is then accessible for editing, modifying and customising[95]. The partnership between Thingiverse and MakerBot means that anyone who has access to a MakerBot 3D printer has access to Thingiverse's plethora of designs, which can be downloaded and printed[96].

88 Available for download from the *iTunes* Store - https://itunes.apple.com/us/app/123d-sculpt/id446119510?mt=8

89 See all apps and their functions at http://www.123dapp.com/create

90 123D states that *Meshmixer* is "the ultimate tool for 3D mashups and remixes". See http://www.123dapp.com/create In the context of 3D printing, 'mashups' and 'remixes' refer to personalising a 3D design by fusing (mash-up/remixing) different design documents. For more about remixing, see also, Lipson H., & Kurman M., *Fabricated: The New World of 3D Printing* (Indiana: John Wiley & Sons, Inc.; 2013), pp. 224-226.

91 http://grabcad.com/workbench

92 Thingiverse can be traced back to the RepRap Project spearheaded by Dr. Adrian Bower in 2001. Jones R., Haufe P., Sells E., Iravani P., Oliver V., Palmer C., & Bowyer A., RepRap – The Replicating Rapid Prototyper (2011) 29 *Robotica,* pp. 177-191.

93 MakerBot, has been a subsidiary of Stratasys since 2013 and manufactures the company's prosumer desktop 3D printers in Brooklyn, New York. It maintains the Thingiverse design-sharing community and facilitates a wide network of user groups. See, http://www.stratasys.com/corporate/about-us

94 http://www.thingiverse.com/apps/customizer

95 http://www.makerbot.com/makerware

96 See http://www.makerbot.com/thingiverse/

Types of Licences and Bureau Services

123D and Thingiverse also provide licensing options. 123D particularly encourages the use of works approved by a Creative Commons licence[97]. However, as established in the quantitative analysis[98], users tend to rely on the GNU General Public Licence as opposed to the Attribution-Non-Commercial licence, a version of the Creative Commons licence[99]. This is also true of 123D.

Thingiverse also encourages the use of works approved under a Creative Commons licence[100]. Users are requested to provide their designs under a Creative Commons licence to other users, sites and services[101]. In addition users grant an irrevocable, royalty-free worldwide licence that allows Thingiverse to reproduce, distribute, publicly display and perform, prepare derivative works of, incorporate into other works, and otherwise make use of User Content, including granting sub-licences[102].

It should also be noted that 123D acts as a "bureau service". 'Bureau services' are akin to existing services such as *Amazon*, from which products can be ordered and paid for online[103] as opposed to 3D printing online platforms, which are mainly involved in facilitating the dissemination and sharing of CAD files. 123D 'doubles-up' both as an online platform and a bureau service to assist users who do not own 3D printers and assist in the printing of products which are incapable of being printed using a home 3D printer[104]. As such, a registered user of 123D can create, edit and share their designs, for printing at home or through a printing and delivery service ("bureau service") provided through companies such as Sculpteo, i.materialise or Shapeways.

97 http://usa.autodesk.com/adsk/servlet/item?siteID=123112&id=21794375

98 See *infra* p. 24. A Creative Commons licence is a type of copyright licence that gives people the right to share, use, and even build upon a creative work. See https://creativecommons.org/licenses/ The types of licences used on 123D and other online platforms vary from Creative Commons Licences to General Public Licence (see below).

99 The GNU General Public Licence (GPL) is a widely used free *software licence* which grants the recipients, rights to copy, modify and redistribute the software and to ensure that the same rights are preserved in all derivative works. The main difference between GNU GPL and Creative Commons (CC) licences is that GNU GPL does not allow changes to the conditions of licensing and standard. Furthermore, CC licences typically apply to 'traditional' or 'conventional' types of copyrighted material such as music, film, literary works, artistic works and so on. For more about GNU GPL, see also, O'Sullivan M., The pluralistic, evolutionary, quasi legal role of the GNU General Public License in free/libre/open source software (FLOSS) 2004 26(8) *European Intellectual Property Review*, pp. 340-348.

100 See *supra* n. 98 and n. 99.

101 *Thingiverse* offers choice of three free software licence options for uploaded files in addition to the Creative Commons Licence options. For more about licensing options in Thingiverse, *see*, Moilanen J., Daly A., Lobato R., & Allen A., Cultures of Sharing in 3D Printing: What Can We Learn From the Licence Choices of Thingiverse Users? (2015) *Journal of Peer Production*, Available at SSRN http://ssrn.com/abstract=2440027

102 http://www.thingiverse.com/legal

103 Hoskins S., *3D Printing for Artists, Designers and Makers* (London: Bloomsbury; 2013), pp. 12-13.

104 123D users can create, edit and share their designs, to either be printed at home or through a printing service. The printing and delivery service is provided through Sculpteo, i.materialise or Shapeways. See http://www.123dapp.com/about

An overview of these online platforms and the functionalities they offer highlights the various copyright implications, which arise from uploading, downloading to using software tools or 'apps' to edit, modify, create mashups and remixes of existing designs. At the same time, it raises questions about how the online platforms operate, how they are governed, their contractual provisions and the effect, if at all they have on UK users. The next part of this report addresses these issues with reference to 123D, GrabCad and Thingiverse.

Governing Laws

123D, GrabCad and Thingiverse provide for software tools as mentioned above and all three online platforms emphasise that the users are responsible for the content they design, edit, modify, customise, remix and share. In other words, the liability remains with the user[105]. This sentiment is echoed by almost all online platforms; however for purposes of this report, the discussion will focus on the three platforms discussed above.

Almost all, if not all, online platforms dedicated to 3D printing, including 123D, GrabCad and Thingiverse are based in America[106] and as such are governed by the laws of the US[107]. This raises the question about how liability is dealt with in the case of an intellectual property infringement as a result of the access and use of these websites.

A reading of 123D's Terms of Service indicates that the jurisdiction is dependent on the location of the subscriber according to where the service was acquired[108]. However, if the use involves an action for intellectual property rights, 123D have the right to bring such an action in the country where the infringement occurred as per the case in intellectual property infringements[109]. For most users, such terms and conditions can be confusing and complex.

As Trakman opines:

> The contract practices of 21st century mass consumers … still do not scrutinise … conditions in "wrap" contract. Either such clauses are too complex for them to understand, or the cost of doing so outweighs the perceived benefit. Consumers may not inform themselves for rational reasons[110].

105 For 123D, see, http://usa.autodesk.com/adsk/servlet/item?siteID=123112&id=21310328 at 2 (2.1). For GrabCad, see, http://grabcad.com/terms and for Thingiverse, see, http://www.thingiverse.com/legal at 3.3 and 6.

106 GrabCad is located in Boston, USA has additional offices in Cambridge, UK and Tallinn, Estonia http://grabcad.com/about ; 123D has their main office in USA with head offices also in Switzerland and Singapore and offices around the world http://usa.autodesk.com/adsk/servlet/index?siteID=123112&id=304753 ; Thingiverse (owned by MakerBot and bought by Stratasys) has dual headquarters in the USA and Israel with additional offices around the world http://www.stratasys.com/corporate/about-us

107 *See*, For example 123D Terms of Service, http://usa.autodesk.com/adsk/servletitem?siteID=123112&id=16910341 at Section 3.

108 http://usa.autodesk.com/adsk/servlet/item?siteID=123112&id=21310328 at Section 19a.

109 *See*, Terms of Service, http://usa.autodesk.com/adsk/servlet/item?siteID=123112&id=21310328 at Section 9.2. "…Nothing in the foregoing will prevent Autodesk from bringing an action for infringement of intellectual property rights in any country where such infringement is alleged to occur. You will be considered to have subscribed to a Service based on where you buy or purchase the Service, regardless of where the Service is delivered or accessed".

110 Trakman L. E., The boundaries of contract law in cyberspace [2009] (2) *International Business Law Journal*, pp. 159-197 at p. 164.

This is very true; in most cases the agreements are complex and users choose not to familiarise themselves with the complex legal implications[111]. "[I]t [is] clear that in some cases, paradoxically, it would be irrational to become fully informed … suppliers, in turn, may take full advantage of this "non-practice" of consumers by including ever more self-serving clauses in their "wrap" contracts"[112]. The consequence of this practice in the 3D printing landscape will unravel if and when there is litigation in this area.

Autodesk (which owns 123D) also makes a distinction between 'registered users' and those who are not registered. If a non-registered user based in the UK accesses the service the terms shall be governed by and construed in accordance with the laws of England and Wales.

> *If (i) you do not have an existing contractual relationship with Autodesk; (ii) you are not a U.S. citizen; … and (vi)* ***you are the citizen of a European Union country who is using the Site for purposes other than for your trade, business or profession, you hereby agree that any disputes … shall be governed by and construed in accordance with the laws of England and Wales, without regarding to applicable conflict of law provisions***[113].

Thingiverse's terms and conditions are quite similar to that of 123D in relation to the Governing Law and are provided for by MakerBot (owners of Thingiverse). Under the title 'Governing Law and Venue' MakerBot states:

> *These Terms of Use shall be governed by the laws of the State of New York without giving effect to any conflict of laws principles that may require the application of the law of another jurisdiction … Notwithstanding anything to the contrary, Company may seek injunctive relief in any court having jurisdiction to protect its intellectual property or confidential or proprietary information*[114].

GrabCad, on the other hand, differs from 123D and Thingiverse in relation to the terms of service. The present authors suggest that this could be due to the fact that GrabCad does not operate the same complex business/company model as Autodesk's 123D or MakerBot's Thingiverse.

111 *Ibid* at pp. 164-165.

112 *Ibid*. However, the Terms of Service provided by MakerBot (owners of Thingiverse) states: "We realize Terms of Service can be confusing and, quite frankly, a snooze-fest; however, they are very important in explaining the basis of what we, the Company, expect of you, the User, while on this Site and how this interaction plays out. We promised "understandability" so, to the right of each term, we provided a summary in "plain English"".

113 http://usa.autodesk.com/adsk/servlet/item?siteID=123112&id=16910341 at 19 (para 3).

114 http://www.thingiverse.com/legal at 11.2 The terms further go on to state that "Any action or proceeding relating to a claim or controversy at law or equity that arises out of or relates to these Terms of Use or the Site or Services (a "Claim") must be brought in a federal or state court located in New York, New York, and each party irrevocably submits to the exclusive jurisdiction and venue of any such court in any such action or proceeding, unless such claim is submitted to arbitration as set forth below. Notwithstanding anything to the contrary, Company may seek injunctive relief in any court having jurisdiction to protect its intellectual property or confidential or proprietary information".

GrabCad states in their Terms of Service that the jurisdiction for any legal disputes will be the law of Massachusetts:

> *These Terms of Service … shall be governed by and construed in accordance with the laws of the Commonwealth of Massachusetts, without giving effect to any principles of conflicts of laws, and will specifically not be governed by the United Nations Conventions on Contracts for the International Sale of Goods, if otherwise applicable*[115].

It is clear from the preceding section and from the terms and conditions that all responsibility and liability of using the online platform, rests with the users who are expected to comply with all rules and regulations applied by these online platforms at the time of becoming a "registered user". In this regard, it is also interesting to note that platforms such as Thingiverse and 123D require their users to waive their moral rights or other rights with respect to attribution of authorship of their content upon registration[116]. It is also clear that whilst online platforms such as 123D, GrabCad and Thingiverse reserve the right to bring an action for intellectual property infringement in the country where the infringement occurs, they have cleared themselves of giving effect to any conflict of laws principles that may require the application of the law of another jurisdiction[117]. The significance of what this means for UK users is considered below in the context of recent European rulings.

Conflict of Laws and Choice of Jurisdiction

Questions arising from the online platforms' reference to the conflict of laws provisions, choice of jurisdiction and what it means for UK/European users when faced with intellectual property infringements can be considered within the context of Brussels I, and its application in the recent European ruling of *Pinckney v. KDG MediaTech AG*[118].

Brussels I, superseding the Brussels Convention 1968 states that the courts with jurisdiction to hear infringement claims of intellectual property rights, at least in EU Member States, are in principle, the courts of the place in which the defendant is domiciled[119]. However, Article 5(3) of Brussels I stipulates that claims relating to tort, delict and quasi-delict (which include intellectual

115 http://grabcad.com/terms *United Nations Conventions on Contracts for the International Sale of Goods*, also known as the Vienna Convention 1980 allows exporters to avoid choice of law issues as the CISG offers "accepted substantive rules on which contracting parties, courts, and arbitrators may rely" unless excluded by the express term of a contract.

116 *See* Thingiverse http://www.thingiverse.com/legal at 3.2; 123D http://usa.autodesk.com/adsk/servlet/item?siteID=123112&id=21310328 at 2 (2.2).

117 123D states: "…The laws of such jurisdictions shall govern without reference to the conflicts-of-laws rules thereof. The UN Convention on Contracts for the International Sale of Goods and the Uniform Computer Information Transaction Act shall not apply to (and are excluded from the laws governing) these Terms" at http://usa.autodesk.com/adsk/servlet/item?siteID=123112&id=21310328 Section 9.2. Thingiverse also provides for a similar clause at

118 *Pinckney v. KDG MediaTech AG* (C-170/12) [2013] Bus. L. R. 1313 (ECJ (4th Chamber)). ***See also***, Alexander R., Questions of Jurisdiction (Case Comment) – *Pinckney* [2014] 25(2) *Entertainment Law Review,* pp. 67-69.

119 Council Regulation (EC) No 44/2001 of 22 December 2000 on Jurisdiction, Recognition and Enforcement of Judgements in Civil and Commercial Matters (Brussels I) [2001] OJ L012/1. Brussels I supersedes the Brussels Convention 1968 http://www.jus.uio.no/lm/brussels.jurisdiction.and.enforcement.of.judgments.in.civil.and.commercial.matters.convention.1968/doc.html

property law) may also be brought before the courts of "the place where the alleged harmful event occurred or may occur"[120].

CJEU invoking Article 5(3) of Brussels I in the case of *Pinckney*[121]considered the meaning of "the place where the alleged harmful event occurred" on the question of online cross-border copyright infringement. The Court ruled that in such cases, the question which needed to be answered was whether copies of copyright works were made accessible online in that particular Member State rather than ask whether the activity of a website was "directed to" that particular Member State[122].

This means that a company that neither acts nor causes any effect through its own actions (in France) can still be sued in France, because a second (unrelated) company from the UK furthered its infringement by making the e-commerce website with infringing goods accessible there[123]. This ruling departs from the general defendant's domicile rule as set out in the Brussels I Regulation and from previously settled case law on infringement of online intellectual property rights[124] such as *Melzer v. MS Global*[125] and *Football Dataco Ltd v. Sportradar GmbH*[126]. In *Football Dataco Ltd*., the CJEU ruled that where an infringing act takes place in another (member) state, there is sufficient evidence to conclude that the act discloses an intention on the part of the person performing the act to 'target' members of the public in that second member state[127].

The ruling in *Pinckney* "… appears to be good news for copyright owners wanting to take action for the infringement of intellectual property rights in the jurisdiction where the infringing contents are made available"[128]. This is further compounded by the fact that it is no longer necessary for copyright owners to show that a website's activity is 'targeted at' or 'directed to' Internet users of particular Member States[129]. The very fact that it is accessible is sufficient to establish jurisdiction in that State.

120 *Ibid.*

121 Mr. Pinckney, a French resident, was the author of 12 songs, which were made into a vinyl disk in the 1970s. An Austrian domiciled company *KDG Mediatech* AG (hereinafter *Mediatech*) copied his songs on to a CD, copies of which were sold by UK companies via websites, which were also accessible from France. Mr. Pinckney brought a claim against *Mediatech* in the Regional Court of Toulouse for copyright infringement, which was referred to the Court of Justice of the European Union.

122 *Pinckney v. KDG MediaTech AG* (C-170/12) [2013] Bus. L. R. 1313 (ECJ (4th Chamber)).

123 Husovec M., Comment on "Pinckney" Council Regulation (EC) No. 44/2201 of 22 December 2000 on Jurisdiction and the Recognition and Enforcement of Judgements in Civil and Commercial Matters, Art 5(3) – *Peter Pinckney v. KDG MediaTech AG* (2014) IIC pp.370-374.

124 Liability only attaches to a website if it is targeted at consumers of the Member State in which the intellectual property right is protected. This means that copyright infringers can only be liable for damage caused within the particular Member State in which the action is taken.

125 C-228/11 [2013] WLR (D) 196.

126 C-173/11 [2013] 1 CMLR 29; [2013] FSR 4.

127 *Ibid*. This decision has been transferred to other IP rights by the UK Courts, most notably, in copyright infringement claims founded on 'communication to the public right' pursuant to section 97A of CDPA 1988 (as amended). See also *EMI Records Ltd., v. British Sky Broadcasting Ltd*. [2013] EWHC 379 (Ch).

128 Smith J., & Leriche A., CJEU ruling in *Pinckney* v. *MediaTech*: jurisdiction in online copyright infringement cases depends on the accessibility of website content [2014] 36(2) *European Intellectual Property Review* pp. 137-138. *See also*, Alexander R., n. 118 pp. 67-69.

129 *See, Melzer v. MS Glogal and Sportradar at n*. 125 and n. 126.

However, the three online platforms examined above specifically state that they will not give effect to conflict of laws principles as discussed above and this could yield concerning results for those involved in the activities of 3D printing online platforms[130]. As Husovec states, "from a technological point of view, the mere accessibility criterion inevitably pushes the website operators to more intensive use of geo-location tools, the use of which is not always to the benefit of society at large"[131].

From a 3D printing online platforms point of view, this is very true. For example, 123D's *Terms of Service* states that in the case of intellectual property infringements, the user "will be considered to have subscribed to a Service based on where they buy or purchase the Service, regardless of where the Service is delivered or accessed"[132]. According to such terms, this means that if a UK user is liable for an intellectual property infringement arising from the access and use of the relevant online platforms, it will be dealt with in accordance with the laws of the UK, regardless of the regulations set out in Brussels I.

Conclusion

A consideration of online platforms dedicated to the creation and dissemination of 3D designs has highlighted a number of issues emphasising the need for further clarification in this area.

The status of CAD files and whether they are capable of copyright protection has given rise to some debate in the USA and the UK. American commentators such as Simon, Nimmer and Rideout argue against copyright subsisting in 3D design files. Rideout asserts that a CAD based digital object design file resembles computer software as opposed to stating that it is computer software.

In the UK, the *Copyright, Designs and Patents Act 1988* (as amended) states that a computer program and its embedded data for example is recognised as a literary work under copyright law thereby suggesting that a CAD file has the potential to be an original work of authorship, which may be protected by literary copyright in the same manner as other types of computer software. Further support for this view can be found in *Autospin (Oil Seals) Ltd. v. Beehive Spinning*[133] where Laddie J makes reference, obiter dictum, to three-dimensional articles being designed by computers and states that "a literary work consisting of computer code represents the three dimensional article"[134]. However guidance from the CJEU in cases such as *Bezpečnostní and SAS Institute Inc*., and subsequent UK consideration of those cases raises more questions than answers about the status of CAD design files. As such, the copyright status of CAD files remains unclear at present.

130 *See* also, Regulation (EC) No 593/2008 of the European Parliament and of the Council of 17 June 2008 on the law applicable to contractual obligations (Rome I) at http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32008R0593 which states that "in the absence of party choice the applicable law is the law of the place where the party which has to perform the main obligations of the contract is normally resident". It is important to note that in order for Rome I to apply, the parties need not have any EU connection.

131 Husovec M., Comment on "Pinckney" Council Regulation (EC) No. 44/2201 of 22 December 2000 on Jurisdiction and the Recognition and Enforcement of Judgements in Civil and Commercial Matters, Art 5(3) – *Peter Pinckney v. KDG MediaTech AG* (2014) IIC pp.370-374 at p. 374.

132 http://usa.autodesk.com/adsk/servlet/item?siteID=123112&id=21310328 Section 9.2.

133 *Autospin (Oil Seals) Ltd., v. Beehive Spinning* [1995] RPC 683. See also, *Nova v. Mazooma Games Ltd.*, [2007] RPC 25.

134 *Autospin (Oil Seals) Ltd., v. Beehive Spinning* [1995] RPC 683 at 698.

The lack of clarity and consistency can lead to complexities borne out of the territorial nature of copyright law coupled with the exterritorial nature of online platforms and CAD files shared amongst users around the world.

In the case of modifying a product through the use of online tools and / or scanning software, the situation is equally unclear. 3D digital models representing rare artefacts appears to attract copyright status as was seen in cases such as *Antiquesportfolio and Painer*. Applying these cases to CAD based digital object design files, it is argued that making creative choices such as selecting particular views of the physical object is sufficient to make the 3D digital model an "intellectual creation of the author reflecting his personality and expressing his free and creative choice"[135] in its production. On the other hand, 3D digital models of works of artistic craftsmanship manufactured on an industrial scale (functional) will not attract copyright as established in *Interlego v. Tyco*[136], although this situation may change following the repeal of section 52 of the *Copyright, Designs and Patents Act 1988* (as amended).

As for the online platforms and the governing law, it is clear that the platforms have absolved themselves of any liability, thereby pointing the finger in the direction of the user with specific terms set out as to the jurisdiction where the user will be held liable. At the same time, although online platforms such as 123D, GrabCad and Thingiverse reserve the right to bring an action for intellectual property infringement in the country where the infringement occurs, they have cleared themselves of giving effect to any conflict of laws principles that may require the application of the law of another jurisdiction. Only time will tell how these online platforms will be regulated, if and when, a court case comes into being.

135 *Painer* at para. 99.

136 *Interlego v. Tyco Industries Inc., and Others* [1988] RPC 343.

SECTION B: EMPIRICAL STUDY

Introduction

This part of the report (Section B) presents a description of the variables available in the data collected to specify operations — i.e. how the online platforms dedicated to 3D printing work. The analysis is also used to provide information on the depth of the phenomenon — i.e. qualifying the content and how it is shared. Finally, the information provided below helps to define the width – i.e. the range and scope of file sharing and what seem to be its drivers.

Most of the analysis presented below has an 'exploratory' nature. In the analysis the researchers do not follow a classic hypothesis-testing scheme but perform the analysis aiming at finding whether relationships among variables exist and what their shape is.

Section B is structured as follows. First, information on methods is provided. Second, data is described and its structure documented. Third, a preliminary analysis on what affects activity on 3D printing platforms is presented.

Methods

Econolyst Ltd.[137] collected and provided the data on 3D printing online platforms. These websites were selected based on their popularity, on information gathered at 3D printing conventions and on previous research. In addition to this, Econolyst also ran an Internet search to screen for online platforms sharing files for 3D printing. These websites allow users to upload and download materials (i.e. files or 'things') on the Internet. The data are organised by users, things/files uploaded, upload date (when available), website, price (when available), number of views (when available), downloads (when available) and type of licence. In addition to these, the data includes how materials have been tagged and provides a short description of the file. Data was extracted in January 2014.

Data varies depending on the information available. The first part of this section of the report provides descriptive information on the websites while the second presents some inferential statistics. Data coding presented significant challenges and, in particular, the coding of product tags and descriptions was not trivial.

The database presents several variables that can be used to analyse the activity on 3D printing (hereinafter 3DP) platforms. In this section of the report, the researchers focus on the number of files (or 'things') uploaded on these websites and try to explain whether that is affected by other elements. The database has many variables and the analysis presents significant challenges due to the heterogeneity of measures and especially to their incompleteness. For example, while calculating the number of files per user is relatively straightforward, identifying the most common brands that appear in the data is not, and requires several steps to be performed before a measure can be obtained. Another issue that comes out of the heterogeneity of sources affects missing data. The database is characterised by thousands of missing data, due to the

137 Econolyst (a research partner on this project) is a UK based Additive Manufacturing and 3D Printing consultancy and research firm working with a broad range of clients across Europe, North America, the Middle East, Far East and Africa. For further information, see, http://www.econolyst.co.uk

fact that there is significant heterogeneity in the information that 3DP platforms allow their users to disclose. For example, not all platforms disclose the licence scheme, not everyone shows a price for their uploaded file, and not all the platforms provide information on the number of downloads.

For these reasons, and before commencing the analysis of the data, we believe it is important to summarise all these measurement issues for each variable of the study. The reader should note that most of the tests conducted differ in their sample size and this is done as an adaptation to missing data. Implications of the variability in the sample size are that (a) it becomes difficult to find generalisation patterns that are valid for all platforms and users, and (b) different results based on different sample sizes may be difficult to compare to each other.

After a description of the coding activity performed on the variables, the section presents results of inferential statistics tests on users, keywords and categories, and licence schemes.

Measurements

As a general disclaimer on what follows below, the indication that missing data were found in the dataset implies that those observations will be excluded when carrying out the analysis. For example, given that the variable 'number of views' shows a significant number of missing values, when regressing the 'number of views' on the 'number of files' uploaded, only valid responses are considered and missing values omitted. In other words, no action has been taken on missing values due to the high uncertainty (i.e. it is difficult to justify a consistent strategy for their substitution) and the large sample size[138]. Table 1 below provides information on the sample.

In the following, the report provides a description of how each variable was coded, excluding those variables in the database that were only available for one platform (e.g. star ratings) or appeared sporadically (e.g. file size).

Users. This variable is treated as categorical[139]. The users are associated with an identity (ID) number and that can be tracked down to their activities on the web (i.e. to the other variables).

Number of files. Each uploaded file is associated with an ID number. This can be tracked down to the user; hence it is relatively easy to calculate the number of files each user uploaded. The figures below (Table 1 and 3) show that the vast majority of users upload a very limited number of files, and this leads to a very skewed distribution with few users uploading the majority of the files.

Websites. As shown in Table 3, there are 17 websites/platforms considered in this study. All files and users are associated with a particular website where they are active. We have no information on whether the same user has activity on two or more websites. Their ID is different depending on the website.

138 Roth P. L., Switzer F. S., & Switzer D. M., Missing data in multiple item scales: A Monte Carlo analysis of missing data techniques (1991) 2(3) *Organizational Research Methods*, pp. 211-232; Roth P. L., Missing data: A conceptual review for applied psychologists (1994) 47 *Personnel Psychology*, pp. 537-560; Roth P. L., Campion J. E., & Jones S. D., The impact of missing data on validity estimates in human resource management (1996) 11 *Journal of Business & Psychology*, pp. 101-112.

139 Agresti A., *Categorical Data Analysis* (New York: Wiley; 1991).

File price. Some platforms allow users to set a price for the file that they upload. The price is expressed in 'web' currency, not using actual existing currency. In this Study, the variable is used as a measure of importance that the user attributes to the file uploaded. This information is provided for 1/3 of the files only. The remaining 2/3 values are therefore coded as missing.

Number of views. Very few websites report the number of views for uploaded files (67,813 observations on 385,118 that is approximately 18%). This is particularly low and it will be difficult to generalise the trend although, as the rough numbers show, there is still scope for analysing the information.

Number of downloads. This is the number of times a given file was downloaded. Here too, there is approximately 1/3 missing values so that the information is available for 225,003 observations in the database.

Licence. There are multiple licence schemes that are subjectively applied to the uploaded files (see Table 2). This information is not available for many observations and it only appears in 68,445 observations.

Time. The information on when a particular file was uploaded in the system is also not available for most websites. This makes it very difficult to generalise the trends and to understand what has shaped the configuration of these 3DP platforms over time. Where available, the information has been coded in months and years, over a period of 6 years (2008-2013).

Categories. Every file is associated with a category (named 'tag') that facilitates their recognition over the web. Some files have multiple attributions and there is a minority (89,909) that appear to have no category at all. There are 38 categories (see Table 4 below) in the dataset. This is another categorical variable and it derives from the words used by users to define their uploads. The researchers have indicated the most commonly used categories and used them in the analysis.

Brands. Some of the uploaded files appear to have a few sentences describing what the file is for and to what it is associated. The researchers screened these descriptions to see whether there were recognised products or company names that appeared. This procedure led to isolating 40 brand names, of which only 27 appeared more than 100 times in the entire dataset (see Table 5 below). The analysis is carried over these most recurrent items, to increase the likelihood to find meaningful relations.

Analytical strategy

Most of the analysis was conducted using multiple ordinary least squares (OLS) regressions[140]. As already mentioned above, the sample size for each regression may vary due to the different information provided in each of the websites. Most of the results have been compared to robust standard errors regressions, to see whether coefficients are consistent enough.

The Structure of 3D Printing Online Platforms

Table 1 shows basic information on the quantitative variables. The overall number of 3D files that is found on the surveyed platforms is 385,118. The mean number of files that can be found in a file-sharing platform is, on average, 22,653, with a standard deviation of 36,738. This means that there is a significant disparity in how files are uploaded amongst different websites (see Table 3 below).

An average user uploads around 3 'things' (files). Here too the standard deviation is particularly high (i.e. 38.42), meaning that there are probably few users that upload most of the files while the vast majority uploads one. Figure 1 shows the first 1,000 users per number of uploads.

Table 1. Descriptive statistics

Variable	Mean	St. Dev.	N	%
Things/files	22,653.88	36,738.49	385,118	100%
Uploaded files per user	3.69	38.42	104,393	27%
Price	276.18	3491.52	19,541	5%
Downloads	14,970.89	24,056.48	40,673,814	–
Files uploaded per year	21,837.67	31,820.32	2008-2013	–

Note: St. Dev. = standard deviation; N = number of observations.

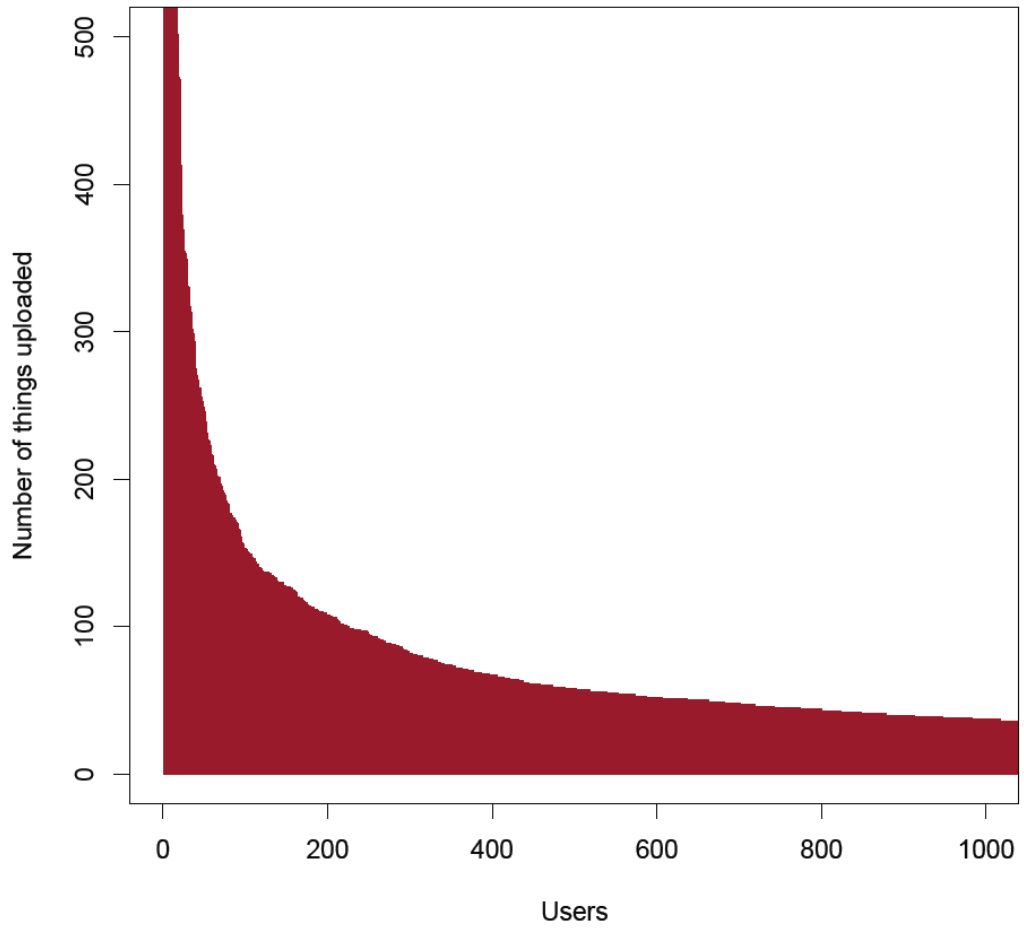
Price is another interesting aspect to consider. This is calculated in the currency of the website[141] that can or cannot be traceable back to a real currency (not provided here). As seen in Table 1, the average price is particularly high and it varies significantly. The researchers found more than 19,000 different prices associated with items, showing a significant variety (*st. dev*. = 3491.52). One of the directions of this study is that of tracking what costs the most and why. Also, it is interesting to see whether users have a strategic approach to pricing their files, or if they follow what was found in the website where they posted their file (see the second part of this section below).

140 Data is treated as cross-sectional. The use of the database as panel data was not possible due to the issues with missing data that does not allow the treatment of the sample as distributed over a time series.

141 The text here refers to digital or virtual currencies adopted by users in some of these online platforms in order to price their items/things.

The total number of downloads for the time period 2008-2014 is around 40,000, with a mean of 14,970 downloads per website. It is difficult to state whether this is a high or low number, given both the newness of the phenomenon and the consequent lack of public (mass) awareness on 3DP.

Figure 1. Number of files uploaded by the 1% most active users (2008-January 2014)



Last but not least is the number of files uploaded per year. Table 1 shows that the files uploaded were, on average, 21,837 every year. However, as the standard deviation suggests (31,820.32), there has been a significant variability over the years (2014 is excluded from this calculation, since only January 2014 is available). Figure 2 (see below) shows how uploads have been increasing over the years. It is not surprising that the trend resembles an exponential curve, with figures doubling almost every year. January 2014 witnessed about the same amount of files uploaded during the year 2010 (ca. 3,300). From this perspective, the year (2014) looks promising although January 2013 peaked at 8,380 files uploaded and that is 2.5 times of the figure calculated for 2014.

Figure 2. Number of files uploaded per year (2008-2014)

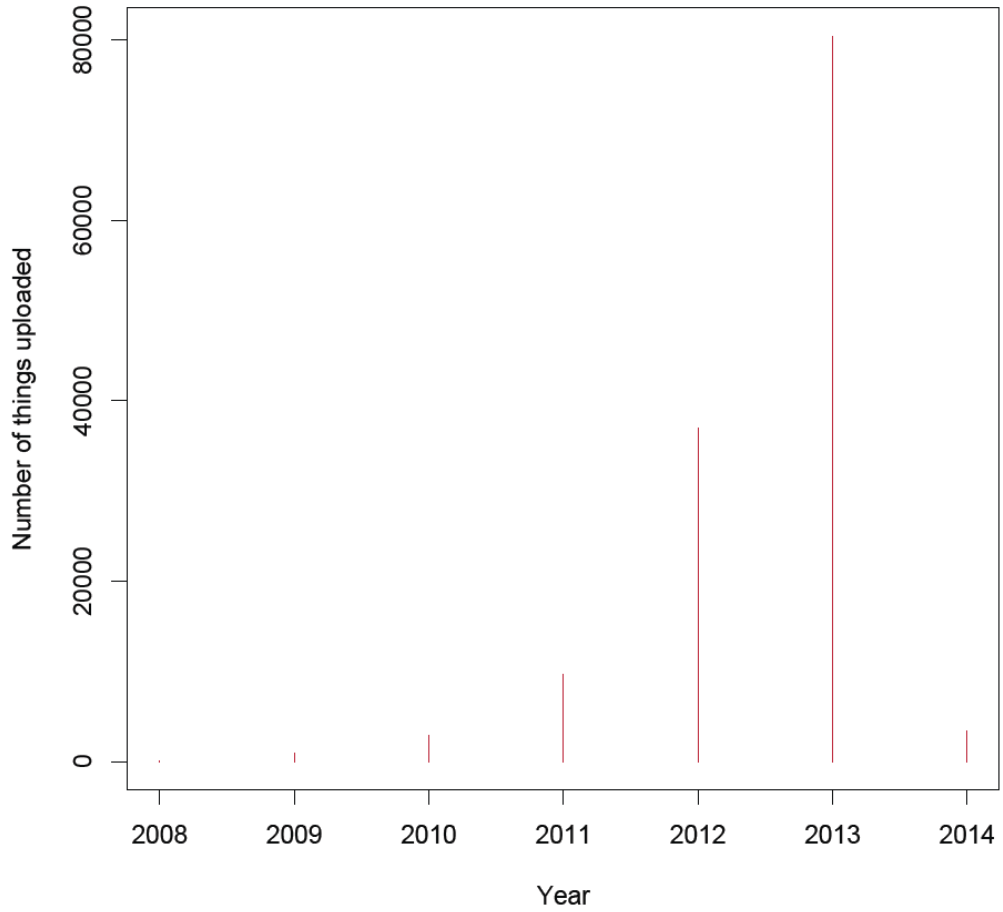


Table 2 provides a summary of the different licence schemes that users claim apply to their files[142]. Most of the uploaded files (65%) do not have any indication of a licence scheme, 16% categorise their files under the "Commons Attribution" licence and another 15% indicates "Creative Commons" as a reference. All of the other licences are around or below 1% of the total number of files. This information requires further investigation, given that no indication of licence may reveal a breach of intellectual property rights or some activity that may not be completely in line with current legislation. It is worth noting that the numbers for the scheme that are below 1% are particularly significant and in the range of a few thousands, with few exceptions ("BSD" and "All Rights Reserved").

142 A recent study on licence choices among *Thingiverse* users show that guidelines and user selections are rather contradictory. Moilanen J., Daly A., Lobato R., & Allen A., Cultures of Sharing in 3D Printing: What Can We Learn from the Licence Choices of Thingiverse Users? (2015) *Journal of Peer Production,* Available at SSRN http://ssrn.com/abstract=2440027

Table 2. Types of Licences

License	Number	Percentage
All Rights Reserved	967	0.02
Attribution-Non-Commercial	4,734	1.20
BSD License	353	0.01
Commons Attribution	64,068	17.00
Creative Commons	57,773	15.00
General License	1,479	0.04
GNU	2,780	0.07
Public Domain	1,511	0.04
NA	251,451	65.30

Table 3 reports the number and percentages of files uploaded and users in each of the 17 websites that were selected for the study. The online platform with the largest community of users is 123D with 31,974 (30.6% of the total number of users). The second is *GrabCad* with 20,632 (19.7%) followed by *thingiverse* with 16,385 users (15.7%). Close to these first three are *sculpteo* and *shapeways* with more than 10,000 users each. With exception of leopoly (5.7%), all other websites have a significantly low number of users.

Turning our attention to the number of files uploaded, the figures follow the number of users most of the time with one significant exception. *GrabCad* occupies the first position per number of files uploaded that are 108,663 (28.2% of the total number of files). As already stated, the other numbers for files uploaded follow the number of users, so that one can expect to find more files in those websites with relatively larger communities of users.

Table 3. Things and users per website

Website	Things	Percentage	Users	Percentage	T/U Ratio
1. 123D	65,326	16.9	31,974	30.6	2.043
2. 3dlt	514	0.01	88	0.01	5.841
3. cgtrader	1,789	0.05	133	0.01	13.451
4. cubehero	143	0.004	82	0.01	1.744
5. cubify	1,610	0.04	383	0.04	4.204
6. cuboyo	124	0.003	27	0.002	4.592
7. GrabCad	108,663	28.2	20,632	19.8	5.267
8. i.materialise	822	0.02	308	0.03	2.669
9. kraftwurx	378	0.01	89	0.01	4.247
10. leopoly	12,241	3.2	5,997	5.7	2.041
11. ponoko	360	0.01	106	0.01	3.396
12. sculpteo	32,002	8.3	15,486	14.8	2.066
13. shapeways	91,489	23.7	12,327	11.8	7.422
14. sketchup	500	0.01	129	0.01	3.876
15. the pirate bay	159	0.004	69	0.01	2.304
16. thingiverse	68,505	17.8	16,385	15.7	4.181
17. youimagine	491	0.01	176	0.02	2.790

Note: T/U Ratio is the Things/User ratio, i.e. the average number of 'things' uploaded by each user per website. Percentages reported are the weight of 'things' and 'users' to the respective total number of 'things' and 'users'.

There is, however, another aspect that can be considered. The last column on the right of Table 3 shows the *Things-User Ratio* (TUR). This indicates the community with the most active users. For example, the researchers noticed that the community of users that operate in the website called *GrabCad* is about 19.7% of the total number of active users in 3DP. This community covers for 28.2% of the total number of 'things' uploaded on all websites. This is done with a TUR of 5.3. To understand what this means, we can reformulate and state that users from *GrabCad* upload, on average, 5.27 files each. Another extremely active community is *shapeways*, where users upload 7.422 files each. However, this is nothing compared to the most active community in the world of 3D printing that is *cgtrader,* with 13.45 files uploaded, on average by their users. This is a very small but extremely active community of users.

The files that are uploaded in these platforms poses another, probably more interesting, question to explore. Some of the websites listed in Table 3 'tag' uploaded files with a short description of the domain to which the file refers. Table 4 shows a summary of these 'tags' or keywords used in the description of the files. These are labelled 'categories' in this report and their appearance is summarised in Table 4 with their relative number *N*, i.e. how many times that category is

repeated, and weight, i.e. the percentage of how many times each category appears on the total number of files associated with a category.

Table 4. Appearance of user-designated categories (tags)

	Category	N	Weight		Category	N	Weight
1	miniature	36596	0.13	21	military	3958	0.01
2	art	27666	0.10	22	aerospace	3904	0.01
3	jewellery	24348	0.09	23	fixture	2831	0.01
4	design	19327	0.07	24	mechanic	2599	0.01
5	household	16083	0.06	25	marine	2037	0.01
6	gadget	16046	0.06	26	medical	1190	0.00
7	games	14643	0.05	27	building	1064	0.00
8	3dp	12629	0.05	28	nature	800	0.00
9	industrial	12585	0.05	29	math	482	0.00
10	tools	11227	0.04	30	tech	432	0.00
11	interior design	8645	0.03	31	robot	343	0.00
12	hobby	7455	0.03	32	accessories	268	0.00
13	home	7247	0.03	33	iphone	151	0.00
14	toys	7027	0.03	34	light	113	0.00
15	electric	6775	0.02	35	creature	54	0.00
16	architecture	6644	0.02	36	music	15	0.00
17	educational	6466	0.02	37	office	6	0.00
18	maker	5583	0.02	38	software	2	0.00
19	model	4853	0.02	39	logo	1	0.00
20	fashion	4196	0.02				

There are three categories around 10% of total attributions: ‘miniature’, ‘art’, and ‘jewellery’. Keeping in mind that some files may have more than one tag, there may be overlaps, meaning that users may tag their file with multiple words. It is apparent that, while category number 3 — i.e. ‘jewellery’ — identifies a domain that is rather specific, the other two categories —i.e. ‘miniature’ and ‘art’ — are extremely generic and, for this reason, slightly uninformative. The word ‘miniature’, for example, may refer to a vast variety of ‘things’ that is not easy to define. Similar arguments can be made for ‘art’.

Category number 4 is ‘design’ (approximately 7%) and, although generic, this may indicate something that has more to do with furniture, home-related products, or something that helps make everyday working or private life easier. The following category, ‘household’, is close to ‘design’. Although Table 4 does not provide specific information on the way these two overlap. To try and test exactly this element, the researchers created dummy variables out of the 39 categories and tested the first 9 with Pearson’s correlation coefficients. These came out mostly negative and significant at the 0.001 level, probably because of a sample size effect. The researchers found that the correlation coefficient never assumes values below -0.10 and consider this as an indication that there is no significant overlap in the attribution of categories. In other words, when a user indicates that the file falls under the ‘art’ category, it is unlikely that she/he also indicates the same file falls under ‘jewellery’.

Table 5. Frequency of descriptive keywords

Note: the 'relative weight' is calculated on the total number of products that are labelled while the absolute weight is calculated on the total number of uploaded things/files.

Label	N	Rel. Weight	Abs. Weight	Label	N	Rel. Weight	Abs. Weight
iPhone	3198	0.2104	0.0128	Ikea	278	0.0183	0.0011
Robo	2479	0.1631	0.0099	Batman	275	0.0181	0.0011
Lego	1309	0.0861	0.0052	lamborghini	270	0.0178	0.0011
USB	760	0.0500	0.0030	Android	262	0.0172	0.0011
Ipod	669	0.0440	0.0027	Nexus	254	0.0167	0.0010
Universal	581	0.0382	0.0023	Snowman	163	0.0107	0.0007
Apple	541	0.0356	0.0022	Star.Wars	162	0.0107	0.0006
iPad.Mini	531	0.0349	0.0021	Canon	143	0.0094	0.0006
Nokia	468	0.0308	0.0019	Porsche	130	0.0086	0.0005
Htc	465	0.0306	0.0019	Galaxy.S4	113	0.0074	0.0005
Samsung.galaxy	414	0.0272	0.0017	Sony.xperia	111	0.0073	0.0004
BMW	389	0.0256	0.0016	Nissan	104	0.0068	0.0004
Sony	330	0.0217	0.0013	X35mm	103	0.0068	0.0004
Ferrari	298	0.0196	0.0012				

Finally, the data allowed the observation of whether the users described their object in relation to a particular product, brand, or recognisable industrial object. Some websites allow users to write a few sentences to describe what they have uploaded. This was used as a proxy of a potential intellectual property violation. This may not necessarily be the case, but the fact that users assign a particular file to known brands makes it more likely that the legal aspects relating to some of the features of those products have been somehow infringed. Of course, the association may relate to the description of the product (i.e. used in relation to the product) and may not actually infringe any particular intellectual property laws.

The first column on the left in Table 5 (named 'Label') shows the top 27 products/brands, or other recognisable trade marks. The second column indicates the number of times this keyword appears in our database. The third column is the weight of the keyword on the total number of keywords while the last column indicates the weight on the total number of files uploaded in all the platforms of our database. From Table 5 it is apparent that the number of times a description tied to a brand appears, is minimal; it is 1.3% in the most cited case (i.e. iPhone). The phenomenon is not very relevant. Nevertheless, it is worth noting that the first four descriptors or labels cover for approximately 50% of all the occurrences. Also, files related to *Apple* products are approximately 30% of all keywords.

Platforms Activity

Users

User-level information needs to be re-interpreted in order to be used in the analysis. Instead of using the user codes, it makes more sense to use a qualifier. This is the number of items that users upload on the 3DP platforms selected for the study. This choice allows us to define low-activity users—i.e. below the median of 28 files per user—, and high-activity users—i.e. beyond the median. The 3rd quartile of the distribution starts with 124 files uploaded.

Table 6. OLS regression results for number of files uploaded[143]

	Model 1	Model 2	Model 3
(Intercept)	2.213***	820.388***	107.641***
	(0.006)	(5.019)	(2.155)
Number of views	0.000***		
	(0.000)		
Downloads	0.000***		
	(0.000)		
Web price		0.064***	726.004***
		(0.002)	(3.710)
R-squared	0.005	0.013	0.095
F	153.729	1645.718	38288.555
p	0.000	0.000	0.000
N	62,567	123,538	366,200

A first analysis was conducted to try and understand what drives users to upload more files on the platform. This can be related to the number of views or downloads. The more visibility one's files have the more the user may be interested in being even more visible, hence uploading more files. Table 6, Model 1, shows results of a regression analysis[144] where 'files per user' (*variable number of files*) is the dependent variable (DV). For every model in Table 6 a new dataset was created, extracting independent variables (IVs) associated with the number of users and associating the mean IVs per user. Model 3 uses a different approach for defining the variables, as detailed below.

Results show no meaningful impact. The regression coefficients are extremely small and the overall explanatory power of the model is also very small (R-squared = 0.005). The R-squared indicates how much of the dependent variable's variance is explained by the model. The value in Model 1 and Model 2 shown in Table 6 is very small, meaning that the *number of files uploaded*

143 Significance codes for this and the other tables are: '†' $p < 0.10$; '*' $p < 0.05$; '**' $p < 0.01$; '***' $p < 0.001$.

144 Cohen J., Cohen P., West S. G., & Aiken L. S. *Applied Multiple Regression/Correlation Analysis for the Behavioural Sciences* (Oxon: Routledge; 2013).

is only minimally explained by views and downloads[145]. The reason is that these are only two among the many variables that determine the decision to upload more files; this affects the count and is one of the limitations of this study. For example, users make decisions to upload higher numbers of files due to their characteristics (e.g. age, gender), to their personality, or, more likely, to their profession (e.g. uploading files may be an easy way to share projects with colleagues or clients).

Model 1 and 2 (Table 6) have been also run having *downloads* and *number of views* regressed as they interact with time (in years). No significant effect has been isolated in the model with both coefficients and R-squared being unchanged. The researchers have not reported details of these statistics in the report.

Given that the regression model is significant ($F = 153.7$, $p < 0.001$), the researchers conducted further investigations with a two-way ANOVA[146] to check whether files that attract more views and/or downloads affect the user differently. We divided the sample in two groups: users with files that are downloaded below and above the average number of files downloaded. We also separated the files that attract below average (low) number of views from those that attract above-average views. The model results[147] confirm that there is a difference between low and high activity users. Figure 3 (available in the Appendix) reports results of this investigation using an interaction plot,[148] where behaviour is clearly different for users that upload files with views below the mean ('0' in Figure 3) compared to those who upload files that register higher number of views ('1' in Figure 3). The sign of the effect is the same (i.e. positive) for both relatively high and low activity users (respectively solid and dotted lines). More views and downloads make users upload more files. However, they do it differently depending on whether the user is in the above or below average group. The plot points out that users who attract a lower number of downloads (dotted line in Figure 3; see the Appendix) tend to upload more files (mean $\approx$ 28) when their files attract more views. Also, the difference between files with low number of views and high number of views when downloads are on the low ($\Delta \approx 6$), is higher than the same difference when downloads are on the high ($\Delta \approx 4$). Users that attract less activity put more effort into uploading more files and eventually jumping into the other category. Users that attract more activity (downloads) become less active as views increase.

Another element that may be relevant for users is 'price'. This may be related to the number of views and downloads and more active users (i.e. those who upload more files) may find their motivation in economic gains. Model 2 (Table 6) shows results of this second regression analysis. Sample size for this second model differs significantly from the first. This means that there is a significant discrepancy on the results so that they are not directly comparable. Model 2 (Table 6) shows that the impact of the price set for the file has an impact on the numbers of files uploaded. Although the variance explained is still very small (R-squared = 0.013), the beta

145 The most sensible way to do this would have been that of regressing the *number of uploaded files* with *views* and *downloads* of the month before. This would have given a more direct causal effect to the analysis and also established a temporal lag for the views and downloads to make an impact on uploads. Unfortunately, the information we have does not allow this type of analysis for all of the platforms and as such the researchers opted to include more platforms rather than focus on three only (i.e. *123D, thingiverse, and youimagine*).

146 Iversen G. R., & Norpoth H., *Analysis of Variance* (Thousand Oaks, CA: SAGE; 1987).

147 Results are statistically significant for views ($F = 371.985$, $p < 0.001$) and downloads ($F = 98.157$, $p < 0.001$).

148 Maindonald J. & Braun J., *Data Analysis and Graphics using R* (Cambridge: Cambridge University Press; 2006).

coefficient is slightly larger than those in Model 1. This model only takes into consideration those files with a price and it shows that there is an effect (albeit small) of higher prices on those who upload more files. However, it was deemed important to compare this to a more general trend, assigning the value "0" to uploaded files with no price and "1" to those that show a price. This is Model 3, shown in Table 6. Both the R-squared (0.09) and the beta coefficient show a significant and relevant impact. In summary, the opportunity to set a price affects the likelihood that users upload more files on the platform.

Price can also be used to see whether users with higher numbers of uploaded files are also those who are more likely to post more than one brand or recognisable company name or product. Put differently, the number of uploaded files may also be related to the number of brands that are named on the websites. These recognisable brand/company names could be connected to the presence of a price. To test this we coded "1" to identify the presence of "recognisable brands" and "0" its absence. The price is also coded with "1" or "0" that indicates presence or absence of price for downloading the file. Results of a two-way ANOVA show that there is a difference in the average number of files uploaded per user, when price and recognisable brands are considered[149]. However, as Figure 4 shows (see Appendix), the findings are different when we consider that price does not depend on whether the file is associated with a product/brand. However, those users that associate their files with a price are more active (i.e. upload more files) than those who do not.

In summary, more active users can be characterised in a way that is consistent with reference to file price, higher number of views and higher number of downloads. However, and surprisingly so, the effects of views and downloads have a very low impact on files uploaded. In addition to that, the price does not help in the understanding of how associations with known brands impact on the number of files uploaded. The presence of price is consistent with highly active users although there is no impact of associating the file with a well-known brand or product.

Categories and Keywords

Table 7 presents three regressions (Models 1-3; see Appendix for details) where the factor 'categories' is used to predict *price*, number of *views* and *downloads*. The regression coefficients of the categories have been levelled using a reference category. This is a standard practice in categorical data analysis and it means that the regression takes a reference point that is used as a benchmark for the coefficients. In Models 1 to 3 (Table 7) the category 'fashion' was selected as the base level[150]. The choice was dictated by its average popularity amongst users (see Table 4 above) so that it would not bias results either upwards or downwards. In addition to this, 'fashion' was one of the few categories that could be found in all the Models, i.e. it related to the three dependent variables.

Table 7 (Model 1) shows results of a regression analysis that attempts to understand how categories impact on price. There are only a few categories that affect price significantly: 'art', 'mechanic', 'robot', 'home', and 'architecture'. The overall variance explained by the model is

149 The F-test was significant for brands/products ($F = 82.733$, $p < 0.001$) and price ($F = 38237.802$, $p < 0.001$) but it is not for the interaction effect between the two ($F = 1.787$, $p = 0.181$).

150 See *supra* n. 144 Cohen *et al* (2013).

very low (R-squared = 0.007). The fact that files labelled 'art' have an effect on price is not surprising, given that this is one of the most recurrent categories. Other two categories — i.e. 'mechanic' and 'robot' — look very similar and refer to more technical and niche applications. Their impact on price seems extremely relevant, judging from the regression coefficients. Finally, 'building', 'home' and 'architecture' have all significant impacts on the dependent variable although their coefficients are relatively smaller than the other mentioned above. All the other categories have no impact on price.

Another strategy that users can employ to increase the number of views and downloads is that of 'tagging' the file correctly. Table 7 reports results of an OLS regression where categories are regressed to number of downloads (Model 2) and to number of views (Model 3). The number of downloads (Model 2) is affected by several categories although most of the regression coefficients are negative. This means that the benchmark variable affects number of downloads more than those variables with negative coefficients. All things considered, a negative coefficient implies that tagging the files with these categories (or labels) decreases the likelihood of downloads. The most significant category with a positive impact on downloads is 'model'[151].

Model 3 (Table 7) uses 'categories' to examine their impact on the number of views. The analysis does not allow us to understand much of what affects the number of views; results only allow us to state that the label 'household' does not contribute to increasing the number of times a file is viewed by web visitors.

The researchers also queried whether different websites have an impact on price, downloads and views. Table 7bis (see the Appendix) shows results of an OLS regression analysis where websites are considered as IVs and the dataset is organised on 'things' for this analysis. Note that the analysis also reveals that most of the websites do not provide all the information necessary to perform the regression on all three DVs. Clearly, different standards apply to most websites with the exception of 'cgtrader' which is the only one to provide information on price, number of views and downloads. Model 1 shows that the price is not affected by the platform hosting the file, i.e. there is no particular website (among the ones that provide this service) that makes the difference. Model 2 tells a different story. The number of downloads is clearly affected by files uploaded in two web platforms, i.e. 'sketchup' and 'thingiverse'[152]. The same two websites also positively impact the number of views (R-squared = 0.29). The values in the regression analysis suggest that these two websites enhance visibility and use of files uploaded.

There is no effect on 'keywords' (also called brands/products above) on price (Table 8, Model 1; see Appendix). None of the top 13 'keywords' seems to impact file price. Table 8 also reports how keywords affect the number of files downloaded (Model 2). If the description of the file contains the words 'iPhone', 'Robo'[153], or 'Universal'[154] the likelihood to have the file downloaded increases. Instead, the word 'Nokia'[155] decreases the likelihood that a file is downloaded.

151 The beta coefficient for this category is 187.456 ($p < 0.001$).

152 The regression coefficients are 40104.565 ($p < 0.001$) for '*sketchup*' and 554.038 ($p < 0.05$) for '*thingiverse*'. Also, the model explains *downloads* particularly well (Model 2, R-squared = 0.25).

153 In most cases, the word 'Robo' is related to a company that specialises in 3D products and printers. In some other cases (few minor occurrences), it maybe that 'robot' is wrongly spelt.

154 Regression coefficients for the three brands/products are: 'iPhone' (beta = 225.972, $p < 0.001$), 'Robo' (beta = 413.104, $p < 0.001$), or 'Universal' (beta = 241.827, $p < 0.01$).

155 The regression coeffiecient is –174.962 ($p < 0.05$).

The column on the right in Table 8 reports results of a regression where the number of views is the dependent variable. The two significant results explaining higher number of file views are the top two words, i.e. 'iPhone' (beta = 1045.320, $p < 0.001$) and 'Robo' (beta = 2207.104, $p < 0.001$).

Licence Schemes

Licence schemes have been classified in seven different categories that are the dependent variables of models in Table 9 (reported in the Appendix): All Rights Reserved (Model 1: ARR); Attribution-Non-Commercial (Model 2: At); BSD Licence (Model 3: BDS); Commons Attribution (Model 4: CA); GNU (Model 5: GNU); Public Domain (Model 6: PD); Creative Commons (Model 7: CC)[156] .

The regression coefficients in Table 9 are log-odds ratios, expressing a function of the probability that a given variable or factor affects the dependent variable. All the licence agreements are regressed on the basis of the same independent variables, i.e. categories (labels).

Model 1, 3, 4, and 7 are extremely poor and do not provide any result which can be commented upon. Model 6 does not fit the data well (likelihood ratio) and its results cannot be considered. Only Model 2 and 5 fit the data well and present results that are of some relevance for this study. Model 2 shows that the indication of Attribution-Non-Commercial licence is less likely to be selected when products are labelled '3dp', 'art', 'hobby', and 'tools'. The GNU is more likely to be selected when files are labelled with almost all of the categories shown in Table 9. In particular, '3dp' tags have a higher impact than the other categories.

Findings from regression analyses where number of views and number of downloads were predicted by the licence schemes have been omitted from this report in that they show no significant result. Hence, it can be concluded that the choice of a licence scheme does not affect downloads or number of views on any platform.

Discussion and Conclusion

Findings of this study allowed the researchers to isolate effects relevant to understanding some of the activity that takes place in online platforms for 3DP file sharing. In the following, the effect is first summarised and then discussed briefly.

The number of views and downloads have an impact on the number of files uploaded. A higher value for downloads and views seem to be a driver for files uploaded by users. This is consistent with what one expects from file sharing activities. The number of views and downloads are read as a sort of 'consensus' on what people upload and serve as an encouragement[157] for them to upload more files. The effect is very small indeed.

156 For this particular analysis the researchers used multiple logistic regressions; *see* Hosmer D. W. & Lemeshow S., *Applied Logistic Regression* (New York: Wiley; 1991); Agresti A., *Categorical Data Analysis* (New York: Wiley; 1991). Regressions were evaluated using an approximation of their R-squared— Nagelkerke N. J. D., A note on a general definition of the coefficient of determination (1991) *Biometrika*, Vol. 78, pp. 691-692–, the likelihood ratio as a measure of the goodness-of-fit, and the Akaike Information Criteria (AIC) as another measure of fit.

157 The work of Skinner B. F., on this aspect can be used to explain the basic motivational mechanism although it is probably expectancy theory that explains this better. *See also*, Vroom V. H., *Work and Motivation* (New York: Wiley; 1964).

Those platforms that allow a price to be set also seem to have a slight advantage to the others that do not allow for items to be priced, as users are marginally more likely to upload more files. This means that, when the platform is structured as an e-commerce marketplace and allows economic transactions then there is an increased likelihood that users are more active. This is also consistent with classic theory on extrinsic motivation[158] (economic incentives in this case) and with classic economics that sees rational actors as profit seeking individuals[159]. However, and given the relatively low number of people that do put a price on their uploaded files, it has to be conceded that the relation is only relevant for those that already uploaded many files. This leads us to consider that there may be some discounts in how the information is read from online platforms[160]. In summary, price is an incentive although it only works for users that are already active.

Another, more subtle finding relates to price, users, and association to known or recognisable brands/products. The price is relevant in determining the impact on the number of files uploaded per user but the association with a known brand is not. In fact, in both groups of files with and without a price, the mean of files uploaded per user is almost the same independent of brand association or its absence. This means that the association to a brand has no impact on having a price or not. Consistently, the association with a brand/company is done for descriptive purposes and not necessarily as something that would affect files uploaded.

If not from brand/company association, price may depend on the way the file is 'tagged' on the website. The researchers found that there are some categories that affect price: 'art', 'mechanic', 'robot', 'home', and 'architecture'. The label used to identify the product is probably also something that attracts high prices (e.g. 'art') or that has a technical nature, thus prices are justified by their paucity (e.g. 'robot'). It is interesting to note that, amongst the top labels used, only 'art' has an impact on price whereas 'miniature' or 'jewellery' have not. One of the interpretations of these findings is that technical and work-oriented artefacts may attract more customers than other hobby-related or more personal-related files. This can be related to some of the structural problems associated with 3DP and to the knowledge gap (i.e. there is not enough awareness on what this is and how it works besides some niches). For this reason, the researchers believe that products with a more technical scope are preferred and more marketable than others more tied to a mass market. The 'mass' is not there on 3DP platforms yet.

158 For a review, see Ryan R. M., & Deci E. L., Intrinsic and extrinsic motivations: Classic definitions and new directions (2000) 25(1) *Contemporary Educational Psychology* pp. 54-67.

159 For example: Von Neumann J., & Morgenstern O., *Theory of Games and Economic Behaviour* (60th Anniversary Commemorative Edition) (New Jersey: Princeton University Press; 2007).

160 Simon H. A., Rational decision making in business organizations (1979) *The American Economic Review*, pp. 493-513; Kahneman D., Maps of bounded rationality: Psychology for Behavioural Economics (2003) *American Economic Review* pp. 1449-1475.

As a partial confirmation of what is discussed above, our findings indicate that the category 'model' has a positive impact on downloads. Although the word 'model' can be associated with a significantly high number of 'things' that can be modelled, the researchers believe this can be interpreted here as a technical word, probably more related to work than to hobbies or other aspects of life.

The number of views follows a different direction. Our findings could not isolate an effect of categories on the number of times a file is viewed. These labels do not seem to affect the online behaviour of visitors. This is somehow interesting, as it seems that visitors do not browse using these elements. The options then are two: (a) visitors browse randomly on the platforms (i.e. she/he is a *novice*), or (b) they know exactly what they are looking for, independent of its label, category, or else (i.e. she/he is an *expert*). Given that these websites are yet to attract a significant number of visitors and look more like niche-oriented, the researchers interpret this finding as the result of the behaviour of an expert rather than a novice.

A slightly different result is associated with the two keywords 'iPhone' and 'Robo' that seem to affect viewers' behaviour. Consistently with what is written above, this result is probably due to the popularity of these two brands/products more than what experts look for in the analysis. Of course, gaps in the data may not support a comparison between these two results.

Limitations

There are several limitations of this study and some have already been mentioned above. First, the incredibly high number of missing values and the gaps in the data make it difficult to generalise, on the one hand, and to compare findings, on the other. Second, the phenomenon is very unstable, it is moving forward very fast, and an analysis that considers the state-of-the-art of 3DP is already 'old' soon after it is published. This makes it difficult to analyse these findings with a 'policy' or forward-looking mind-set. Third, we have not analysed the impact of time on the websites and the other variables. This is due to a partial lack of data but it is probably an aspect of the study that should be developed further and has the potential to provide relevant information for the interpretation of trends and overall developments.

Conclusion

After reviewing the structure and the basic elements of 3DP online platforms, the report analysed relationships amongst variables in an attempt to understand general online dynamics and behaviours. The study took an exploratory approach rather than a test of hypotheses in order to be more open to alternative explanations. From the findings, online user behaviour seems to be affected by price more than number of views and downloaded files. Also, it seems that all of these online platforms are more expert-oriented rather than open to the masses, as results on price and categories indicate.

Future research in this area should focus on analysing the impact of time on the users active in the different websites.

SECTION C: CONCLUSIONS AND RECOMMENDATIONS

The following pages are dedicated to summarise the work conducted in Sections A and B — the legal and empirical analyses — of this report (Study I) on 3D printing. After drawing some concluding remarks, the researchers offer recommendations for policy makers, the industry, and other interested parties.

Conclusions

The current landscape of 3D printing online platforms appears to be diverse and many options are presented to users. There are large players that attract a significant number of users (e.g. *thingiverse*, *123D, GrabCad*) and small players that attract a more specialised user base (e.g. *cgtrader, sketchup*). From the data retrieved, there is nothing to indicate that the activity on 3D printing online platforms is a mass phenomenon yet. As such, the infringement of intellectual property laws, at the moment, does not give rise to immediate concern.

As 3D printing continues to grow, there is also evidence of intellectual property infringement, *albeit* on a small scale, on these online platforms. For example, trademarked or copyrighted designs, like an *Iron Man* helmet or figurines from *Games Workshop, Star Wars* and the *videogame Doom* or *Disney* figures are easy to locate. This shows that interest and activity is growing exponentially every year highlighting the potential for future intellectual property issues. However, this report does not aim to provide specific information on files that are, and are not protected on these websites but it is possible to define the characteristics of files and how users behave and drawn conclusions accordingly.

Files that carry the label 'fashion' attract a higher number of views and downloads while labels such as 'art' and 'robot' are marketed at higher prices. This indicates that the landscape is diverse and it attracts users with different objectives and needs.

We also conclude that higher views and downloads are dependant on (a) the choice of the platform and (b) the type of brand/product. A typical example is the *iPhone*-labelled files, which attract more downloads and views. This is a paradigmatic example of what can be achieved with the instrumental use of a popular brand/product. The more popular a product the more likely it is that people would look for something to complement it (e.g. a case, a decorative stand). However, there is nothing that can be stated on infringement here except that results suggest that users show the tendency to search, view, and download files attached to well-known brands/products.

It can also be concluded that the sharing of files bearing the tag 'miniature', 'art', and 'jewellery' are more prevalent on the online communities analysed in the report. This may lead to hypothesise that hobby and leisure is one of the most attractive areas for these platforms. The proliferation of by-products such as mobile software applications that interact with 3D printing platforms may also signal this tendency. It is possible to read this trend as an attempt of the major online platforms to move the interest on 3D printing from technology-oriented professionals to the general public. Although it is too early to tell whether this will happen, it is noted that a technological breakthrough (see below) is needed to make 3D printing an everyday reality.

The two platforms that attract the highest number of views and downloads are *sketchup* and *thingiverse*. The former is not very popular and has a rather small number of users while the latter is one of the largest. This is somewhat interesting because the files are more likely to be downloaded and viewed significantly more if uploaded to the smaller platform. What makes a platform more attractive to users is difficult to define from the analysis. However, smaller platforms may be more flexible and able to target their audience better than large platforms that cater for larger audiences.

One of the points that help to understand the diversity of these platforms is the presence of communities that are more akin to sharing specialised files/items and that tend to have fewer but more active users (*cgtrader* is one such example). This points to the fact that smaller communities of a more technical nature still remain active.

The vast majority of people (65%) who use these online platforms do not license their work. The minority that do license their work (35%), seem to have some understanding of the various licences and make their choice in accordance with the product they are uploading. From the data, it can be concluded that this category of people who fall within the ambit of the 35% are more inclined to use Creative Commons licence, followed closely by Commons Attribution and GNU Public Licence.

From the data analysed in the report, we determine that the number of downloads is unrelated to the price. This is a very interesting aspect of 3D printing platforms and shows on average, users are not interested in an economic transaction for the file they download. This may be explained by the fact that most users are attracted by hobby and leisure. Or, there may be a lack of accessibility to the relevant 3DP materials (e.g. the elements and materials used to print) or lack of access to more sophisticated 3D printers (e.g. those that are capable of printing more expensive files).

Recommendations

For Government

As the research demonstrates, the emergence of 3D printing is still in its infancy although there is sufficient evidence to suggest that the technology will continue to grow[161]. At the same time, and in view of the increased rise in online platforms, it is suggested that the number of intellectual property issues in relation to 3D printing will concurrently grow[162]. However, at the moment it is not widespread and as such does not give rise to major concern.

Therefore, a premature call for legislative and judicial action in the realm of 3D printing could stifle the public interest of "fostering creativity and innovation and the right of manufacturers and content creators to protect their livelihoods"[163]. Yet it is important to address the intellectual property issues arising in this area. As such, it will be prudent to take steps to cultivate a climate better suited to tackle impending intellectual property issues more successfully and in a manner, which takes into account the interests of all stakeholders.

The research highlighted the inconsistency and lack of clarity arising from the copyright status of CAD files, in the UK and USA with CJEU cases raising more questions than answers. There needs to be clearer guidance on defining whether a CAD file is capable of copyright protection. The territorial nature of copyright law, coupled with the exterritorial nature of online platforms and CAD files shared therein could lead to uncertainty and complex issues in the future.

As such, it is recommended that the UK Intellectual Property Office (UKIPO) establish a Working Group to cover the various intellectual property rights which may need to be tackled in the future. The Working Group should also provide clarity on the status of CAD files and how they can best be used in industry.

For Intermediaries (Online Platforms)

Online platforms encourage the use of licences such as Creative Commons, Commons Attribution and GNU Public Licence. However, as mentioned above, 65% of users engaged in the activities of 3D printing online platforms do not license their work, leaving their creations vulnerable and open to infringement whilst losing the ability to claim authorship. Although a lack of licence attribution may be linked to a user's ignorance or misunderstanding of the intricacies associated with each licence, it may sometimes be done intentionally as the file has been uploaded in breach of intellectual property laws.

In view of this, it is recommended that online platforms provide more awareness and understanding of the different types of licences. This can be achieved by explaining the nuances

161 Lipson H., & Kurman M., *Fabricated: The New World of 3D Printing* (Indiana: John Wiley & Sons, Inc.; 2013); Hoskins S, *3D Printing for Artists, Designers and Makers* (London: Bloomsbury; 2013); Anderson C., *Makers: The New Industrial Revolution* (New York, London: Random House; 2012).

162 Pokémon targets 3D printed design, citing copyright infringement (21 August 2014) *World Intellectual Property Review*, Available at http://www.worldipreview.com/news/pok-mon-targets-3d-printed-design-citing-copyright-infringement-7067

163 Susson M., Watch the World "Burn": Copyright, Micropatent and the Emergence of 3D Printing [January 2013] Chapman *University School of Law*, Available at http://works.bepress.com/matthew_susson/3 at p. 39.

relating to each licence in clear and simple language, rather than simply 'encouraging' the user to adopt a particular type of licence. Furthermore, online platforms can assign the most appropriate licence (e.g. GNU, Creative Commons) as a default with 'opt-out' as an option. This can also act as a mechanism for online platforms to protect their users that are not "up to speed" with licensing systems. At the same time, it will allow people to 'think twice' before infringing the law. Finally, it will strengthen the online platforms' position of working within the parameters of the law.

Online platforms increasingly offer tools for the creation, modification, and transformation of object design files, which provide for different functions. For example, *Meshmixer* allows users to edit, change and mix designs to be 3D printed whilst *MakerBotDigitizer* allows users to scan physical objects for modification and transformation. These online tools and scanning software give rise to a number of issues relating to intellectual property and already it is possible to see the emergence of complex issues in this area creeping in. As online platforms continue to grow and with this user-numbers, it would be sensible to monitor these spin-offs and by-products offered by the online platforms.

For Industry

The markets in the future will be focused on the dissemination of CAD files (or similar formats) and therefore efforts should be directed towards defining clearer rules and guidance for the access and use of these CAD files. One suggestion would be for manufacturers to license 3D file more widely[164]. The reasoning here is that manufacturers may lack the expertise to sell their final product to consumers – for which they will need the help of stores. In this context if manufacturers are willing to license their 3D files, they will open doors to a range of intellectual property rights holders and a vast range of outlets[165]. This will avoid locking the manufacturer into an agreement through a system such as a 'one-stop-shop' for (spare) parts. Although a one-stop-shop may take away the costs of manufacture, transportation and storage whilst reducing potential infringement of intellectual property laws, it can lead to a monopoly-situation, which should be avoided.

A further recommendation can be drawn from companies such as *Authentise*[166], *FabSecure*[167], *Secure3D*[168] and *ToyFabb*[169]. These companies allow for the secure streaming of 3D CAD files via an Application Programming Interface (API) and adopt a 'pay-per-print' business model[170]. This model removes the need for a CAD file to be sent to the consumer[171]; instead

164 Weinberg M., *Public Knowledge* White Paper on 3D Printing (November 2010), Available at https://www.publicknowledge.org/news-blog/blogs/it-will-be-awesome-if-they-dont-screw-it-up-3d-printing

165 Barraclough E., A Five-Step Strategy for the 2D Revolution [2011] November, *Managing Intellectual Property*, pp. 24-27 at p. 25. *See also*, Mendis D., Clone Wars: Episode I – The Rise of 3D Printing and its Implications for Intellectual Property Law: Learning Lessons from the Past? [2013] 35(3) *European Intellectual Property Review* pp. 155-169.

166 *Authentise* at http://www.authentise.com

167 *FabSecure* at http://www.fabsecure.com

168 *Secure3D* at http://secured3d.com

169 *ToyFabb* at http://www.toyfabb.com

170 See *Authentise's* API at http://www.authentise.com/api

171 However, companies such as *ToyFabb* allow for both options. Customers can either buy the 3D design file as an STL file or it can be streamed directly to the customers' 3D printer. See, http://www.toyfabb.com/get-creative

the build instructions are sent directly to the printer, which, in turn, prints out the number of objects that have been purchased. It is an effective business model for manufacturers and designers who wish to protect their intellectual property whilst giving the consumers the option of printing toys and other smaller products at home[172].

3D printing is clearly growing and will continue to grow. At the same time, the research and the accompanying data concludes that taking into account accessibility to materials, sophisticated printing machines, costs and economics for the average user, the impact of this technology will not be felt among the general public for a few years to come. However, this position could change if there is a significant technological breakthrough in the hardware and software sectors reaching a point where a product can be printed relatively easily and quickly without requiring technical expertise.

172 Secure3D states on their website: "Intellectual property is at the core of any business, and protecting your 3D IP is the single most important thing to ensure you can sustain a viable competitive business".

APPENDICES

Numbering is consistent and continues from tables and figures in the main text.

Figure 3. Interaction plot for the mean number of files per user on the number of views grouped by number of downloads

Note: Reported mean values; the dotted line groups downloads below the mean of 684.5; the *solid line* represents downloads above the mean. N. of views = 0 are views below the mean of 2,170 views; N. of views = 1 are views above the mean.

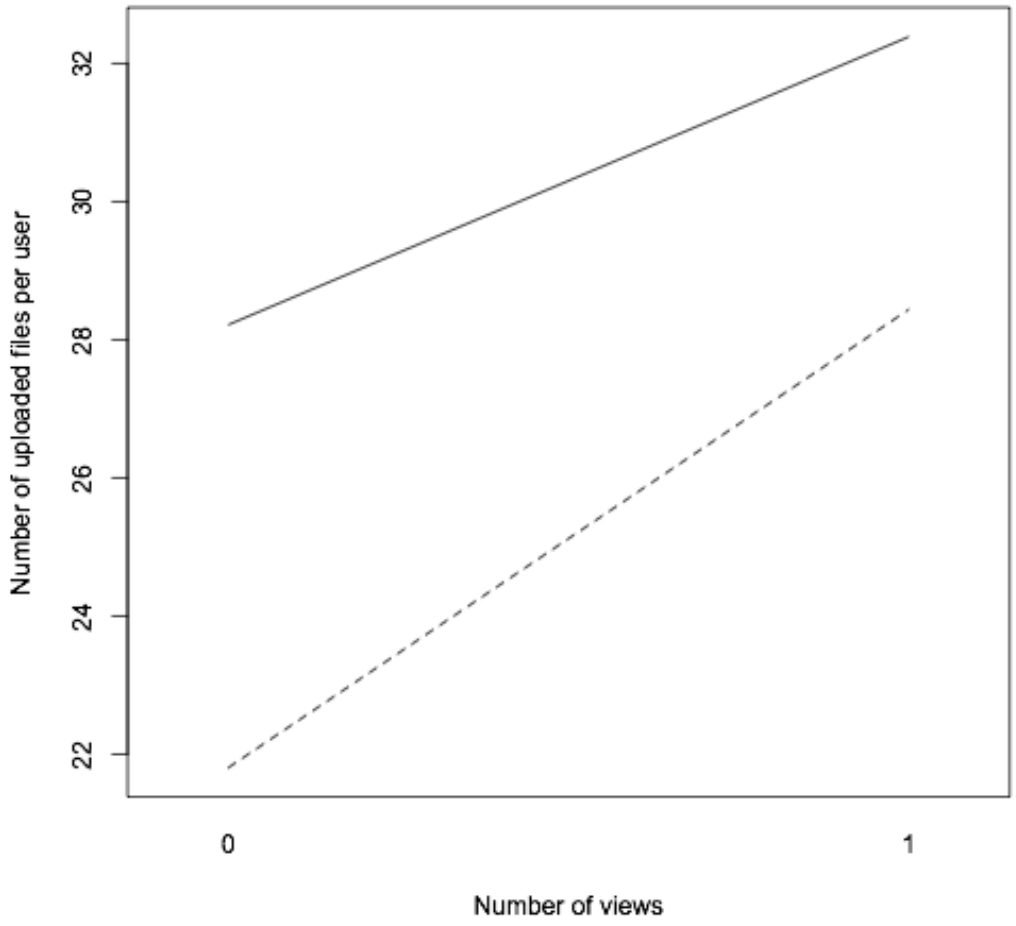
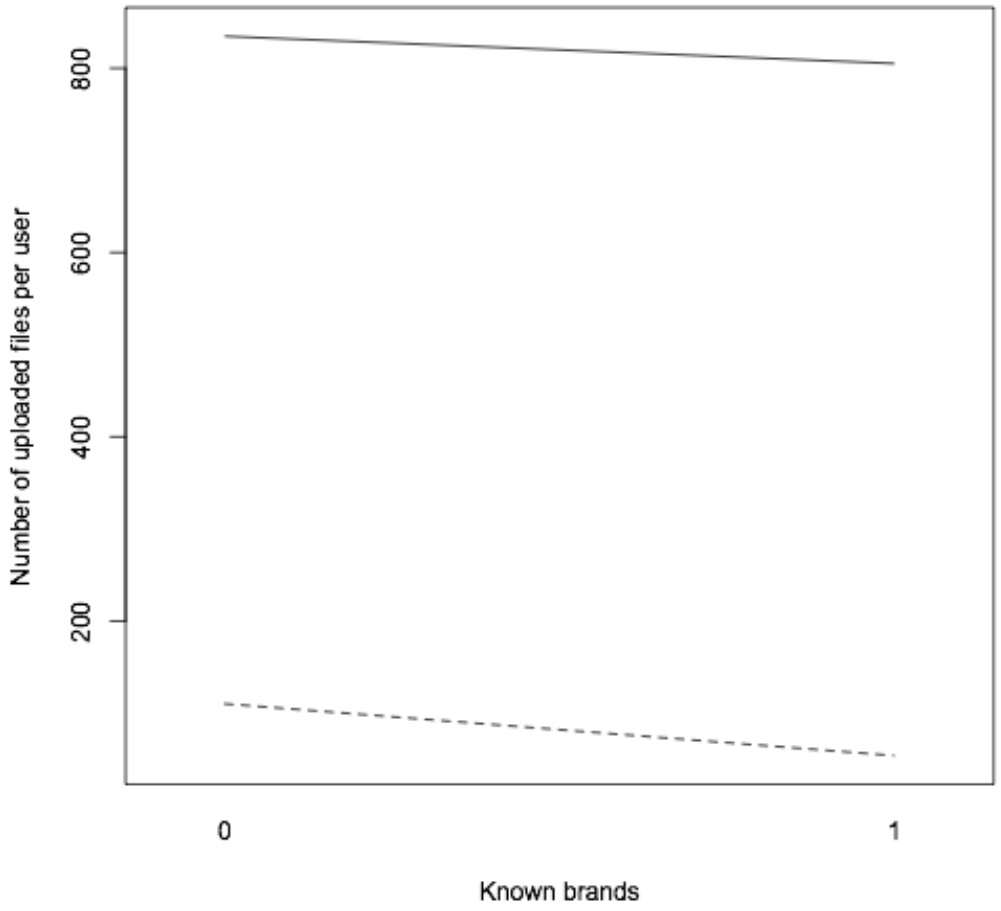


Figure 4. Interaction plot for the means of the number of files per user divided by association with known brands by file price



Note: Reported mean values for the dependent variable; the *dotted line* groups absence of price; the solid line represents presence of price. "1" is the presence of known brands wile "0" is the absence of known brands.

Table 7. OLS Regression of Categories/Labels on Price, Number of Downloads and Number of Views (ref. fashion)

(Intercept)	50.619	487.893***	2105.575***
	(83.327)	(30.818)	(120.328)
accessories	−44.067		
	(217.229)		
architecture	302.700*	−359.313***	
	(120.868)	(37.687)	
art	745.509***	20.494	−277.150†
	(86.445)	(36.770)	(143.307)
building	317.795*		
	(137.385)		
gadget	−5.978	36.136	226.676
	(88.838)	(39.814)	(155.035)
games	44.638		
	(87.937)		
home	239.462**		
	(92.693)		
interior design	112.837	−374.977***	
	(109.152)	(36.386)	
iphone	200.058		
	(295.691)		
jewellery	−6.867	−425.307***	
	(86.252)	(57.174)	
light	181.468		
	(329.443)		
logo	−49.619		
	(3235.834)		
maker	0.331		
	(96.024)		
math	126.087		
	(174.520)		
mechanic	305.507**		
	(108.305)		
miniature	−2.311		
	(85.252)		
music	221.477		
	(839.358)		
robot	543.949**		
	(204.222)		
toys	−14.018	49.233	196.010
	(198.593)	(36.135)	(155.176)
3dp		41.465	45.794
		(33.731)	(132.588)
aerospace		−329.604***	
		(39.412)	
creature		−477.597*	
		(211.150)	
design		−336.081***	
		(32.736)	
educational		−377.099***	
		(36.251)	
electric		−356.283***	
		(36.021)	
fixture		−348.766***	
		(42.214)	
hobby		11.050	−84.829
		(35.605)	(142.500)
household		−244.084***	−683.264***
		(33.114)	(138.055)

Table 7. OLS Regression of Categories/Labels on Price, Number of Downloads and Number of Views (ref. fashion)...Cont.

industrial		−390.229***	
		(33.719)	
marine		−326.846***	
		(45.896)	
medical		−324.271***	
		(54.128)	
military		−266.499***	
		(39.307)	
model		187.456***	−32.663
		(37.937)	(147.750)
nature		−366.643***	
		(62.410)	
office		−403.060	−1852.242
		(627.425)	(2441.406)
software		−469.893	−1829.575
		(1085.857)	(4225.214)
tech		−462.210***	
		(80.025)	
tools		−267.637***	−199.733
		(34.057)	(174.928)
R-squared	0.007	0.014	0.002
F	45.546	78.910	10.847
p	0.000	0.000	0.000
N	117947	143367	48293

Table 7bis. OLS Regression of websites on Price, Number of Downloads and Number of Views

	Model 1 *DV: Web price*	**Model 2** *DV: N. of Downl.*	**Model 3** *DV: N. of Views*
(Intercept)	0.000	90.517	394.692
	(3490.732)	(265.493)	(639.897)
cgtrader	19.893	−27.811	−314.456
	(3512.481)	(452.637)	(664.994)
cubify	40.111		
	(3491.889)		
cuboyo	2.476		
	(3504.779)		
i.materialise	58.468		
	(3493.620)		
kraftwurx	109.148		
	(3495.346)		
ponoko	570.938		1060.491
	(3496.033)		(756.385)
sculpteo	398.619		
	(3490.792)		
shapeways	238.505		
	(3490.753)		
cubehero		−90.517	−394.692
		(3185.912)	(7678.763)
123D		−68.829	
		(265.789)	
GrabCad		16.777	
		(265.667)	
sketchup		40104.565***	62975.186***
		(301.074)	(725.656)
the pirate bay		−83.131	
		(366.444)	
thingiverse		554.038*	1659.480**
		(265.776)	(640.573)
youimagine		−88.375	
		(301.687)	
leopoly			−373.950
			(643.624)
R-squared	0.001	0.251	0.286
F	7.379	10079.292	5515.934
p	0.000	0.000	0.000
N	113518	241043	82694

Table 8. OLS Regression of Keywords on Price, Number of Downloads and Number of Views

	Model 1 *DV: Web price*	Model 2 *DV: N. of Downl.*	Model 3 *DV: N. of Views*
(Intercept)	211.466***	268.640***	1948.124***
	(9.590)	(4.153)	(27.865)
iPhone	−173.287†	225.972***	1045.320***
	(93.311)	(45.503)	(230.621)
Robo	−147.054	413.104***	2207.104***
	(137.765)	(45.802)	(287.844)
Lego	−152.973	155.594*	−86.687
	(180.330)	(68.200)	(350.215)
USB	−90.251	−71.837	−417.757
	(344.313)	(70.275)	(459.069)
Ipod	−141.958	19.567	−278.292
	(283.415)	(82.108)	(392.160)
Universal	−147.635	241.827**	569.230
	(309.060)	(83.518)	(432.149)
Apple	−35.720	−75.066	−139.646
	(247.527)	(101.296)	(631.460)
iPad.Mini	−132.409	159.476	145.302
	(229.359)	(102.458)	(483.363)
Nokia	−190.806	−174.962*	140.604
	(725.982)	(86.190)	(813.774)
Htc	−180.923	99.466	−691.627
	(182.313)	(156.926)	(753.488)
Samsung.galaxy	−185.628	206.336	1208.987†
	(206.419)	(136.114)	(690.968)
BMW	−93.588	−97.913	−943.854
	(811.658)	(135.549)	(1150.190)
Sony	−187.349	−101.585	−763.308
	(278.542)	(129.730)	(778.973)
R-squared	0.000	0.001	0.002
F	0.673	10.131	6.698
p	0.791	0.000	0.000
N	117947	143367	48293

Table 9. Results of Multiple Logistic Regressions

	Model 1 *DV: ARR*	Model 2 *DV: At*	Model 3 *DV: BSD*	Model 4 *DV: CA*	Model 5 *DV: GNU*	Model 6 *DV: PD*	Model 7 *DV: CC*
(Intercept)	−6.723***	−2.463***	−5.622***	−4.225***	−4.594***	−7.129***	2.106***
	(0.578)	(0.074)	(0.334)	(0.168)	(0.201)	(0.707)	(0.064)
creature	−10.843	−12.103	−10.944	27.791	−10.972	−10.437	−16.672
	(538.368)	(120.126)	(326.537)	(10813.408)	(198.055)	(538.368)	(120.126)
3dp	−1.018	−0.473***	0.082	−19.341	1.593***	0.958	0.045
	(0.731)	(0.086)	(0.366)	(740.794)	(0.206)	(0.736)	(0.071)
art	0.123	−0.239**	−0.492	−19.341	0.257	1.284	0.307***
	(0.677)	(0.092)	(0.434)	(1035.473)	(0.232)	(0.748)	(0.080)
educational	−10.843	−12.103	−10.944	27.791	−10.972	−10.437	−16.672
	(843.461)	(188.202)	(511.585)	(16941.360)	(310.292)	(843.461)	(188.202)
gadget	−0.807	−0.132	−0.403	−2.389***	0.562*	0.853	0.171*
	(0.913)	(0.098)	(0.472)	(0.478)	(0.237)	(0.802)	(0.086)
hobby	0.067	−0.352***	0.185	0.169	0.906***	0.879	0.032
	(0.677)	(0.092)	(0.386)	(0.194)	(0.217)	(0.764)	(0.076)
household	−0.851	−0.057	0.100	−19.341	0.717***	0.943	0.077
	(0.764)	(0.086)	(0.379)	(900.365)	(0.216)	(0.750)	(0.074)
model	0.636	−0.107	−0.666	−19.341	0.069	1.417	0.217**
	(0.652)	(0.093)	(0.472)	(1140.655)	(0.245)	(0.750)	(0.082)
tools	−0.285	−0.344**	−0.286	−19.341	1.031***	1.510	0.187
	(0.913)	(0.118)	(0.528)	(1689.152)	(0.239)	(0.791)	(0.098)
toys	−0.800	0.108	−0.395	−19.341	0.488*	1.313	−0.003
	(0.913)	(0.095)	(0.472)	(1305.994)	(0.239)	(0.769)	(0.083)
Nagelkerke R-sq.	0.022	0.006	0.006	0.471	0.035	0.006	0.017
Likelihood-ratio	15.711	112.400	12.907	1318.663	346.856	9.516	391.725
p	0.108	0.000	0.229	0.000	0.000	0.484	0.000
AIC	724.655	23111.218	2134.111	1548.591	10878.418	1608.138	31212.432
N	48483	48483	48483	48483	48483	48483	48483

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Other Websites

ChocEdge: http://www.chocedge.com

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Concept House
Cardiff Road
Newport
NP10 8QQ

Tel: 0300 300 2000
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