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# Regulating Three-Dimensional Printing: The Converging Worlds of Bits and Atoms

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TABLE OF CONTENTS

I. INTRODUCTION .......... 554
II. 3D PRINTING AND THE CONVERGING WORLDS OF BITS AND ATOMS .......... 558
  A. *The Technology* .......... 558
  B. *The Technology's Effect* .......... 560
III. NEW ISSUES RAISED BY 3D PRINTING .......... 562
  A. *Environmental Law* .......... 564
  B. *Products Liability* .......... 566
    1. *Is a CAD File a "Product"?* .......... 567
    2. *Who Is Potentiality Liable as "Selling" or "Otherwise Distributing" Products?* .......... 569
  C. *Contract Law* .......... 571
    1. *When Are CAD Files Goods?* .......... 571
    2. *When Are CAD File Sellers "Merchants"?* .......... 573
    3. *Sale Versus License* .......... 575
  D. *Criminal Law and Firearms Control* .......... 576
    1. *Domestic Firearm Manufacturing and Distribution* .......... 577

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2. *Regulation of Exports* .......... 580
E. *Intellectual Property Law* .......... 582
1. *Trademark Law* .......... 582
a. *How Far Will Trademark-as-Property Go?* .......... 582
b. *When Is a CAD File or 3D Printed Item Infringing, if Ever?* .......... 584
2. *Patent Law* .......... 586
a. *Patenting the Bits Along with the Atoms* .......... 586
b. *Additional Stresses in Patent Law* .......... 587
3. *Copyright Law* .......... 589
IV. CONSTRUCTING A REGULATORY FRAMEWORK .......... 593
A. *Private Ordering* .......... 593
1. *Norms* .......... 594
2. *Individual Action* .......... 595
3. *Contracts* .......... 595
4. *Collective Action: Online Feedback* .......... 596
5. *Limits to Private Ordering* .......... 597
B. *Legal Regulation* .......... 598
1. *Default Rules* .......... 599
2. *Mandatory Rules* .......... 601
C. *Code as Regulation* .......... 602
D. *Responses to Regulation* .......... 604
1. *Obedience* .......... 604
2. *Change and Avoidance* .......... 605
V. REGULATING BITS AND ATOMS .......... 607
A. *The Political Economy of 3D Printing* .......... 609
B. *Regulatory Competition* .......... 612
C. *Vulnerabilities to Code-Based Avoidance Mechanisms* .......... 615
1. *Trademark Law Vulnerabilities to Code* .......... 617
2. *Patent Law Vulnerabilities to Code* .......... 618
3. *Gun Control Vulnerabilities to Code* .......... 619
VI. CONCLUSION .......... 620


## I. INTRODUCTION

For thousands of years, humans have developed laws governing the physical world—the world of "atoms." Whether property, contracts, or another area, the law contemplated things made up of atoms: people, goods, and land. Since the advent of computer technology, however, the law has struggled with how to apply the law of atoms to the computer world of zeros and ones—the world of "bits."

Software entered the mainstream in the 1960s and created upheaval as lawmakers fitfully endeavored to characterize and regulate it.[1] Questions abounded regarding whether software was a "good" under the Uniform

1. *See* Mark A. Lemley, *Convergence in the Law of Software Copyright?*, 10 HIGH TECH. L.J. 1, 1–3, 22–25 (1995).

Commercial Code (UCC), whether it was subject to strict products liability provisions, whether it could be copyrighted and patented, and so on.[2] Just when the law had—mostly—settled the major questions surrounding software,[3] cyberspace entered everyday life, bringing with it additional waves of legal consternation.[4] Early talk was of a cyberspace legally disembodied from the real world: *separate* legal regimes for bits and atoms.[5] Others disagreed sharply, contending that, for the most part, cyberspace did not require its own isolated legal regime.[6] Nearly twenty years later, the law finally settled on the major contours of cyberspace governance.[7]

Just when we thought the law had comfortably accommodated bits and atoms, a new wave of uncertainty is crashing ashore, one that will explode the dividing line between bits and atoms. Three-dimensional (3D) printing and its related technologies are invading society, bringing with them the ability to print objects—atoms—from computer files—bits.[8] As 3D printers improve and become ubiquitous, having a computer-aided design (CAD) file of an object, such as a coffee cup or a toy, will essentially be the equivalent of having the physical object—it is

2. *See* Julie E. Cohen & Mark A. Lemley, *Patent Scope and Innovation in the Software Industry*, 89 CALIF. L. REV. 1, 7 (2001); Lemley, *supra* note 1, at 1–3; Andrew Rodau, *Computer Software: Does Article 2 of the Uniform Commercial Code Apply?*, 35 EMORY L.J. 853, 855 (1986); Michael R. Maule, Comment, *Applying Strict Products Liability to Computer Software*, 27 TULSA L.J. 735, 737 (1992).

3. *See, e.g.*, Cohen & Lemley, *supra* note 2, at 7 ("[S]oftware's status as patentable subject matter was first doubted, then grudgingly admitted, and finally embraced.").

4. *See, e.g.*, Timothy L. Skelton, Comment, *Internet Copyright Infringement and Service Providers: The Case for a Negotiated Rulemaking Alternative*, 35 SAN DIEGO L. REV. 219, 219–21 (1998) (describing the growth of the Internet and associated copyright legal issues).

5. *E.g.*, David R. Johnson & David Post, *Law and Borders—The Rise of Law in Cyberspace*, 48 STAN. L. REV. 1367 *passim* (1996).

6. *See, e.g.*, Jack L. Goldsmith, *Against Cyberanarchy*, 65 U. CHI. L. REV. 1199 *passim* (1998).

7. *See, e.g.*, Digital Millennium Copyright Act, Pub. L. No. 105-304, 112 Stat. 2860 (1998) (codified as amended at 17 U.S.C. §§ 1201–1205 (2012)).

8. *Additive manufacturing* more accurately describes what these machines do. Before 3D printing, many machines made objects through "subtractive" manufacturing: like a sculptor, these machines started with a large block of material and removed pieces until forming the desired shape. In contrast, 3D printers create objects additively: by depositing the bottom layer of material—plastic, metal, et cetera—and building up layer-by-layer. *See infra* Part II.

just a click away.[9] The convergence of the world of bits and atoms heralds seismic shifts in manufacturing, trade, medicine, and other fields[10] and will require an *integrated* legal regime for the world of bits and atoms.

This Article represents the first proposal for constructing an integrated regulatory regime to govern 3D printing[11] and is guided by a rich literature concerning regulation and governance.[12] The Article is further informed by a truth made manifest over years of technological progress: Society never fully understands in advance how a disruptive technology will alter the status quo. Leading thinkers in the 1960s could not fathom the uses a "home" computer would have—they thought it might be useful for recipe management.[13] A 1980 McKinsey report advised that mobile phones would have little widespread impact.[14]

As a guiding theme, this Article argues that the uncertain but promising state of 3D printing technology necessitates a flexible and iterative

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9. *See* HOD LIPSON & MELBA KURMAN, FABRICATED: THE NEW WORLD OF 3D PRINTING 103 (2013).

10. *See generally* CHRIS ANDERSON, MAKERS: THE NEW INDUSTRIAL REVOLUTION (2012) (noting that "anyone with an invention or good design can upload files to a service to have that product made . . . or make it themselves with . . . 3-D printers," thus reducing the "distinction between amateur and entrepreneur"); LIPSON & KURMAN, *supra* note 9 ("3D printed production . . . represents an evolutionary leap forward . . . . Rapid advances in medical and 3D printing technologies will transform medicine."); *The Third Industrial Revolution*, ECONOMIST, Apr. 21, 2012, at 15 (postulating that 3D printers may, in time, "be able to make almost anything, anywhere—from your garage to an African village").

11. Throughout this Article, this Author uses *regulatory* in the broad sense of any force or act, whether legal, social, or other force, that constrains behavior. Although a few well-written law student notes and practitioner articles have begun exploring specific aspects of 3D printing, none offers a holistic analysis or suggests an overarching regulatory strategy. *See, e.g.*, Daniel Harris Brean, *Asserting Patents To Combat Infringement via 3D Printing: It's No "Use,"* 23 FORDHAM INTELL. PROP. MEDIA & ENT. L.J. 771 (2013) (discussing how protecting the underlying CAD files may "help to address the gap in enforceability of product patents"); Brian Rideout, *Printing the Impossible Triangle: The Copyright Implications of Three-Dimensional Printing*, 5 J. BUS. ENTREPRENEURSHIP & LAW 161 (2011) (discussing prospective copyright concerns in the 3D printing context); Davis Doherty, Note, *Downloading Infringement: Patent Law as a Roadblock to the 3D Printing Revolution*, 26 HARV. J.L. & TECH. 353 (2012) (proposing modifications to patent law to strike a balance between "preserving the public goods generated by the DIY community and providing patentees with a method for good faith extrajudicial enforcement of their rights" (footnote omitted)); Charles W. Finocchiaro, Note, *Personal Factory or Catalyst for Piracy? The Hype, Hysteria, and Hard Realities of Consumer 3-D Printing*, 31 CARDOZO ARTS & ENT. L.J. 473 (2013) (suggesting limiting regulatory "intrusions" in the 3D printing realm).

12. *See infra* Parts IV and V.

13. ANDERSON, *supra* note 10, at 56.

14. Spencer Thompson, *3D Printing: Is It Really All That?*, NEW STATESMAN (Oct. 16, 2012, 6:17 PM), http://www.newstatesman.com/print/economics/2012/10/3d-printing-it-really-all.

regulatory response. After introducing the technology in Part II, Part III of this Article looks broadly at the impact of 3D printing on the law. Building on insights from previous disruptive technologies, such as software and the Internet, this Article separates the truly novel issues raised by 3D printing from the issues that may be interesting but are readily analogous to existing legal problems. The Part continues by offering specific normative and doctrinal suggestions for responding to the novel legal issues.

In addition to delineating novel legal issues, Part III also addresses the higher-order question of *why* certain issues are novel and extricates several factors to answer the question. These factors include the extent to which the area of law is affected by (1) the uniqueness of a 3D-printable CAD file, which is a bridge between the worlds of bits and atoms having no complete analog in current legal systems; (2) the ease with which even amateurs can create, modify, distribute, and print CAD files, which alters incentives and allows conduct previously unrealizable; and (3) the ways in which the technology will influence—and be influenced by—societal norms.

Part IV utilizes regulatory theory to construct a framework for regulating the 3D printing ecosystem. Building on insights from scholars of law and society theory, public choice theory, and cyberspace regulation, this Article examines how norms, technology, and law will work together to assemble the regulatory regime for 3D printing. The regime will consist of familiar elements such as private ordering, default rules, mandatory rules, and technology (code), but these elements will need to be structured appropriately for the 3D printing world. The analysis then proceeds to look at group responses to regulation, such as obedience, change, and avoidance, and introduces along the way Professor Tim Wu's theory of code as an avoidance strategy.[15]

Part V applies the framework of Part IV to the world of 3D printing. It offers an overarching principle: Because 3D printing is a rapidly evolving technology whose potential benefits outweigh its risks, regulation should be flexible, preferring private ordering to default rules and default rules to mandatory rules. It analyzes the political economy of the 3D printing ecosystem to determine which groups might support or

15. *See generally* Tim Wu, *When Code Isn't Law*, 89 VA. L. REV. 679 (2003) ("Code design, as a means of avoiding laws, serves as a particularly useful device for exploiting the internal dynamics of regulated groups.").

oppose 3D printing and draws on the music industry's response to digital piracy to predict regulatory battlegrounds. Finally, the Article uses Professor Wu's code-as-avoidance insights to demonstrate that various areas of the law, including patent, trademark, and gun control law, suffer from doctrinal and normative weaknesses that make them susceptible to massive code-based attacks in a world of 3D printing.

This Article makes several contributions. It introduces novel legal issues raised by a transformative technology and, more importantly, explains *why* certain issues are novel. Understanding why certain issues are novel helps inform overall regulatory strategy. Further, this Article interrogates diverse regulatory theories to highlight each theory's contribution to a world where bits and atoms become interchangeable. It then provides specific applications of theories of political economy and code-based avoidance strategies to the world of 3D printing, thus providing insight for lawmakers and courts regarding the upcoming challenges.

More broadly, this Article provides a foundational, pluritheoretical analysis of 3D printing regulation. Given the disruptiveness of 3D printing and the constraints of space in this Article, many issues remain to be analyzed more fully. Hence, this Article provides a rich set of guideposts for future doctrinal and theoretical explorations of 3D printing technology.

## II. 3D PRINTING AND THE CONVERGING WORLDS OF BITS AND ATOMS

"[S]ociety is becoming more dependent for its well-being on scientifically complex technology, so, to an increasing degree, this technology underlies legal issues of importance to all of us."[16] This observation from Justice Stephen Breyer underscores the importance of studying how new, disruptive technologies impact the law. This Part introduces 3D printing and its related technologies with an eye toward understanding their effects on the law.

### *A. The Technology*

Simply put, 3D printers use bits to print atoms. 3D printing, also called additive manufacturing[17] or rapid prototyping,[18] involves making

16. Stephen Breyer, *The Interdependence of Science and Law*, 280 SCIENCE 537, 537 (1998).

17. *See supra* note 8. Although *additive manufacturing* may be a better technical description, *3D printing*, probably developed as a marketing term, has taken over as the dominant usage.

3D objects from computer design files.[19] Unlike traditional two-dimensional (2D) ink printers, 3D printers do not print a single layer on paper; rather, they additively build up multiple layers.[20] 3D printers come in two main types: deposition printers and binding printers.[21]

Deposition printers deposit materials layer-by-layer until a 3D object is built.[22] The "ink" is the deposited material, which can be plastic, paste, food, and even human cells.[23] In contrast to deposition printers, binding printers build the object by binding—usually by adhesive or laser—layers of some sort of raw material, such as a metal, cement, sawdust, plastic powder or a liquid polymer.[24] With either type of 3D printer, after completing the first layer, the printer moves the print head vertically upward—or the base downward—by a fraction of a millimeter and prints a second layer on top of the first.[25] The printer continues printing layer upon layer until it forms the final product.[26] Each new layer fuses to the underlying layers, creating a whole object at the end of the process.[27]

Before a 3D printer can make anything, it needs a CAD file, such as a Google SketchUp or AutoCAD file, to provide the information on what to print—much like a conventional printer needs a text document to tell it what to print.[28] A person can create a CAD file from scratch using a computer program.[29] Alternatively, a user can simply scan an existing object using a 3D scanner, and software will convert the scan into a CAD file.[30] The CAD file must then be translated into a special file format that a 3D printer can understand.[31] Currently, the most common such file

18. *See* LIPSON & KURMAN, *supra* note 9, at 30. Rapid prototyping refers to the fact that 3D printers can usually build custom prototypes much more quickly and cheaply than traditional machine techniques. *See id.*

19. *Id.* at 65. Technology summaries can be found in many sources. *See, e.g.*, *id.* at 68–84.

20. *See id.* at 65.

21. *Id.* at 68.

22. *Id.*

23. *Id.*

24. *Id.* at 68, 73, 75.

25. *Id.* at 69, 73.

26. *Id.*

27. *Id.* at 65.

28. *See id.* at 85.

29. *Id.* at 87.

30. *3D Scanners: A Guide to 3D Scanner Technology*, GEOMAGIC, http://www.rapidform.com/3d-scanners (last visited Apr. 28, 2014).

31. *Id.*

format is the STL format, which is a shortening of the word *stereolithography*, one type of printing technique.[32] For convenience, this Article refers generically to CAD files as including STL files and other printable files.

### *B. The Technology's Effect*

3D printing will revolutionize society, affecting manufacturing, the environment, 3D art, entrepreneurship, and global trade.[33] Although 3D printing technology has been around for years,[34] the printers are getting smaller, better, and cheaper.[35] They are making their way into homes, just like computers and 2D printers did in previous years.[36] The coming ubiquity of 3D printing signals a new era of individual empowerment and creativity.[37]

Before 3D printing, building a prototype typically required the time-consuming and costly machining of parts, which often required third-party expertise.[38] Even if the creators successfully made a prototype, they faced a large upfront investment in specialized machines to scale up production, a process that generally required contracting with third-party specialists.[39] In contrast, 3D printers allow individuals to bypass the expense of specialized machinery and the complexity of contractual commitments.[40] Each home becomes a factory to build whatever the owner dreams up.

What is more, pairing 3D printing with the Internet allows users to share instantaneously CAD files of innumerous devices around the world.

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32. 3D printing pioneer Chuck Hull coined the term to describe his 3D printing technique. *The Journey of a Lifetime*, 3D SYSTEMS, http://www.3dsystems.com/30-years-innovation (last visited Apr. 28, 2014). Industry participants also understand *STL* to be an acronym for "Standard Tessellation Language." LIPSON & KURMAN, *supra* note 9, at 101. Other more sophisticated file formats, such as AMF, may soon replace the STL format. *See id.*

33. *See* sources cited *supra* note 10.

34. *See, e.g.*, U.S. Patent No. 5,204,055 (filed Dec. 8, 1989); U.S. Patent No. 5,121,329 (filed Oct. 30, 1989); U.S. Patent No. 4,863,538 (filed Oct. 17, 1986); U.S. Patent No. 4,575,330 (filed Aug. 8, 1984).

35. *See* Gil Laroya, *3D Printing Can Turn You into a Designer*, HUFFINGTON POST (Dec. 16, 2013, 10:39 PM), http://www.huffingtonpost.com/gil-laroya/3d-printing-design_b_4440463.html; *see also* LIPSON & KURMAN, *supra* note 9, at 20, 22 (noting that with 3D printing, "complexity costs the same as simplicity" and "high production capacity . . . makes 3D printers ideal for home use").

36. *See* LIPSON & KURMAN, *supra* note 9, at 22.

37. *See id.* at 103.

38. *See, e.g.*, Juho Vesanto, *Saving Resources by Prototyping with 3D Printing—A Lamplight Case Study*, 3D PRINTING INDUSTRY (Sept. 30, 2013), http://3dprintingindustry.com/2013/09/30/saving-resources-prototyping-3d-printing-lamplight-case-study.

39. *See, e.g.*, *id.*

40. *Id.*

Users can find a file on the Internet, download it, modify it if they want to, and print the resulting object.[41] The widespread ability to print complex physical objects from computer files brings the worlds of bits and atoms together in a way never before experienced. E-mailing a CAD file of a coffee cup to a person with a 3D printer is virtually equivalent to physically mailing the cup but with one important difference: unlike with physical mailing, the one who e-mails the CAD file does not lose possession of it. After the file is sent, both the sender and receiver have it—and thus, in a sense, they both have the cup.

Already, 3D printers can make a remarkable range of products. Fascinating examples include food,[42] shoes,[43] human body parts,[44] working guns,[45] clothes,[46] and bicycles.[47] Of course, at this stage, inexpensive home 3D printers are relatively simple and print only in plastic.[48] But over time, the costs will fall, and the capabilities will rise.[49] Further, individuals can access more advanced 3D printers at 3D printing services shops, much like 2D copy shops.[50]

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41. One such website allowing this sharing is Thingiverse.com. THINGIVERSE, http://www.thingiverse.com/about (last visited Apr. 28, 2014).

42. Bianca Bosker, *3D Printers Could Actually Make Donuts Healthy*, HUFFINGTON POST, http://www.huffingtonpost.com/2013/04/24/3d-printed-food_n_3148598.html (last updated Apr. 24, 2013, 3:26 PM).

43. Michael Fitzgerald, *With 3-D Printing, the Shoe Really Fits*, MIT SLOAN MGMT. REV. (May 15, 2013), http://sloanreview.mit.edu/article/with-3-d-printing-the-shoe-really-fits.

44. Dan Solmon, *Listening to the Future with a 3D-Printed Ear*, TECHCRUNCH (May 27, 2013), http://techcrunch.com/2013/05/27/listening-to-the-future-with-a-3d-printed-ear.

45. Alexis Kleinman, *The First 3D-Printed Gun Has Been Fired*, HUFFINGTON POST, http://www.huffingtonpost.com/2013/05/06/3d-printed-gun-fired_n_3222669.html (last updated May 7, 2013, 2:28 AM); Graham Templeton, *3D-Printed Rifle Takes Us One Step Further Down a Long, Shadowy Road*, EXTREMETECH (July 25, 2013, 1:31 PM), http://www.extremetech.com/extreme/162324-3d-printed-rifle-takes-us-one-step-further-down-a-long-shadowy-road.

46. Rachel Hennessey, *3D Printing Hits the Fashion World*, FORBES (Aug. 7, 2013, 7:38 PM), http://www.forbes.com/sites/rachelhennessey/2013/08/07/3-d-printed-clothes-could-be-the-next-big-thing-to-hit-fashion.

47. Richard Lai, *EADS's Airbike Is a 3D-Printed Nylon Bicycle, Actually Looks Rather Decent*, ENGADGET (Mar. 9, 2011, 2:50 PM), http://www.engadget.com/2011/03/09/eadss-airbike-is-a-3d-printed-nylon-bicycle-actually-looks-rat.

48. *See* LIPSON & KURMAN, *supra* note 9, at 68.

49. *See id.* at 84.

50. *See, e.g.*, Press Release, UPS Store, The UPS Store Makes 3D Printing Accessible to Start-Ups and Small Business Owners (July 31, 2013), *available at* http://www.press

The technology is entering the mainstream: Microsoft added 3D printing capabilities to version 8.1 of its Windows operating system[51] and retailers such as Staples, Amazon.com, and Microsoft are selling 3D printers.[52] To many, this technology brings hope of new freedoms, innovation, and creativity.[53] To others, however, it brings fear; fear of 3D printed guns in the wrong hands;[54] fear of massive decentralized infringement of products protected by patents, trademarks, and copyrights;[55] and fear of carelessly designed goods that injure people.[56] These and other promises and perils of 3D printing are considered in the remainder of this Article.

## III. NEW ISSUES RAISED BY 3D PRINTING

This Part outlines some of the significant doctrinal disruptions that 3D printing will cause. Although excitement surrounds 3D printing, not every issue raised by 3D printing is truly novel. New technologies bring with them a range of legal issues. Some are straightforward applications of existing law, whereas others require careful thought to balance competing policies and develop new legal mechanisms.

What separates the new from the not-so-new? The answer is somewhat subjective, and no bright line exists—or ever will. Even so, the next subparts extract several factors that help identify novel legal issues. These factors include the extent to which the area of law is affected by (1) the uniqueness of a 3D printable CAD file, which is a bridge between the worlds of bits and atoms, having no complete analog in current legal systems; (2) the ease with which even amateurs can create, modify, distribute, and print CAD files, which alters incentives and allows previously unrealizable conduct; and (3) the changes in societal norms caused by the technology.

Given space constraints, this Article does not provide an exhaustive list of novel legal issues, nor does it explore each issue exhaustively. Instead, this Part seeks to establish the breadth of disruption 3D printing

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room.ups.com/Press+Releases/Archive/2013/Q3/The+UPS+Store+Makes+3D+Printing+Accessi ble +to+Start-Ups+and+Small+Business+Owners.

51. Michael Endler, *Microsoft Touts Windows 8.1 3-D Printing*, INFORMATIONWEEK (Aug. 8, 2013, 3:45 PM), http://www.informationweek.com/hardware/peripherals/microsoft-touts-windows-81-3-d-printing/240159700.

52. *Id.*; Ian Paul, *Amazon Quietly Launches Complete 3D Printing Store*, TECHHIVE (June 14, 2013, 10:15 AM), http://www.techhive.com/article/2042076/amazon-quietly-launches-complete-3d-printing-store.html.

53. *See, e.g.*, ANDERSON, *supra* note 10, *passim*.

54. *See infra* Parts III.D, V.C.3.

55. *See infra* Part III.E.

56. *See infra* Part III.B.

will bring so that the subsequent Parts can construct and apply a regulatory framework.

To demonstrate the contrast between new and not-so-new legal issues, consider an issue that is not new: jurisdiction. Imagine a person in Germany creates a CAD file for a toy and posts it to the Internet. A user in China downloads the CAD file, makes changes to it, and posts it on the Internet for sale. Next, a user in the United States purchases the CAD file, prints it, and is subsequently injured by it. Who can sue whom and where? And what law will apply to the case?

Such fact patterns raise complex questions of transnational personal jurisdiction, forum non conveniens, and choice of law.[57] Although such issues are complex, they are not new. Courts have confronted foreign parties and foreign law for decades, if not centuries.[58] The issues recall early Internet debates. Although some thought the jurisdictional issues raised by the Internet needed an entirely new paradigm,[59] the better arguments came from those suggesting that existing legal doctrines were already capable of handling complex jurisdictional issues.[60] Although 3D printing will increase the number of cases with complex jurisdictional and related issues, the cases will not differ in substance from previous complex cases.

In contrast to jurisdiction, other areas of law will see new issues from 3D printing. The next subparts explore these issues.

57. *E.g.*, Gary B. Born, *Reflections on Judicial Jurisdiction in International Cases*, 17 GA. J. INT'L & COMP. L. 1, 1 (1987) ("United States courts and legal commentators have long wrestled with problems of judicial jurisdiction in disputes between parties from different states of the Union."); Donald Earl Childress III, *Rethinking Legal Globalization: The Case of Transnational Personal Jurisdiction*, 54 WM. & MARY L. REV. 1489, 1489, 1518–25 (2013) (noting that courts and commentators have yet to answer the question, "[u]nder what circumstances may a United States court exercise personal jurisdiction over alien defendants?"); Christopher A. Whytock & Cassandra Burke Robertson, *Forum Non Conveniens and the Enforcement of Foreign Judgments*, 111 COLUM. L. REV. 1444, 1452–62 (2011) (discussing the different issues raised by the forum non conveniens doctrine and judgment enforcement doctrine in the context of the transnational litigation process).

58. *See, e.g.*, Perkins v. Benguet Consol. Mining Co., 342 U.S. 437 (1952) (finding it possible for a U.S. court to exercise jurisdiction over a corporation located in the Philippines); Hilton v. Guyot, 159 U.S. 113 (1895) (holding that a French judgment was not conclusive in the United States).

59. *See, e.g.*, Johnson & Post, *supra* note 5, at 1367.

60. *See, e.g.*, Goldsmith, *supra* note 6, at 1200–01.

### *A. Environmental Law*

3D printers will affect the environment in positive and negative ways. To focus on the negative, for a moment, industrial 3D printers emit toxic fumes, and some feedstock powders can be explosive.[61] Even home-based 3D printers emit volatile organic compounds and ultrafine particles, which may be health hazards.[62]

Although 3D printer emissions are a concern, the existing regulatory regime is largely well suited to handle them. For instance, the Clean Air Act requires the U.S. Environmental Protection Agency (EPA) to establish emission standards for sources of hazardous air pollutants.[63] The EPA could amend these standards to include any new hazardous chemicals used by or emitted from 3D printers. Similar procedures exist for state regulations.[64] Thus, although we should strive to understand, from a scientific standpoint, the environmental impacts of 3D printers, these are not truly new legal issues. The current, robust legal framework should handle the challenges reasonably well.

In contrast to well rehearsed emissions issues, the holistic environmental impact of 3D printing raises more novel and complex regulatory issues. 3D printing heralds a major shift in the methods of manufacturing and supply chains. Rather than centralized mass production, 3D printing encourages decentralized, local manufacturing, which would reduce supply chains—and their concomitant effect on the environment.[65] Manufacturing used to move to low-wage countries to take advantage of low labor costs, but if 3D printers are making the products, labor costs would largely disappear.[66] Add to that the ability to bypass increasing transport costs and many goods currently made abroad could be brought back to the United States.[67] Decentralized, ultra local manufacturing will reduce the cost and environmental impact of cross-country and international transport.[68]

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61. LIPSON & KURMAN, *supra* note 9, at 74–75.

62. Brent Stephens et al., *Ultrafine Particle Emissions from Desktop 3D Printers*, 79 ATMOSPHERIC ENV'T 334, 334–35, 337–39 (2013) (studying emissions from home-based printers using polylactic acid feedstock and acrylonitrile butadiene styrene feedstock).

63. Clean Air Act § 112(b), (d), 42 U.S.C. § 7412(b), (d) (2006) (listing hazardous air pollutants subject to regulation).

64. *E.g.*, CAL. HEALTH & SAFETY CODE §§ 25531–25539 (West 2013).

65. *See* LIPSON & KURMAN, *supra* note 9, at 61, 63.

66. *See id.*

67. *The Third Industrial Revolution*, *supra* note 10, at 15 (referencing the Boston Consulting Group estimate that ten to thirty percent of the goods America currently imports from China could be made in the United States by 2020, boosting American output by $20 billion to $55 billion per year).

68. Megan Kreiger & Joshua M. Pearce, *Environmental Impacts of Distributed Manufacturing from 3-D Printing of Polymer Components and Products*, 1492 MATERIALS

3D printing can also lessen the environmental impact of manufacturing by reducing subtractive waste and taking advantage of advanced manufacturing geometries.[69] Subtractive processes start with large blocks of material, progressively milling and cutting away unwanted material—like a sculptor chipping away unwanted stone.[70] In some cases, up to ninety percent of the material ends up wasted on the factory floor.[71] With 3D printing, most or all of that waste disappears because the printer prints only what it needs.[72]

Besides reducing waste, 3D printers can make objects lighter and with less material than traditional techniques. By removing unnecessary material from internal portions of an object, for example, by printing a honeycomb shape instead of a solid block, the weight and waste—and thus the environmental impact—of the product can be reduced.[73] Making cars, ships, and planes—and anything they carry—lighter reduces fuel consumption. For instance, American Airlines states that for every pound of weight removed from an aircraft, it saves up to 11,000 gallons of fuel annually fleetwide.[74] Using 3D printing, one company reduced the weight of its robot arm tool by seventy to ninety percent.[75]

In sum, 3D printing has the potential to affect the environment in dramatic ways. Its meta-effect on the environment will be complex and difficult to foresee because of the technology's nascent stage. Scientific and empirical research will greatly benefit policymakers. Given the

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RES. SOC'Y ONLINE PROC. LIBR., mrsf12-1492-g01-02 (2013) (providing a comparison of traditional manufacturing and 3D printing of a household object).

69. *Id.*

70. *See* ANDERSON, *supra* note 10, at 90.

71. Jermey N. A. Matthews, *3D Printing Breaks Out of Its Mold*, PHYSICS TODAY, Oct. 2011, at 25, 26, *available at* http://www.physicstoday.org/resource/1/phtoad/v64/i10/p25_s1.

72. ANDERSON, *supra* note 10, at 86.

73. *See* Matthews, *supra* note 71, at 26. ("Aircraft and racecar manufacturers have been among the early adopters of 3D printing, with which engineers can digitally optimize density and other structural properties to manufacture customized, lightweight components such as impellers, fuel-injection nozzles, and door hinges."). Against these benefits, lawmakers should weigh the potential for increased waste that might come when millions of hobbyists print experiments and novelties, only to throw them away shortly thereafter.

74. *Fuel Smart Celebrates Its 5th Anniversary*, AM. AIRLINES, http://www.aa.com/i18n/aboutUs/environmental/article2.jsp (last visited Apr. 28, 2014).

75. *61-Year-Old Company Re-Invents Itself with FDM*, STRATASYS, http://www.stratasys.com/en/resources/case-studies/commercial-products/thogus-products (last visited Apr. 28, 2014).

potential for significant environmental—and economic—benefits, policymakers should study 3D printing closely and allow it the opportunity to mature.

### *B. Products Liability*

3D printing will empower millions to design and manufacture products.[76] The technology could lead to a flood of innovation, but pessimists will be apt to worry about millions of amateurs unintentionally making shoddy and outright dangerous products.

To understand better the issues raised by 3D printing, imagine a 3D printed toy's lifecycle: Maker designs the toy on her CAD program and uploads the file to the Internet, allowing others to access it for free. Intermediate-Maker retrieves, downloads, and modifies the file and then posts the file on Project Shapeshifter, a website that allows anyone either (1) to download the file—perhaps for a fee—and print it at home or (2) to pay Project Shapeshifter to print the item with its high-end printers and mail the item to the purchaser. Buyer purchases a fully printed version of the toy from Project Shapeshifter. The toy subsequently injures Buyer.

Who can Buyer sue, and by what standard will the tort liability suit be judged? Worries about defective products call to mind strict products liability law, an offshoot of tort law that seeks to compensate individuals for losses and to incentivize the proper level of care in the manufacture and sale of products.[77] The law must balance incentivizing proper care with incentivizing manufacturing and related commercial activity.[78] If the laws are too burdensome, no one will manufacture goods.[79] But if the laws are too lenient, shoddy products will harm too many people.[80]

Unsurprisingly, given their emergence during a time when large corporations dominated manufacturing, the rationales in support of strict products liability focus on the economic and marketing power held by the manufacturers and sellers.[81] Although commentators challenge the justifications for strict liability,[82] for purposes of this analysis, this Article

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76. *See* ANDERSON, *supra* note 10, at 58–59.

77. *See* DAVID G. OWEN, PRODUCTS LIABILITY LAW 3–7 (2005).

78. *See* Joanna M. Shepherd, *Products Liability and Economic Activity: An Empirical Analysis of Tort Reform's Impact on Businesses, Employment, and Production*, 66 VAND. L. REV. 257, 258 (2013) (discussing the "optimal scope" of products liability law).

79. *See id.* at 289.

80. *See id.* at 281–82.

81. *See, e.g.*, RESTATEMENT (THIRD) OF TORTS: PRODS. LIAB. § 2 cmt. a, § 19 cmt. a (1998) (discussing the objectives fostered by and the policy considerations in imposing strict liability).

82. *See, e.g.*, William Powers, Jr., *A Modest Proposal To Abandon Strict Products Liability*, 1991 U. ILL. L. REV. 639 (advocating for the complete abandonment of strict

will assume that the justifications have some merit and will analyze how the justifications might apply to 3D printing.

Before continuing, it is important to highlight that the law recognizes three primary types of product defects: manufacturing, design, and warning defects.[83] Although people sometimes refer to all defective products liability as "strict" liability, in truth, most modern courts treat only *manufacturing* defects as true strict liability.[84] Design and warning defects are most often governed by tests similar to negligence standards, similar but not identical.[85] The tests for design and warning defects carry benefits—at least to plaintiffs—over pure negligence theories, including (1) the inability for sellers to limit liability by contract[86] and (2) a focus on products rather than sellers, which leads to more rulings in favor of plaintiffs against smaller, less sophisticated sellers.[87]

To capture the law's unique treatment of manufacturing, design, and warning defects, commentators use the term of art *strict products liability*, even though the law may treat each defect type with a different test.[88]

### *1. Is a CAD File a "Product"?*

A CAD file, like a Microsoft Word document, is less tangible than most products. Can a CAD file even be considered a product as needed to invoke strict products liability law? If not, product harms would be governed by the relatively defendant-friendly negligence standards.[89]

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products liability); Alan Schwartz, *The Case Against Strict Liability*, 60 FORDHAM L. REV. 819 (1992) (identifying and arguing against the "foundational assumptions of strict products liability law").

83. RESTATEMENT (THIRD) OF TORTS: PRODS. LIAB. § 2(a)–(c) (1998).

84. *See, e.g.*, OWEN, *supra* note 77, at 319–20.

85. *See id.* ("When the issue shifts away from manufacturing defects to dangers in a product's design or inadequate warnings and instructions, there can be little difference between negligence and strict liability because the plaintiff in each such case is required to show effectively the same thing—that the product contained a danger that is *unreasonable*.").

86. RESTATEMENT (THIRD) OF TORTS: PRODS. LIAB. § 18 (1998) (noting that sellers are unable to limit liability to *persons*); OWEN, *supra* note 77, at 265 (noting that a "seller's contractual efforts to disclaim liability or limit damages are simply null and void").

87. *See* RESTATEMENT (THIRD) OF TORTS: PRODS. LIAB. § 1 cmt. a (1998).

88. *See* Ellen Wertheimer, *Unknowable Dangers and the Death of Strict Products Liability: The Empire Strikes Back*, 60 U. CIN. L. REV. 1183, 1190 (1992).

89. *See* William C. Powers, Jr., *Distinguishing Between Products and Services in Strict Liability*, 62 N.C. L. REV. 415, 418, 425 (1984).

Two historical debates help illuminate whether to treat CAD files as products: the treatment of electricity and software.[90] For a while, courts struggled to categorize electricity[91] but now generally treat it as a product, especially once it has passed through a customer's meter.[92] Like electricity, CAD files can be "produced by men, confined, controlled, transmitted, and distributed . . . in the stream of commerce"[93] and therefore, might be characterized as a product. Although large businesses generally dominate electricity generation, individuals and small businesses are likely to dominate CAD file design.[94] Thus, policy rationales that favor treating electricity as a product—those assuming large companies with economic power—do not apply across the CAD file ecosystem.

A more direct analogy may be the debate whether computer software should be treated as a product, and thus, subject to products liability law, or merely a service, and thus not.[95] Much, though not all, of the commentary on applying strict products liability to software focuses on whether the software has a greater *service* aspect—custom-made, customer-specific programs—or *product* aspect—mass-marketed software.[96] The same distinction could apply to CAD files, and thus, courts could label mass-marketed files as products while labeling custom-made files, such as complex 3D art, as services.

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90. A substantial amount of literature has examined the meaning of the term *product*. *See, e.g.*, Charles E. Cantu, *The Illusive Meaning of the Term "Product" Under Section 402A of the Restatement (Second) of Torts*, 44 OKLA. L. REV. 635, 652–56 (1991) (discussing the jurisdictional split over whether electricity is a service to which "only the action of negligence is applicable," a service to which "non-code implied warranties . . . apply," or a "thing" subject to the UCC); David W. Lannetti, *Toward a Revised Definition of "Product" Under the Restatement (Third) of Torts: Products Liability*, 35 TORT & INS. L.J. 845, 862–63 (2000) (asserting that although "[s]ome have . . . implied that the question of whether computer software constitutes a 'product' is settled . . . . This associative analysis falls apart . . . once the software loses its tangibleness" (footnote omitted)); Powers, *supra* note 89, at 428 (discerning two rationales that "explain the distinction between product injuries and other personal injuries: (1) the unique problems of proof a plaintiff confronts in a products case; and (2) the tacit representations of safety that constitute part of a consumer bargain").

91. *See* Cantu, *supra* note 90, at 652–56.

92. OWEN, *supra* note 77, at 1047.

93. Ransome v. Wis. Elec. Power Co., 275 N.W.2d 641, 643 (Wis. 1979) (discussing electricity).

94. LIPSON & KURMAN, *supra* note 9, at 28.

95. Michael D. Scott, *Tort Liability for Vendors of Insecure Software: Has the Time Finally Come?*, 67 MD. L. REV. 425, 434 (2008); Frances E. Zollers et al., *No More Soft Landings for Software: Liability for Defects in an Industry that Has Come of Age*, 21 SANTA CLARA COMPUTER & HIGH TECH. L.J. 745, 745 n.1, 756 nn.57–58 (2005) (collecting sources that discuss the debate).

96. *E.g.*, Scott, *supra* note 95, at 461–62 (explaining why it would not be unreasonable to hold modern-day software vendors responsible to the same degree as other product designers).

The software debates largely neglect a third category of software—lightly marketed software given away for free or for nominal sums by individuals or small companies. For years, such software was rare, but in the days of smart phone applications (apps), it is common.[97] Creators of such apps can be unsophisticated individuals—in the business sense—who do not put much emphasis on marketing their programs.[98] Although the apps are widely available and may sell millions of copies, they are not mass-marketed in the sense of proactive, expensive marketing campaigns.[99]

The same is true for many creators of CAD files. Even computer savvy teenagers can create CAD files and post them for sale on the Internet—either through their own website or via a third-party website such as Shapeways.com.[100] The diversity of actors in the CAD file economy suggests that courts should take a careful, nuanced approach to the treatment of CAD files.

### *2. Who Is Potentially Liable as "Selling" or "Otherwise Distributing" Products?*

Even assuming CAD files may be products, strict products liability applies only to those "engaged in the business of selling or otherwise distributing" products.[101] It does not apply to occasional or casual sales or to products given away with no commercial intent.[102] This "business" limitation may dramatically limit strict products liability's application to

97. *See* Kristen Purcell, *Half of Adult Cell Phone Owners Have Apps on Their Phones*, PEW RES. CENTER (Nov. 2, 2011), http://pewinternet.org/Reports/2011/Apps-update.aspx.

98. *See* Margaret Butler, *Android: Changing the Mobile Landscape*, PERVASIVE COMPUTING, Jan.–Mar. 2011, at 4, 5.

99. The recent viral success of the mobile game app "Flappy Bird" provides a potent example of the ability of apps to succeed without much marketing. *See* Catherine E. Shoichet, *Developer Yanks 'Flappy Bird' After Game Soars to Success*, CNN, http://www.cnn.com/2014/02/09/tech/flappy-bird-removed-from-app-stores (last updated Feb. 11, 2014, 10:27 AM).

100. *Linear Helps Teen Create 3D Watch*, LINEAR MOLD & ENGINEERING (Aug. 16, 2013), http://www.linearmold.com/blog/linear-helps-teen-create-3d-watch/.

101. RESTATEMENT (THIRD) OF TORTS: PRODS. LIAB. § 1 cmt. c (1998).

102. *Id.* ("The rule does not apply to a noncommercial seller or distributor of such products . . . . [T]he rule does not cover occasional sales (frequently referred to as 'casual sales') outside the regular course of the seller's business."); *see also* RESTATEMENT (SECOND) OF TORTS § 402A cmt. f (1965) ("The rule does not, however, apply to the occasional seller of food or other such products who is not engaged in that activity as a part of his business.").

CAD files. Because 3D printing technology fundamentally lowers the costs of design and distribution,[103] many people will give away CAD files for free, circumventing strict products liability.[104]

The more complex questions surround the boundaries of an "occasional" or "casual" seller of CAD files. The exemption exists because casual sellers are not large or sophisticated like the actors targeted by strict products liability doctrine.[105] But a one-time, casually uploaded CAD file could go viral and sell millions of copies. Can a million-copy seller be a casual seller?

An additional unique issue raised by 3D printing involves the liability of 3D printing services (3DP services). 3DP services charge a fee for printing CAD files on behalf of customers. The service may be remote, such that it mails the physical products to the customer, or alternatively, the user might come to the service and use the printers, similar to using a 2D copier at a FedEx or Kinkos.[106] If the printed product later injures consumers, can they successfully sue the 3DP service under a strict products liability theory? Is the 3DP service "engaged in the business of selling or otherwise distributing" products?

It is tempting to equate the 3DP service with a "manufacturer"—after all, another term for 3D printing is *additive manufacturing*. But traditional manufacturers know a great deal about their products, whereas a 3DP service is unlikely to know very much at all about the products it prints.[107] Hence, the 3DP service has almost no opportunity or expectation to consider product safety.[108] Moreover, 3DP services might be exempt from

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103. VIVEK SRINIVASAN & JARROD BASSAN, CSC LEADING EDGE FORUM, 3D PRINTING AND THE FUTURE OF MANUFACTURING 2–3 (2012), *available at* http://lef.csc.com/assets/3705.

104. Indeed, an "open source hardware" movement, analogous to the free and open source software (FOSS) movement, distributes CAD files—usually STL files, schematics, and other information—for free. *See, e.g.*, ANDERSON, *supra* note 10, at 107–15 (discussing open source communities). For more on FOSS, see Greg R. Vetter, *Commercial Free and Open Source Software: Knowledge Production, Hybrid Appropriability, and Patents*, 77 FORDHAM L. REV. 2087, 2094–108 (2009).

105. *See* Sukljian v. Charles Ross & Son Co., 503 N.E.2d 1358, 1360–61 (N.Y. 1986) (listing reasons for an occasional seller exception).

106. Such services already exist. *See* Press Release, UPS Store, *supra* note 50 (brick and mortar retail 3D printing service); *see also* I.MATERIALISE, http://i.materialise.com (last visited Apr. 28, 2014) (remote 3D printing service); SHAPEWAYS, http://www.shapeways.com (last visited Apr. 28, 2014) (remote 3D printing service). A consumer using a 3DP service gains access to higher quality printers without the cost of buying a printer.

107. *See* Lisa L. Kirchner, *Who's Liable for Crimes Committed with a 3D Printed Gun?*, TECHNEWS DAILY (May 10, 2013, 10:34 AM), http://www.technewsdaily.com/18019-3d-printing-liability.html.

108. *See id.*; Adam Marcus, *3D Printing: The Future is Here*, TECH. LIBERATION (June 10, 2011), http://techliberation.com/2011/06/10/3d-printing-the-future-is-here.

strict products liability treatment because, as their name suggests, they are more akin to service providers than product producers.

Courts and lawmakers will need to wrestle with these novel issues.

### *C. Contract Law*

Some novel contract law issues raised by 3D printing resemble those in products liability law.[109] For example, are CAD files "goods" under Article 2 of the UCC?[110] When are donors or sellers of CAD files considered "merchants" under the UCC?

Article 2 of the UCC applies only to "transactions in goods,"[111] and most of its provisions require a "sale" of goods.[112] Thus, Article 2 would not govern true gifts or noncommercial exchanges, such as when someone posts a CAD file on the Internet for others to freely use, unless a court chooses to do so by analogy.[113] But what are goods?

#### *1. When Are CAD Files Goods?*

The UCC primarily defines *goods* as "all things . . . which are movable at the time of identification to the contract for sale."[114] Although the UCC clearly applies to sales of physically printed 3D objects—the atoms—it is not clear that it covers CAD files—the bits. As with products liability, analogy to the law's treatment of software applications is enlightening.

Courts and commentators debate whether and when software applications are a good or a service.[115] Like many transactions, software transactions

109. This is unsurprising, as product liability law has roots in both contract law and tort law. *See, e.g.,* RESTATEMENT (THIRD) OF TORTS: PRODS. LIAB. § 1 cmt. a (1998).

110. For the remainder of this Article, generic references to the UCC are directed to Articles 1 and 2 of the code.

111. U.C.C. § 2-102 (2013).

112. Rodau, *supra* note 2, at 893 (noting that only ten sections of Article 2 of the UCC fail to explicitly mention the term *sale* and seven of the ten sections refer to "contracts" or "agreements," which are defined in Article 2: "contracts or agreements for the present or future sale of goods").

113. Even then, there must be some basis for the court to find a contractual relationship of some kind between the parties.

114. U.C.C. § 2-105(1) (2013).

115. *E.g.*, JAMES J. WHITE & ROBERT S. SUMMERS, UNIFORM COMMERCIAL CODE 25–27 (6th ed. 2010) (noting that there is a "vast body of case law" regarding whether computer software are goods, and if the software are goods, whether they fall outside the scope of Article 2); Jean Braucher, *Contracting Out of Article 2 Using a "License" Label: A Strategy that Should Not Work for Software Products*, 40 LOY. L.A. L. REV.

have both a goods aspect and a services aspect. The majority of courts typically handle this dual nature conundrum using the "predominant purpose" test, which applies the UCC if the goods aspect dominates but not if the services aspect dominates.[116] Under the predominant purpose test, courts tend to treat mass-marketed software as a good but custom-built software as a service.[117]

Transferring software application jurisprudence to CAD files suggests that courts would treat a CAD file as a good if its owner widely advertised and promoted the file. Alternatively, if an industrial manufacturer, or artist, created a complex CAD file for a specific customer, the service aspect would dominate.

Yet here, as in the products liability context,[118] one must consider a tertium quid to the mass-marketed and custom-built benchmarks. Because 3D printing technology dramatically lowers the costs of design and distribution, amateur designers and hobbyists—who may even be minors—may create and distribute such files casually or freely.[119]

Unlike the products liability context, however, the policies behind the UCC do not presuppose large, sophisticated manufacturing enterprises that should bear the risks imposed by their products. Instead, the UCC creates a uniform set of rules that apply to a vast array of transactions, from small to large and formal to informal.[120] In essence, although strict products liability is largely proconsumer, the UCC is more balanced and permits contracting around many of its default rules. Because the UCC is relatively balanced and flexible, courts should feel less angst over labeling CAD files as goods under the UCC as compared with products under strict products liability.

If a court decides to treat a particular CAD file as a good, then many provisions of Article 2 of the UCC will apply. But some sections of Article 2 only apply in special circumstances, and the next subpart analyzes the most important aspect of these specialized rules.

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261, 268–71 (2006) (discussing whether software applications are goods or services); Rodau, *supra* note 2, at 918 (concluding that software transactions are within the domain of Article 2 of the UCC).

116. WHITE & SUMMERS, *supra* note 115, at 28.

117. *Id.* at 25–26; *see also* RESTATEMENT (THIRD) OF TORTS: PRODS. LIAB. § 19, reporter's note, cmt. d (1998) (citing cases).

118. *See supra* Part III.B.2.

119. *See infra* note 337 and accompanying text.

120. *See* U.C.C. § 1-103 cmt. 1 (2013).

### *2. When Are CAD File Sellers "Merchants"?*

Although the UCC applies to all manner of sellers, it has a subset of rules applicable to more sophisticated sellers, which the UCC calls "merchants."[121] Generally, merchants are those who regularly deal in the kind of goods involved in the transaction of interest.[122] The UCC's merchant definition works well in the world of physical goods but less so when the worlds of bits and atoms coalesce.

Suppose a college student designs a CAD file for a simple widget in her dorm room for fun. She uploads it to a website and puts a price of five dollars for the CAD file, thinking little of it. For the first three months, she sells only one—to her mother. Is she a merchant at this point? It would seem not. To her amazement, in the next three months—while she does nothing but study for classes—the widget goes viral and she sells 20,000. Is she now a merchant? In one sense, yes, because she has sold 20,000 of the same widget. In another sense, no, because she expended no more effort and became no more sophisticated than when her mother was her only customer.

Being a merchant matters because the UCC applies special rules to merchants who regularly deal in specific goods, the most significant of which are a warranty of merchantability[123] and a warranty against infringement.[124] For CAD files, the most relevant portion of the UCC's warranty of merchantability requires that the products be "fit for the ordinary purposes for which such goods are used."[125] The warranty protects the buyer against substandard goods and thus, imposes additional potential costs on the seller.[126] Absent such an implied warranty, a seller would largely be bound only by express warranties, if any.[127]

121. *See id.* § 2-104(1).

122. *Id.* The UCC actually creates three different categories of consequences of being a merchant. *See id.* cmt. 2. The focus here is on the merchant category that might trigger an implied warranty.

123. *Id.* § 2-314(1).

124. *Id.* § 2-312(3).

125. *Id.* § 2-314(2)(c).

126. Interestingly, courts analyzing whether a CAD file is merchantable will likely look not only at the CAD file itself but also at the functionality of the resulting printed product. In short, the convergence of the worlds of bits and atoms forces the court to look at two goods: the file and the printed product.

127. *See* U.C.C. § 2-313 cmts. 1–2 (2013).

In addition to the warranty of merchantability, the UCC implies a warranty against infringement for the buyer's protection if the seller is a merchant with respect to the goods in the transaction.[128] This could have a significant impact on sellers of CAD files that infringe patents, trademarks, or copyrights. Although sometimes the sale of the CAD file itself may infringe an intellectual property right, other times only the act of printing the product will infringe.[129] Hence, the implied warranty against infringement adds additional potential costs to a seller.

Although merchants can modify or exclude these implied warranties,[130] many unsophisticated CAD file sellers will be unlikely to jump through the hoops necessary to do so. Hence, courts should be careful before labeling a CAD file seller as a merchant.[131]

The key to when a CAD file seller should qualify as a merchant lies with the purpose behind creating special rules for merchants. The comments to the UCC explain that "transactions between professionals in a given field require special and clear rules which may not apply to a casual or inexperienced seller or buyer."[132] In many cases, people who upload CAD files will simply be "casual" or "inexperienced" sellers, not "professionals."[133] Hence, many times these sellers should not be treated as merchants.

At some point, however, individuals who make a repeated practice of selling a variety of CAD files might become merchants. This issue is reminiscent of debates regarding other classes of sellers, such as farmers. Although farmers regularly dealt in their crops, the law often refused to treat "simple" farmers as merchants under the UCC.[134] A prevailing view is

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128. *Id.* § 2-312(3).

129. *See infra* Part III.E.2.a.

130. U.C.C. § 2-316 (2013). However, the 1975 Magnuson-Moss Warranty–Federal Trade Commission Improvement Act may limit the ability of a seller to disclaim or alter warranties. *See* 15 U.S.C. §§ 2301–2312 (2012).

131. Although products liability claims generally overshadow contract claims, sometimes a breach of warranty claim will stand even though a products liability claim fails—because the product is not unreasonably dangerous. Jay M. Feinman, *Implied Warranty, Products Liability, and the Boundary Between Contract and Tort*, 75 WASH. U. L.Q. 469, 469 (1997).

132. U.C.C. § 2-104 cmt. 1 (2013). For more in-depth discussions of the policy behind the special rules for merchants, see John F. Dolan, *The Merchant Class of Article 2: Farmers, Doctors, and Others*, 1977 WASH. U. L.Q. 1, and Ingrid Michelsen Hillinger, *The Article 2 Merchant Rules: Karl Llewellyn's Attempt To Achieve the Good, the True, the Beautiful in Commercial Law*, 73 GEO. L.J. 1141 (1985).

133. *See infra* note 337 and accompanying text.

134. Jan W. Henkel & Peter J. Shedd, *Article 2 of the Uniform Commercial Code: Is a Farmer a "Merchant" or a "Tiller of the Soil"?*, 18 AM. BUS. L.J. 323, 326–29 (1981); *see also* William M. Goebel, *The Uniform Commercial Code and the Farmer*, 1962 U. ILL. L.F. 374, 379.

that the law cannot treat farmers as a unified class: some are huge agri-businesses while others are simple, small-scale farmers.[135] Given the diversity of CAD file sellers, courts are likely to follow the treatment given to farmers. They will likely determine whether a CAD file seller is a merchant on a case-by-case basis, focusing on factors such as the sophistication of the seller, the number of transactions, and the expectations of the buyer.[136]

#### *3. Sale Versus License*

A final issue raised by CAD files under contract law is the distinction between a sale and a license. Like most software, many CAD files are likely to be licensed, not sold. Software vendors structure their transactions as licenses in an effort to avoid exhaustion principles in intellectual property law.[137] Under the exhaustion, or "first sale," doctrine, once a particular copy or device is sold, the intellectual property owner loses rights with respect to that particular product—the purchaser may resell it, throw it away, or otherwise dispose of it.[138]

Distributors of CAD files may often license their files. This may be to avoid exhaustion but also may be for less selfish motives, such as those found in the Creative Commons and open source licenses.[139] By structuring agreements as licenses instead of sales, the distributors may also avoid the provisions of the UCC pertaining to sales or leases of goods. Whether and when courts should permit a distributor to avoid the UCC—including the sections specific to merchants—will require analysis of the transaction and the policies of the UCC.[140]

In summary, CAD files raise several unique issues under the UCC. Focusing on the policies behind the UCC's provisions and the ways in which 3D printing technology alters behavior patterns will help courts and commentators untangle these issues as the technology proliferates.

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135. *See* Dolan, *supra* note 132, at 23–24 (recommending that courts decide whether to treat farmers as merchants on a case-by-case basis); Henkel & Shedd, *supra* note 134, at 323–36 (arguing the same).

136. *See* Dolan, *supra* note 132, at 27–33.

137. *See* Braucher, *supra* note 115, at 271.

138. *See id.* (citing 17 U.S.C. § 109(a) (2006)).

139. *See infra* note 255 and accompanying text (discussing these licenses).

140. *See* Braucher, *supra* note 115, at 275–79 (arguing that end-user licenses of software should be treated as sales under the UCC).

### *D. Criminal Law and Firearms Control*

Imagine you walk up to your car with keys in hand, open the door, start the car, and drive off. Unbeknownst to you, someone photographed your keys as you had them in your hand. Based on those photographs, the interloper builds a 3D CAD file of your car and house keys and prints them on a 3D printer, saving them for an opportune time.

Does this sound fanciful? It already happened—in 2011, albeit with a handcuff key,[141] though researchers have since recreated much more advanced keys.[142] 3D printing provides a new, powerful tool in criminals' belts, bringing opportunity for petty crimes, such as drug paraphernalia, and more serious crimes. Currently, the most headline-catching aspect relates to 3D printed guns.

On May 5, 2013, the founder of Defense Distributed, a do-it-yourself firearms company, fired the world's first 3D printed gun, the "Liberator."[143] Made from only 3D printed parts, plus a simple nail as a firing pin, Defense Distributed released plans for this weapon on its website for free downloading.[144] On May 8, 2013, Defense Distributed received a takedown demand from the U.S. Department of State.[145] In the days after its removal from the Defense Distributed website, the Liberator CAD file remained available on BitTorrent networks.[146] Moreover, soon after Defense Distributed's release, additional improved 3D printed guns appeared on the Internet.[147]

One thing is clear: 3D printed firearms and weapons are not going away. 3D printers have already printed highly sophisticated parts for

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141. David Daw, *Criminals Find New Uses for 3D Printing*, PCWORLD (Oct. 10, 2011, 6:00 PM), http://www.pcworld.com/article/241605/criminals_find_new_uses_for_3d_printing (detailing 3D printed key and an ATM "skimming" machine).

142. Wesley Fenlon, *MIT Hackers Copy High Tech Primus Keys with 3D Printing*, TESTED (Aug. 8, 2013, 11:00 AM), http://www.tested.com/tech/3d-printing/457055-mit-hackers-copy-high-tech-primus-keys-3d-printing.

143. Kleinman, *supra* note 45.

144. *Id.*

145. Letter from Glenn E. Smith, Chief, Enforcement Div., U.S. Dep't of State, to Cody Wilson, Co-Founder, Def. Distributed (May 8, 2013), *available at* http://static.infowars.com/2013/05/i/general/ddtakedownnotice.pdf (relying on the International Traffic in Arms Regulations (ITAR) restrictions of "technical data"). *See infra* notes 171, 173–77 (explaining ITAR).

146. Ernesto, *Pirate Bay Takes over Distribution of Censored 3D Printable Gun*, TORRENTFREAK (May 10, 2013), https://torrentfreak.com/pirate-bay-takes-over-distribution-of-censored-3d-printable-gun-130510/. BitTorrent is a content distribution protocol that allows for efficient peer-to-peer file sharing of large files. *See* Margaret Rouse, *TORRENT File Format: Bit Torrent File*, TECHTARGET (Aug. 4, 2010), http://whatis.techtarget.com/fileformat/TORRENT-BitTorrent-file.

147. Templeton, *supra* note 45.

military equipment, including mounts for gun sights on M1 Abrams tanks and Bradley Fighting Vehicles,[148] castings for a gear set used in the Patriot surface-to-air missle system,[149] military rocket hybrid solid fuel grains,[150] and a NASA rocket engine fuel injector.[151]

3D printed weapons raise at least two important issues: (1) how to regulate them, if at all, and (2) can the regulations be enforced effectively? Answering these questions requires a basic understanding of three sets of firearm regulations: manufacturing, domestic distribution—sale or otherwise—and import and export.[152]

### *1. Domestic Firearm Manufacturing and Distribution*

Within the United States, arms manufacturing and distribution occurs under a broad system of overlapping state and federal laws. Federal law requires those "engaged in the business"[153] of manufacturing or domestically dealing in firearms to have a license.[154] It also requires those engaged in the business of manufacturing to engrave a serial number on the "receiver or frame"[155] of any firearm to help with tracing.[156] The definition

148. *Case Study: Tough Enough for Armored Tanks*, STRATASYS, http://www. stratasys. com/~/media/Case%20Studies/Defense/SSYS-CS-Dimension-EOIR-08-13.ashx (last visited Apr. 28, 2013).

149. *Case Study: RLM Industries*, STRATASYS, http://www.stratasys.com/resources/ case-studies/defense/rlm-industries (last visited Apr. 28, 2014).

150. *It's Rocket Science: Hybrid Rocket Engines Use Additive Manufacturing To Combine the Advantages of Solid and Liquid Propellants*, STRATASYS, http://www. stratasys.com.~/media/Case%20Studies/Aerospace/SSYS-CS-Fortus-RocketCrafters-08-13.ashx (last visited Apr. 28, 2014).

151. *NASA Tests 3D-Printed Rocket Engine Fuel Injector*, BBC NEWS (July 15, 2013, 8:24 AM), http://www.bbc.co.uk/news/technology-23313921.

152. The law governing firearms is voluminous and cannot be treated holistically here. For a more detailed account of self-defense and firearms regulation, see Peter Jensen-Haxel, Comment, *3D Printers, Obsolete Firearm Supply Controls, and the Right To Build Self-Defense Weapons Under* Heller, 42 GOLDEN GATE U. L. REV. 447, 456–63 (2012).

153. 18 U.S.C. § 921(a)(21)(A) (2012) (defining *engaged in the business* to mean "a person who devotes time, attention, and labor to manufacturing firearms as a regular course of trade or business with the principal objective of livelihood and *profit* through the sale or distribution of the firearms manufactured" (emphasis added)).

154. 18 U.S.C. §§ 922(a)(1)(A), 923(a) (2012). Federal laws governing firearms dealing focus on interstate transactions, leaving states to regulate most intrastate transactions. *See* VIVIAN S. CHU, CONG. RESEARCH SERV., R43033, CONGRESSIONAL AUTHORITY TO REGULATE FIREARMS: A LEGAL OVERVIEW 14 (2013).

155. 18 U.S.C. § 923(i) (2012).

of *engaged in the business* of manufacturing or dealing would cover a person who 3D printed firearms or receivers and sold them for profit as part of a regular business.[157]

On the manufacturing side, federal law permits unlicensed individuals to make their own firearms for personal use, and such firearms do not require a serial number.[158] Before 3D printing, home manufacture and assembly of firearms was minimal because of the special skill required.[159] But 3D printing empowers almost anyone to manufacture guns or components thereof.[160] At a minimum, this creates a headache for those worried about homemade firearms leaking into the distribution network.[161]

Regarding firearm distribution, numerous state and federal laws regulate various aspects of the firearm trade.[162] Further, federal law creates heightened standards for automatic weapons.[163] Alongside this highly regulated primary market, there exists a secondary market of private transactions, accounting for approximately thirty to forty percent of annual domestic weapon sales.[164] Firearms, even those made at home for personal use,

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156. *See* 27 C.F.R. § 478.123 (2013) (specifying, inter alia, record-keeping requirements for manufacturers); 27 C.F.R. § 478.124 (2013) (governing dealers).

157. *See* 18 U.S.C. § 921(a)(21)(A) (2012).

158. Such individuals are free from all regulations directed at people "engaged in the business" of manufacturing firearms. *See* 18 U.S.C. §§ 921(a)(21)(A), 922(a)(1)(A), 923(i) (2012); *see also Frequently Asked Questions: Firearms Technology*, BUREAU ALCOHOL, TOBACCO, FIREARMS & EXPLOSIVES, U.S. DEP'T JUST., http://www.atf.gov/firearms/faq/firearms-technology.html (last visited Apr. 28, 2014).

159. *See* Mike LaBossiere, *Ethics and 3D Printing*, TALKING PHIL. BLOG (July 12, 2013), http://blog.talkingphilosophy.com/?p=7311.

160. *See id. But see* Keith Wagstaff, *Despite Plastic Gun Ban, 3-D Printed Firearms Still Have a Future*, NBC NEWS (Dec. 9, 2013, 5:02 PM), http://www.nbcnews.com/technology/despite-congressional-ban-3-d-printed-guns-still-have-future-2D11718212 (noting that despite the greater accessibility and improving quality of 3D printing, traditional home-manufactured black market guns are much cheaper and do not require the technological ability to read CAD files and use a 3D printer).

161. The U.S. Senate has already demonstrated concern over this issue by extending the Undetectable Firearms Act for another ten years in an attempt to regulate and deter plastic firearms. Wagstaff, *supra* note 160.

162. By some counts, there are approximately 300 major state and federal laws. *See, e.g.*, JON S. VERNICK & LISA M. HEPBURN, BROOKINGS INST., TWENTY THOUSAND GUN-CONTROL LAWS? 1 (2002).

163. *See* National Firearms Act, 26 U.S.C. § 5845 (2012).

164. *See* PHILIP J. COOK & JENS LUDWIG, NAT'L INST. OF JUSTICE, GUNS IN AMERICA: NATIONAL SURVEY ON PRIVATE OWNERSHIP AND USE OF FIREARMS 6–7, *available at* https://www.ncjrs.gov/pdffiles/165476.pdf. This figure has been under fire of late. *See, e.g.*, Glenn Kessler, *The Stale Claim that 40 Percent of Gun Sales Lack Background Checks*, WASH. POST (Jan. 21, 2013, 6:02 AM), http://www.washingtonpost.com/blogs/fact-checker/post/the-stale-claim-that-40-percent-of-gun-sales-lack-background-checks/2013/01/20/e42ec050-629a-11e2-b05a-605528f6b712_blog.html (noting that Cook and Ludwig "acknowledge the ambiguity" in their answers).

cannot legally be distributed to certain classes of people, such as felons.[165] Of course, enforcing these rules is easier said than done.

Despite numerous federal laws governing the manufacture and domestic distribution of firearms, not one of them regulates CAD files, blueprints or other templates, on its face. None of this mattered much before the advent of 3D printing. But this new technology allows anyone to design, domestically distribute, or domestically sell CAD files of firearms without running afoul of the law.

To overcome the lack of regulation for CAD files, the law could designate CAD files for certain firearm components as "firearms" or otherwise attempt to regulate CAD files for firearm components.[166] The law could require some form of technical protection measures that allow tracing or control of CAD files—though these are easy to circumvent.

Another novel issue raised by 3D printing in the firearm context is the potential liability for intermediaries such as website hosts and 3DP services.[167] Do intermediaries have an obligation to monitor the files that they host or print? What are the potential liabilities for a 3DP service that prints a firearm or allows one to be printed on its premises? Does a 3DP service have a duty to visually monitor everything printed on its premises? Such a time-consuming requirement could cripple a high-volume shop. Moreover, the expertise required to identify prohibited firearms and firearm components would likely be too expensive for such businesses to acquire.

Certainly it may be desirable to prevent a business from knowingly hosting or printing prohibited firearm components and perhaps to require warnings against illegal conduct. In addition, the law could require 3DP services to utilize industry-accepted software to monitor the files people want printed. This would dramatically reduce the time and expense required from the business and would likely be more effective than visual inspections, at least for oddly shaped parts.

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165. 18 U.S.C. § 922(d) (2012) (prohibiting "any person to sell or otherwise dispose of any firearm or ammunition" to certain classes of people).

166. Additional proposals focus on regulations and markings on ammunition, some of which have already been implemented in individual states. *See Ammunition Regulation Policy Summary*, LAW CENTER TO PREVENT GUN VIOLENCE (May 21, 2012), http://smartgun laws.org/ammunition-regulation-policy-summary.

167. Recall that 3DP services print CAD files on behalf of others. *See supra* note 106 and accompanying text.

Any such laws will need to pass Second Amendment constitutional muster.[168] Further, the above technical measures suffer from the weakness that the computer savvy can easily circumvent them. Given hidden identities on the Internet and other technical challenges, there will be obvious difficulties in enforcing such laws. But laws need not be 100% successful to be effective.[169] Moreover, possible alternatives, such as regulating 3D printers themselves or the printing materials, risk unnecessarily impeding the growth of 3D printing technology.

### *2. Regulation of Exports*

In contrast to domestic manufacturing and distribution controls, export controls are far more robust and regulate not only physical devices but also schematics, blueprints, and the like. Three different government units currently share the responsibilities for export control: the U.S. Departments of State, Commerce, and Treasury.[170] Key export control regulations include the International Traffic in Arms Regulations (ITAR), administered by the Department of State,[171] and the Export Administration Regulations (EAR), administered by the Department of Commerce.[172] Both sets of regulations cover a broad range of military arms and equipment, and ITAR includes simple firearms.[173] ITAR and EAR do not prohibit all exports of the material; rather, they require approval before exports are allowed.[174]

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168. *See* U.S. CONST. amend. II.

169. *E.g.*, Lawrence Lessig, *The Zones of Cyberspace*, 48 STAN. L. REV. 1403, 1405 (1996) ("A regulation need not be absolutely effective to be sufficiently effective.").

170. *Overview of U.S. Export Control System*, U.S. DEP'T ST., http://www.state.gov/strategictrade/overview/index.htm (last visited Apr. 28, 2014). Efforts are underway to consolidate this divided control. *Id.*

171. ITAR, 22 C.F.R. §§ 120–130 (2013), is the U.S. Department of State's implementation of the Arms Export Control Act, 22 U.S.C. §§ 2751–2799 (2012).

172. EAR, 15 C.F.R. §§ 730–774 (2013), is the U.S. Department of Commerce's implementation of the Export Administration Act, 50 U.S.C. §§ 2401–2420 (2006), which expired. *See* Matthew D. Burris, *Tilting at Windmills? The Counterposing Policy Interests Driving the U.S. Commercial Satellite Export Control Reform Debate*, 66 A.F. L. REV. 255, 261 n.20 (2010) (citing IAN F. FERGUSSON, CONG. RESEARCH SERV., THE EXPORT ADMINISTRATION ACT: EVOLUTION, PROVISIONS, AND DEBATE 3 (2009), *available at* http://www.fas.org/sgp/crs/secrecy/RL31832.pdf). But the regulations continue in force by Executive Order 13222, which is renewed yearly, under the International Emergency Economic Powers Act, 50 U.S.C. §§ 1701–1707. *Id.* (citing FERGUSSON, *supra*, at 3).

173. ITAR restricts the export of many weapons, vehicles, and equipment, 22 C.F.R. § 126.1(a) (2013), including simple firearms, *id.* § 121.1, category I(j)(1), and such articles in a partially completed state, *id.* § 121.10. EAR covers things including nuclear materials and electronics. 15 C.F.R. § 774 Supp. No. 1 (2013).

174. *See* 22 C.F.R. § 126.1 (2013); *Summary of Export Control Laws*, USC OFFICE COMPLIANCE, http://ooc.usc.edu/summary-export-control-laws (last visited Apr. 28, 2014).

More importantly for 3D printing, ITAR defines *export* very broadly and includes within the definition "[d]isclosing (including oral or visual disclosure) or transferring technical data to a foreign person, whether in the United States or abroad."[175] In addition, the export restrictions apply beyond whole devices to component parts[176] *and technical data* for manufacturing the devices and parts.[177] The regulations define *technical data* very broadly such that they unmistakably would cover CAD files, not to mention the subsequently printed devices.[178] Thus, ITAR and EAR prohibit the unauthorized export of CAD files falling under any one of the statutes' broad categories, and this includes the simple posting of controlled CAD files to the Internet—assuming the Internet is available everywhere.[179]

Questions remain in the firearm export area. The fact that simply posting a CAD file of a firearm to the Internet violates export controls raises free speech and Second Amendment concerns. Courts will need to address this issue in light of currently available geolocation technology that allows websites to be accessible in specific countries and filtered in others.[180] The more difficult issue, however, is the enforcement of any rules. CAD files of firearms are likely to proliferate on the Internet, perhaps overwhelming law enforcement efforts. Any serious effort to restrict CAD

175. 22 C.F.R. § 120.17(a)(4) (2013).

176. *See, e.g.*, *id.* § 121.1 category III(d)(3) (regulating "components, parts, accessories, attachments and associated equipment specifically designed or modified for [ammunition, ordnance, ammunition and ordnance handling equipment, and equipment and tooling specifically designed or modified for ammunition or ordnance]").

177. For ITAR, *technical data* is defined broadly as "[i]nformation . . . which is required for the design, development, production, manufacture, assembly, operation, repair, testing, maintenance or modification of defense articles . . . . This includes information in the form of blueprints, drawings, photographs, plans, instructions or documentation." *Id.* § 120.10(a)(1). For EAR, *technical data* includes "blueprints, plans, diagrams, models, formulae, tables, engineering designs and specifications, manuals and instructions written or recorded on other media or devices such as disk, tape, read-only memories." 15 C.F.R. § 772.1 (2013).

178. *See supra* note 177.

179. *See* 22 C.F.R. § 120.17(4) (2013); *see also* Letter from Glenn E. Smith, *supra* note 145 (demanding, under authority of ITAR, the take down of the Internet posting of the "Liberator" firearm CAD file).

180. *See, e.g.*, Kevin F. King, *Personal Jurisdiction, Internet Commerce, and Privacy: The Pervasive Legal Consequences of Modern Geolocation Technologies*, 21 ALB. L.J. SCI. & TECH. 61, 66–78 (2011) (describing the technology by which companies can, among other things, limit where their websites appear).

files of firearms on the Internet would require extensive international cooperation.

### *E. Intellectual Property Law*

#### *1. Trademark Law*

Trademark law concerns the symbols, such as the Nike "swoosh," that companies use to connote themselves as the source of goods or services.[181] Trademark law rests on two sometimes competing rationales, the "consumer protection" and the "producer incentive" rationales,[182] and 3D printing will dramatically expose the differences between them. Under the consumer protection rationale, trademark law protects consumers against confusion as to the quality and source of certain goods: consumers associate a trademark with the producer of those goods and thus, the quality of the goods.[183] Under the producer incentive rationale, trademark law incentivizes companies to invest in high-quality goods by allowing the trademark holder to control use of the mark, thereby protecting consumers' associations between the high-quality goods and the producer.[184]

##### *a. How Far Will Trademark-as-Property Go?*

Although trademark law has long rested on both rationales, the producer incentive rationale dramatically rose in prominence in the twentieth century,[185] giving rise to actions not only for traditional "point of sale"

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181. *See* 15 U.S.C. § 1127 (2012).

182. 1 J. THOMAS MCCARTHY, MCCARTHY ON TRADEMARKS AND UNFAIR COMPETITION § 2:2 (4th ed. 2013) (discussing the dual goals of trademark law to "protect both consumers from deception and confusion over trade symbols *and* to protect the plaintiff's infringed trademark as property").

183. Dan L. Burk, *Trademark Doctrines for Global Electronic Commerce*, 49 S.C. L. REV. 695, 699–700 (1998) (citing William M. Landes & Richard A. Posner, *Trademark Law: An Economic Perspective*, 30 J.L. & ECON. 265, 275 (1987)).

184. *See* Qualitex Co. v. Jacobson Prods. Co., 514 U.S. 159, 164 (1995) ("[Trademark] law helps assure a producer that it (and not an imitating competitor) will reap the financial, reputation-related rewards associated with a desirable product. The law thereby 'encourages the production of quality products." (quoting 1 J. MCCARTHY, MCCARTHY ON TRADEMARKS AND UNFAIR COMPETITION § 2.01[2] (3d ed. 1994))); Park 'N Fly, Inc. v. Dollar Park & Fly, Inc., 469 U.S. 189, 198 (1985) ("[T]rademarks foster . . . the maintenance of quality by securing to the producer the benefits of good reputation.").

185. Though it did so not without criticism. *See, e.g.*, Felix S. Cohen, *Transcendental Nonsense and the Functional Approach*, 35 COLUM. L. REV. 809, 814–17 (1935) (noting that "[i]ncreasingly the courts have departed from" the theory that "the law of trade marks and trade-names was an attempt to protect the consumer against the 'passing off' of inferior goods under misleading labels").

confusion but also for "sponsorship" confusion and "postsale" confusion.[186] Without these later forms of confusion, the purchase or use of pirated goods by a knowing buyer would not infringe because they were not confused as to the source.[187] Some feel that the doctrine of postsale confusion has gone too far,[188] and some even seek its abolition.[189]

3D printing will explode the dividing line between the consumer protection and producer incentive rationales by giving individuals the ability to print a remarkable range of fake trademarked goods in the privacy of their own homes. The individual, if printing the good for personal consumption, will not be confused about the source of the goods—the individual will know that they are not from the brand owner—thus, traditional consumer confusion will not be an issue.[190] Trademark owners will be forced to rely on a heavy-handed version of postsale confusion—or, if able, dilution—and even then, the trademark owner may need to prove not only that the person printed the goods but also that they wore or used them in public.[191] This strongly property-centric version of trademark law will raise new and difficult questions about the proper role of regulation for brand names.

Why are these questions new? After all, knockoffs have been around as long as brand names, and those who want them know where to buy

186. *See* Michael J. Allen, *The Scope of Confusion Actionable Under Federal Trademark Law: Who Must Be Confused and when?*, 26 WAKE FOREST L. REV. 321, 325–26 (1991) (discussing sponsorship confusion and its lack of relation to consumer protection). Postsale confusion relates to confusion not at the point of sale but at the point when onlookers later see the purchaser wearing or using the goods and are arguably confused. *See* Mark A. Lemley, *The Modern Lanham Act and the Death of Common Sense*, 108 YALE L.J. 1687, 1706–07 (1999); Anne M. McCarthy, Note, *The Post-Sale Confusion Doctrine: Why the General Public Should Be Included in the Likelihood of Confusion Inquiry*, 67 FORDHAM L. REV. 3337, 3348–52 (1999).

187. *See* McCarthy, *supra* note 186, at 3350–51.

188. Glynn S. Lunney, Jr., *Trademark Monopolies*, 48 EMORY L.J. 367, 396 n.106 (1999) (stating that courts "pretend[]" there is postsale confusion).

189. Jeremy N. Sheff, *Veblen Brands*, 96 MINN. L. REV. 769, 776 (2012).

190. *See* 15 U.S.C. § 1114(1)(a) (2012). Also, if the individual creates a trademarked good for personal consumption, the use of the good is arguably not "in connection with the sale, offering for sale, distribution, or advertising of any good or services" and is thus outside the ambit of infringement on another potentially independent ground. *Id.*

191. For an example of the uphill battle trademark owners face when attempting to prove postsale confusion, see Gibson Guitar Corp. v. Paul Reed Smith Guitars, LP, 423 F.3d 539 (6th Cir. 2005). In that case, Gibson tried and failed to prove that the defendant Paul Reed Smith's guitars could be confused in a "smoky-bar context" for Gibson's guitars. *See id.* at 549, 552–53.

them. But 3D printing removes the third party, large-scale knockoff manufacturer and brings the "piracy" into the home. Norms change when people are empowered to create and acquire things digitally in their homes, just look at the music scene when Napster came along.[192] Such empowerment may demystify and defenestrate the brand's power. What is more, people may not be content to simply make bland copies of trademarked goods. Instead, they may shape and personalize them, leading them to feelings of ownership and entitlement.

*b. When Is a CAD File or 3D Printed Item Infringing, if Ever?*

The Lanham Act defines *trademark infringement* as the unconsented "use in commerce" of a mark "in connection with the sale, offering for sale, distribution, or advertising of any goods or services on or in connection with which such use is likely to cause confusion, or to cause mistake, or to deceive."[193] The definition of *trademark infringement* raises several questions.

First, if a CAD file of a trademarked good is never sold, but only freely distributed, is it "used in commerce?" Unlike patents and copyrights, which exist via the Constitution's Patent and Copyright Clause,[194] the federal statutory regime for trademarks is grounded in the Commerce Clause.[195] 3D printing allows behavior not generally encountered before: freely distributed "counterfeit" goods. Because one can easily design—and if desired, distribute freely—a CAD file for a trademarked good, the need to recoup costs largely disappears.[196] Courts will need to determine whether these goods are used in commerce in a trademark sense.[197]

Even if the CAD file of a trademarked item is *used* in commerce, is the file itself a *product* under the Lanham Act?[198] As with the UCC and

192. *See* Richard Nieva, *Ashes to Ashes, Peer to Peer: An Oral History of Napster*, CNN MONEY (Sept. 5, 2013, 5:00 AM), http://tech.fortune.cnn.com/2013/09/05/napster-oral-history.

193. 15 U.S.C. § 1114(1)(a) (2012) (registered marks); *see also id.* § 1125(a) (2012) (providing a parallel cause of action for unregistered marks).

194. U.S. CONST. art. I, § 8, cl. 8.

195. Trade-Mark Cases, 100 U.S. 82, 93–99 (1879) (invalidating the first federal trademark statute but noting potential future validity if based on the commerce clause).

196. Although not a trademarked good, the rampant distribution of the design files for the "Liberator" 3D printed gun illustrates the ease with which CAD files can be disseminated. *See* Kleinman, *supra* note 143.

197. Courts often read the used in commerce requirements broadly, such that even nonsale uses can count as *in commerce*. *See, e.g.*, Wickard v. Filburn, 317 U.S. 111, 128–29 (1942) (holding, in an agricultural regulation case, that wheat grown for personal use can be federally regulated because it removes a customer from the interstate wheat market).

198. This harks back to the question of what constitutes a *product* in products liability law, *supra* Part III.B.1, and a *good* under the UCC, *supra* Part III.C.1.

product liability law, an argument can be made that the CAD file is a product. Yet even if this is true, is the *trademark* used in connection with the CAD file transfer?[199] In many cases, the answer might be yes because the sale of the CAD file will be accompanied by a description of what the CAD file will print, for example, "CAD file for Gucci purse." But savvy users will circumvent this problem by omitting reference to the particular brand name or by separating the logo files and the item files, allowing the users to place the logo on the file on their computers before printing.

Additional questions surround indirect infringement liability for the creators and distributors of CAD files,[200] as well as end-user liability for using the goods in public.[201] Assuming a user creates a CAD file in her home, is she infringing by printing the item and personally using the item in public? Theoretically, one could have made pirated goods in the home, such as knitting a sweater with a trademark on it, but no one bothered to bring suit because the effort was not worth it. But 3D printing allows users to make trademarked goods effortlessly. This state of affairs will seriously stress the existing trademark regime and force difficult questions about the property-like characteristics of trademarks and the outer limits of trademark use in commerce.

Thus far, the discussion has focused on blatant copying of trademarks, but there is an additional aspect to consider. 3D printing will allow a torrent of creativity as users create 3D customizations, mash-ups, and parodies of trademarked goods. As in the case of copyright law, these uses will raise intriguing questions of fair use and free speech, not to mention societal norms. In addition, individuals will demand access to customized brand-name goods, for example, one's name on shoes or a purse. Trademark owners would be wise to accommodate them by offering their own certified

199. *See* Stacey L. Dogan & Mark A. Lemley, *Grounding Trademark Law Through Trademark Use*, 92 IOWA L. REV. 1669, 1682 (2007) (arguing for a requirement that the mark be used "as a [trade]mark").

200. *See* Inwood Labs., Inc. v. Ives Labs., Inc., 456 U.S. 844, 853–54 (1982) ("[L]iability for trademark infringement can extend beyond those who actually mislabel goods with the mark of another. Even if a manufacturer does not directly control others in the chain of distribution, it can be held responsible for their infringing activities under certain circumstances.").

201. *See supra* note 191 and accompanying text.

3D printable and customizable files, lest they face a backlash similar to that of the music industry when it resisted change.[202]

Additional new issues surround intermediary liability for websites that host CAD files or facilitate their transfer. As with so many other areas of the law in a 3D printing world, courts will need to ascertain whether and when intermediaries should be subject to liability.

### *2. Patent Law*

Patent law grants inventors a right to exclude others from making, using, selling, offering to sell, and domestically importing their inventions.[203] As with other areas of law, 3D printing will raise a host of issues for patent law, some of which are familiar. Take, for example, the multitude of relatively small, inexpensive innovations that will occur as millions of people become designers and manufacturers. Many of these inventions will not be widely known or publicized, leading to the possibility that others will later invent the same thing and claim to deserve a patent. Something similar happened with software inventions, where the patent office granted undeserving patents because it could not readily search, or understand, the prior art record.[204] As with previous new technologies, the patent system must work to find ways to harness the knowledge and prior art that 3D printing will bring so that only deserving inventors obtain a patent.

#### *a. Patenting the Bits Along with the Atoms*

But other issues pose more novel questions. For instance, suppose a patent covers an improved mousetrap and contains claims to the mousetrap itself, as well as a method of making the mousetrap. If someone makes a CAD file for the mousetrap and sells it to others, would this infringe the patent? Thus far, no one has "made" or "sold" the actual product. Of course, actually printing the mousetrap would infringe, but detecting in-

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202. *See* Bob Lefsetz, *Losing the Press War*, LEFSETZ LETTER (Nov. 28, 2005), http://lefsetz.com/wordpress/index.php/archives/2005/11/28/238/ ("[T]he labels had the media on their side. But, by not coming up with a reasonable alternative to [peer-to-peer networks for downloading music], or authorizing it, and SUING traders, they've lost all their good will.").

203. 35 U.S.C. § 271(a) (2006).

204. *E.g.*, Robert P. Merges, *As Many as Six Impossible Patents Before Breakfast: Property Rights for Business Concepts and Patent System Reform*, 14 BERKELEY TECH. L.J. 577, 589–91 (1999).

home acts of infringement might be difficult. What the patent holder would desire is to control the CAD file itself.[205]

Going forward, patent holders can attempt to circumvent many of these issues by including additional claims covering a CAD file that would print their invention.[206] But what about those patents without CAD file claims? The patent owner could claim the CAD file infringes under the doctrine of equivalents. The doctrine of equivalents provides that an accused technology that does not literally meet the patent claim's requirements may nevertheless be "equivalent."[207] Such an argument would be truly novel; usually the doctrine is reserved for substituting one part—a screw—for a claimed piece—a nail. If a court analogizes a CAD file to a blueprint, it would probably not infringe even under the doctrine of equivalents.[208] But as 3D printing brings closer together the worlds of bits and atoms, the equivalents argument does not seem that far-fetched—the CAD file is practically the same thing as the physical product.

### *b. Additional Stresses in Patent Law*

Commentators have already begun to take notice of the ways in which 3D printing stresses patent law. At least two papers highlight the issue of immunity for intermediary websites and Internet companies that host potentially infringing CAD files and propose a solution similar to the

205. A patentee might be able to sue the CAD file distributor for inducing infringement or contributory infringement but would need to prove knowledge of the patent and intent to infringe. 35 U.S.C. § 271(b)–(c) (2006).

206. The patentee can make a Beauregard-style claim to cover the STL file and perhaps the CAD file precursor to the STL file. *See In re* Beauregard, 53 F.3d 1583, 1584 (Fed. Cir. 1995). Such claims would be eligible subject matter to the extent that a method claim is patentable. Examination Guidelines for Computer-Related Inventions, 61 Fed. Reg. 7478, 7482–83 (Feb. 28, 1996) ("If a claim is found to encompass any and every product embodiment of the underlying process, and if the underlying process is statutory, the product claim should be classified as a statutory product.").

207. Under the doctrine of equivalents, the "scope of a patent is not limited to its literal terms but instead embraces all equivalents to the claims described" to prevent competitors from avoiding infringement by making unimportant and insubstantial differences to their technology. *See* Festo Corp. v. Shoketsu Kinzoku Kogyo Kabushiki Co., 535 U.S. 722, 732–33 (2002).

208. *See, e.g.*, Microsoft Corp. v. AT&T Corp., 550 U.S. 437, 450 (2007) ("A blueprint may contain precise instructions for the construction and combination of the components of a patented device, but it is not itself a combinable component of that device.").

takedown provisions of the Digital Millennium Copyright Act (DMCA).[209] It is an interesting proposal but one that requires further analysis. The analogy to Internet service providers (ISPs) in copyright infringement is inexact for at least three reasons, some of which the authors recognize. First, whereas the majority of online copyright infringement was willful, verbatim copying,[210] patent infringement is much more difficult to analyze.[211] Second, one might expect an order of magnitude less patent infringement than copyright infringement.[212] Third, although the liability of ISPs for *direct* copyright infringement was perhaps dubious, but never clear,[213] 3D printing services that print patented devices for customers would unquestionably infringe directly,[214] thus, making their case for an exemption more difficult.

3D printing also introduces interesting issues in patent law's repair-reconstruction doctrine because users will be able to design and print their own replacement parts.[215] The doctrine states that an owner of a patented device may lawfully *repair* it without infringing the patent but may not *reconstruct* it—because buying a patented item does not give one the right to make additional copies of the item.[216] As one might expect, the line between repair and reconstruction is ephemeral at best.[217]

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209. Doherty, *supra* note 11, at 362–68; Deven R. Desai & Gerard N. Magliocca, *Patents, Meet Napster: 3D Printing and the Digitization of Things* (Oct. 9, 2013) (draft research paper) (on file with authors), *available at* http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2338067.

210. *See, e.g.*, Nieva, *supra* note 192.

211. Mr. Doherty's note acknowledges this, but his solution for a plain language description of the patent coverage seems unworkable: patent claim language is so specialized that summaries will always be inexact. *See* Doherty, *supra* note 11, at 367. Further, although some copyright cases require a difficult fair use analysis, all patent cases require claim construction issues that confound even judges. *See, e.g.*, Kimberly A. Moore, Markman *Eight Years Later: Is Claim Construction More Predictable?*, 9 LEWIS & CLARK L. REV. 231, 233 (2005). Never mind the near impossible task of analyzing infringement under the doctrine of equivalents. *See Festo*, 535 U.S. at 732 (admitting that the doctrine of equivalents "renders the scope of patents less certain").

212. It is difficult to imagine millions of high school students getting online to print out the newest mousetrap.

213. *See* Alfred C. Yen, *Internet Service Provider Liability for Subscriber Copyright Infringement, Enterprise Liability, and the First Amendment*, 88 GEO. L.J. 1833, 1840–43 (2000) (discussing the fact that the users are uploading the content, not the ISP).

214. Making a patented device is an act of infringement. 35 U.S.C. § 271(a) (2006). ISPs who simply host content and do not print it might infringe contributorily or might directly infringe a claim to a CAD file. *See id.* § 271(a), (c).

215. *See* Kelsey B. Wilbanks, Comment, *The Challenges of 3D Printing to the Repair-Reconstruction Doctrine in Patent Law*, 20 GEO. MASON L. REV. 1147, 1156–58 (2013).

216. *See* Aro Mfg. Co. v. Convertible Top Replacement Co., 365 U.S. 336, 345–46 (1961).

217. *See* Mark D. Janis, *A Tale of the Apocryphal Axe: Repair, Reconstruction, and the Implied License in Intellectual Property Law*, 58 MD. L. REV. 423, 425–26 (1999).

Although suing one's customers is generally not good business, it happens frequently in this area. As 3D printers increase the ease and frequency of repairing even complex parts, litigation in this area will increase.

Individuals' ability to make their own replacement parts will also shine light on another controversial area: design patents for replacement parts.[218] Although such controversies have generally been limited to high-end manufacturing, as manufacturers of household items lose the ability to profit from selling replacement parts, they are likely to seek additional protection from design patents.

### 3. *Copyright Law*

Copyright is no stranger to digital piracy concerns; it battled Napster and related offshoots in the 1990s and 2000s.[219] Copyright law protects original works of authorship.[220] For a work to be "original," it must (1) be independently created and (2) possess a modicum of creativity.[221] CAD files and STL files can sometimes meet these requirements and thus *may* be copyrightable. Furthermore, copyright law protects creative aspects of computer programs,[222] and CAD files are computer programs within the meaning of copyright law.[223]

But because CAD files are computer precursors—bits—to real-world objects—atoms—copyright law will struggle with how to handle both CAD files and 3D printed objects.[224] This is especially true when the CAD file represents a utilitarian article because copyright law does not protect purely utilitarian articles. Although copyright law protects "pictorial, graphic,

218. *See, e.g.*, Promoting Automotive Repair, Trade, and Sales Act of 2013, H.R. 1663, 113th Cong. § 2 (2013) (proposing, among other things, to reduce the exclusivity period car companies hold on design patents for collision repair parts from fourteen years to thirty months).

219. *See* Nieva, *supra* note 192; *RIAA v. The People: Five Years Later*, ELECTRONIC FRONTIER FOUND. (Sept. 30, 2008), https://www.eff.org/wp/riaa-v-people-five-years-later.

220. 17 U.S.C. § 102(a) (2012).

221. Feist Publ'ns, Inc. v. Rural Tel. Serv. Co., 499 U.S. 340, 345 (1991) (citing 1 MELVILLE B. NIMMER & DAVID NIMMER, COPYRIGHT § 2.01[A], [B] (1990)).

222. *See* 17 U.S.C. § 117 (2012).

223. *See id.* § 101 (defining *computer program* as "a set of statements or instructions to be used directly or indirectly in a computer in order to bring about a certain result").

224. For excellent introductions on this issue, see MICHAEL WEINBERG, INST. FOR EMERGING INNOVATION, WHAT'S THE DEAL WITH COPYRIGHT AND 3D PRINTING? 18–19 (2013), *available at* http://www.publicknowledge.org/files/What's%20the%20Deal%20with%20Copyright_%20Final%20version2.pdf, and Edward Lee, *Digital Originality*, 14 VAND. J. ENT. & TECH. L. 919, 948–50 (2012).

and sculptural works," it defines the protectable elements of those works as those elements whose "design incorporates pictorial, graphic, or sculptural features that can be identified separately from, and are capable of existing independently of, the utilitarian aspects of the article."[225] Thus, although a drinking cup is not protectable, an artistic print applied to the cup can be copyrighted because it can be separated from the cup.

However, the utilitarian-artistic divide blurs at its intersection. For example, when, if ever, can one copyright a CAD file depicting a utilitarian article—a screw—made for the purpose of printing the screw? To help see the troubling issues, consider what can be copyrighted: (1) an artist's realistic canvas painting of a screw; (2) a ten-foot tall sculpture of a screw as modern art; (3) a hand-drawn picture of a screw used for advertising the screw;[226] and, at least sometimes, (4) a photograph of a screw used for advertising the screw.[227]

To begin to answer the question, one first must specify how the CAD file was created. If someone three-dimensionally scanned the screw to make the CAD file, then the closest analogy might be photographs. Initially, one might suppose that one could not copyright a photograph because it is simply an accurate depiction of the real world. But courts find that almost all photographs contain copyrightable original expression through the choices of "posing the subjects, lighting, angle, selection of film and camera, evoking the desired expression, and almost any other variant involved."[228] Hence, courts must decide whether and when similar strands of originality accompany 3D scanning. This is a new question in copyright because the technology has only now developed to the point of raising the issue.

Instead of scanning the object, one may create a CAD file of a screw by "drawing" it in a CAD program.[229] In that case, analogies to hand-drawing artists suggest themselves. Although one may not copyright useful

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225. 17 U.S.C. § 101 (2012) (internal quotation marks omitted).

226. *See* Cannon Grp., Inc. v. Better Bags, Inc., 250 F. Supp. 2d 893, 901 (S.D. Ohio 2003) (finding originality sufficient for copyright protection in a realistic drawing of ears of corn on a grocery bag).

227. E. Am. Trio Prods., Inc. v. Tang Elec. Corp., 97 F. Supp. 2d 395, 417–18 (S.D.N.Y. 2000) (finding originality in photographs of electrical products for use in sales catalogues). *But see* Bridgeman Art Library, Ltd. v. Corel Corp., 36 F. Supp. 2d 191, 197 (S.D.N.Y. 1999) (stating that photographs that represent no more than "slavish copies" of public domain original works of art are not copyrightable); *accord* Schrock v. Learning Curve Int'l, Inc., 586 F.3d 513, 519 (7th Cir. 2009).

228. Rogers v. Koons, 960 F.2d 301, 307 (2d Cir. 1992); *see also* Burrow-Giles Lithographic Co. v. Sarony, 111 U.S. 53, 60 (1884) (seminal case recognizing copyrightability of photographs). *But see Schrock*, 586 F.3d at 519; *Bridgeman Art Library*, 36 F. Supp. 2d at 197 (indicating that some photographs are not protectable).

229. *See* LIPSON & KURMAN, *supra* note 9, at 94–95.

articles, one may copyright drawings of useful articles[230] to the extent they contain a "modicum of creativity."[231] Courts have protected architectural plans and other technical drawings.[232]

Yet, because CAD drawings in a 3D printing world are virtually equivalent to the physical article, new questions lurk. In the hand-drawing artist's case, the purpose of the drawing is to create the image itself and to convey information. In contrast, the CAD creator's purpose is not—under this Article's assumption—simply to create the image or convey information but to create the image *as a means to* make a utilitarian article. In this sense, it is like a cast or an injection molding shape, which is not copyrightable.[233]

Rather than treating CAD files like 2D drawings, courts might apply existing copyright law on computer programs to them.[234] Copyright law specifically protects some aspects of computer programs.[235] If other computer programs are copyrightable, then perhaps CAD files should be as well.[236] Yet computer programs may receive copyright protection only

230. The Copyright Act defines *useful article* as "an article having an intrinsic utilitarian function that is not merely to portray the appearance of the article or to convey information." 17 U.S.C. § 101 (2012). Because a technical drawing "conveys information," it is not a "useful article." *See id.*

231. *See* Feist Publ'ns, Inc. v. Rural Tel. Serv. Co., 499 U.S. 340, 345 (1991). Whether or not the drawing has a modicum of creativity is a question courts must answer on a case-by-case basis.

232. *E.g.*, Eales v. Envtl. Lifestyles, Inc., 958 F.2d 876, 880 (9th Cir. 1992), *abrogated on other grounds by* Hunt v. Pasternack, 192 F.3d 877 (9th Cir. 1998) ("It is settled law that architectural drawings and plans are thus eligible for protection under the copyright code . . . .").

233. *See supra* note 230 and accompanying text.

234. These cases concern software *applications*, as opposed to *files*, such as CAD files, that run on the applications. *See, e.g.*, Gates Rubber Co. v. Bando Chem. Indus., Ltd., 9 F.3d 823 (10th Cir. 1993).

235. *E.g.*, Apple Computer, Inc. v. Franklin Computer Corp., 714 F.2d 1240, 1247–48 (3d Cir. 1983) (discussing statute and legislative history with respect to copyright protection for computer programs).

236. The analogy, however, is not perfect because computer programs are typically seen as copyrightable "literary works." H.R. REP. NO. 94-1476, at 54 (1976) (literary works include "computer programs to the extent that they incorporate authorship"). CAD files, although falling under the definition of a *computer program*, are "pictorial, graphic, and sculptural works." *See id.* (pictorial, graphic, and sculptural works include works of "graphic art and illustration" and "plans and drawings"). The distinction between literary works and pictorial, graphic, and sculptural works should not matter. As long as a work falls into a statutory category, it can be protected. *See* 17 U.S.C. § 102(a) (2012) (listing statutory categories of works of authorship to which copyright protection extends).

"to the extent that they incorporate authorship in the programmer's expression of original ideas, as distinguished from the ideas themselves."[237] Courts have developed complex tests to determine what aspects of computer programs are expression versus ideas, but the general result is that computer programs receive relatively thin protection against verbatim copying but very little else.[238] By analogy, one would expect any copyright in a CAD file depicting a useful article to be very thin.

In addition to figuring out how to treat CAD files, copyright law will wrestle with many other 3D printing issues. Some will be relatively familiar: like the earlier song and movie pirating, the ability to create CAD files of 3D structures such as sculptures or buildings[239] will likely lead to numerous, often innocent or unintentional, acts of infringement. But not all of 3D printing's effects will be negative. It will bring the fields of art, science, and technology into more intimate contact. Already artists involved in the areas of nanotechnology[240] and genetics[241]—just to name two—use 3D printers to generate new forms of art. Further, the technology will allow the dissemination and preservation of 3D art. Priceless artifacts can be replicated with exact precision so that thousands may touch and experience perfect copies.[242] It is clear that courts and lawmakers should conduct a careful, holistic analysis of copyright law as applied to 3D printing to achieve a balance between progress of the arts and incentives to create.

To conclude this Part, it should be clear that 3D printing's impact on the law is broad and varied. The technology raises new issues surrounding the treatment of CAD files, the legal responsibilities of CAD file intermediaries, and the normative reaction to 3D printing capabilities, just to name a few. Next, Part IV uses these issues as a backdrop in constructing a regulatory framework for the 3D printing ecosystem.

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237. H.R. REP. NO. 94-1476, at 54.

238. *See, e.g.*, Computer Assocs. Int'l, Inc. v. Altai, Inc., 982 F.2d 693, 703–12 (2d Cir. 1992).

239. The law protects sculptural works in 17 U.S.C. § 102(a)(5) (2012). As of 1990, copyright law protects nonfunctional and nonstandard original building designs, whether embodied in a constructed building, architectural plans, or 3D models. Architectural Works Copyright Protection Act, Pub. L. 101-650, §§ 702(a), 703, 104 Stat. 5089 (codified at 17 U.S.C. §§ 101, 102(a)(8) (2012)).

240. David Behringer, *Shane Hope's 3D Printed Art*, DESIGN MILK (Apr. 18, 2013), http://design-milk.com/shane-hopes-3d-printed-art/.

241. Amanda Kooser, *Artist 3D-Prints Portraits from DNA Left in Public Places*, CNET (May 8, 2013, 8:31 AM), http://news.cnet.com/8301-17938_105-57583442-1/artist-3d-prints-portraits-from-dna-left-in-public-places/.

242. *A Whale of a Story: 3D Printing Meets Palaeontology*, ECONOMIST, Feb. 23, 2013, at 77.

## IV. CONSTRUCTING A REGULATORY FRAMEWORK

Part III demonstrated that 3D printing and related technologies will bring many new challenges and opportunities for society. The difficult part, as always, is maximizing the benefits and minimizing the problems of the new technology. When thinking about regulation,[243] one must broaden the focus beyond simply positive law. The law and society movement reminded us that many extralegal mechanisms—norms, markets, customs, culture, and architecture—have regulatory power.[244] Each of these forces regulates individuals and behaviors, and understanding how each interacts with 3D printing will give a more complete picture than studying positive law in isolation. Performing a thorough analysis of all these forces would be a monumental task and obviously cannot be undertaken here. Instead, this Part introduces a regulatory framework and situates it in the context of 3D printing, leaving more specialized analyses to future scholarship.

### *A. Private Ordering*

One option for regulating 3D printing is to do nothing. It may be that the existing regulatory paradigm works well for some aspects of the 3D printing ecosystem. The existing set of default laws and mandatory laws permits a large amount of private legal ordering. The paradigmatic private legal ordering mechanism is contract,[245] but other mechanisms exist, including simply having no rules or informally adopting self-governing rules and norms.[246]

243. As should be clear, I use *regulate* more broadly than simply an action by a legal body. Instead, I mean the constraining result of some force or action.

244. *See, e.g.*, ROBERT C. ELLICKSON, ORDER WITHOUT LAW: HOW NEIGHBORS SETTLE DISPUTES (1991) (studying the relationship of law and norms); Lawrence M. Friedman, *The Law and Society Movement*, 38 STAN. L. REV. 763 (1986); Lawrence Lessig, *The New Chicago School*, 27 J. LEGAL STUD. 661 (1998); Eric A. Posner, *The Regulation of Groups: The Influence of Legal and Nonlegal Sanctions on Collective Action*, 63 U. CHI. L. REV. 133 (1996).

245. Robert B. Thompson, *Corporate Law Criteria: Law's Relation to Private Ordering*, 2 BERKELEY BUS. L.J. 95, 98 (2005).

246. Computer architecture and software, often referred to as code, can be seen as a type of private ordering. Code is discussed in Part IV.C, *infra*.

### *1. Norms*

Norms develop through subtle and often unseen mechanisms and can have a tremendous influence on private ordering and lawmaking. Norms play a particularly interesting role in regulating new technology because many legal rules, such as negligence and contract law, among others, involve "reasonableness" standards or are informed by what is "normal."[247] But equilibriums regarding reasonableness are unlikely to come about until the new technology becomes more established.

Thus, when technologies are new and evolving, groups are well placed to influence what is reasonable by coordinating behavior and developing codes of conduct, standard practices, laws, and other regulations.[248] But groups, especially lawmakers, must be careful to act with subtlety. When people see powerful groups attempting to manipulate norms, they can react strongly in the opposite direction.[249]

3D printing proponents can attempt to foster 3D printer-friendly norms, including that making backup copies of physical objects is permissible, that open design rather than proprietary rights is preferred, that CAD file creators owe a low duty of care to subsequent users, that consumers should have personalization rights to trademarked goods they purchase, and so on. Similarly, groups who might face accusations of intermediary liability, such as website administrators and ISPs, would be wise to propel norms that would tend to shield them from liability for things that occur through their websites, such as hosting or facilitating the transfer of CAD files for guns, infringing goods, and the like. Conversely, opponents of 3D printing will want to develop norms of their own. Intellectual property owners who fear piracy will want to engender a culture in which CAD files and 3D printers are tightly controlled or in which violating intellectual property rights is frowned upon.[250]

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247. *See, e.g.*, U.C.C. § 2-513(1) (2011) (giving a buyer the right to inspect the goods sold "at any reasonable place and time in any reasonable manner"); MODEL PENAL CODE § 2.02(d) (1985) (defining *negligent act* as one involving a "gross deviation from the standard of care that a reasonable person would observe in the actor's situation").

248. *See* I. Trotter Hardy, *The Proper Legal Regime for "Cyberspace,"* 55 U. PITT. L. REV. 993, 1040–41 (1994).

249. *See* William Hubbard, *Inventing Norms*, 44 CONN. L. REV. 369, 392 (2011) (quoting Lawrence Lessig, *The Regulation of Social Meaning*, 62 U. CHI. L. REV. 943, 1017 (1995); William J. Stuntz, *Self-Defeating Crimes*, 86 VA. L. REV. 1871, 1872–74 (2000)).

250. Copyright holders have attempted to achieve a similar objective in the area of digital music. They encourage "copyright school" to incoming college freshmen to establish a norm against downloading music without paying for it. Rebecca Dana, *To Fight Music Piracy, Industry Goes to Schools*, WASH. POST, Aug. 28, 2003, at A1.

### *2. Individual Action*

Unlike norms, which can be exceedingly difficult to shape, a very basic manner of private ordering is individual action.[251] If an individual does not like an aspect of 3D printing, the individual can engage in self-help by simply avoiding it. The individual can choose not to buy a 3D printer and not to buy goods made by 3D printers. Theorists explain that unilateral avoidance works well when an activity does not have significant externalities and the transaction costs are high relative to the activity's value.[252] But in many cases, one or both of these conditions will fail—in the instant case, 3D printing may allow guns and crime to proliferate, or the Internet may minimize transaction costs.

### *3. Contracts*

Where the transaction costs are relatively low, bilateral and multilateral contracts are feasible.[253] Contracts can take many forms in the 3D printing ecosystem. 3D printing websites might condition access or privileges, such as posting CAD files, on acceptance of terms and conditions. Administrators can contract for authority to police usage by removing offending conduct or banning recalcitrant users. Thus, one who repeatedly posts a CAD file for a gun or violates intellectual property rights might be temporarily or permanently banned and have his files removed. Note that because this is private legal ordering as opposed to governmental rules, constitutional constraints, such as the Free Speech Clause of the First Amendment, apply with much less force.[254]

User groups and websites can use more complex contract-based ordering to govern dispute resolution through private arbitration, forum selection, and choice of law provisions. Moving up the chain of contractual complexity, 3D printing users can form employer-employee relationships, associations, businesses, and the like.

In addition to website-based contract models, *individual* creators of CAD files may rely on contracts to govern downstream uses of their

251. Hardy, *supra* note 248, at 1016.
252. *Id.* at 1017.
253. *See* George S. Geis, *Broadcast Contracting*, 106 NW. U. L. REV. 1153, 1189 (2012).
254. There exist, however, plenty of restraints against behavior, including numerous mandatory laws, such as civil rights laws. *See, e.g.*, 20 U.S.C. §§ 1681–1688 (2012) (prohibiting discrimination on various bases).

files. Prominent instantiations of this model include the family of open source and Creative Commons licenses governing rights in artistic expression and intellectual property.[255] These licenses spell out the terms under which others can use, modify, and build on a given creation.

Contract-based models intersect with norms in at least two ways. First, parties can incorporate their norms into the contract itself, unless a mandatory rule trumps the norm. Second, regardless of the contract's legal significance, norms affect how the parties will resolve disputes.[256]

#### *4. Collective Action: Online Feedback*

Contract models of private ordering represent an important regulatory tool, but the Internet provides another powerful and efficient method of private ordering in the form of online word of mouth, such as online feedback or ratings.[257] Online word of mouth refers to the process of transmitting information from person to person on the Internet.[258] Broadly, it includes things such as blog posts and e-mail, but a particular, more focused type relating to user and product ratings and feedback has unique regulatory potential in the world of 3D printing.

Although traditional word of mouth has been around for centuries, online word of mouth dramatically reduces the costs of sharing views—one can reach one's entire social network via one Internet post—and extends the reach of those views—one can reach beyond one's social network to anyone on the Internet.[259] Online feedback provides valuable regulatory action by punishing the bad products and behaviors and promoting the good ones, sometimes circumventing contract-based and

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255. *See, e.g.*, Greg R. Vetter, *"Infectious" Open Source Software: Spreading Incentives or Promoting Resistance?*, 36 RUTGERS L.J. 53, 70–94, 160–61 (2004) (describing various open source licenses). Open source licenses can govern aspects beyond copyright, including patent rights. *See, e.g.*, *id.* at 87.

256. The relational contracts scholarship shows this effectively. *E.g.*, Stewart Macaulay, *Non-Contractual Relations in Business: A Preliminary Study*, 28 AM. SOC. REV. 55 (1963); Ian R. Macneil, *Restatement (Second) of Contracts and Presentiation*, 60 VA. L. REV. 589 (1974).

257. For a law-centric study of online word of mouth, see generally Eric Goldman, *Online Word of Mouth and Its Implications for Trademark Law*, *in* TRADEMARK LAW AND THEORY 404 (Graeme B. Dinwoodie & Mark D. Janis eds., 2008). Nonlegal literature has covered the topic much more thoroughly. *See, e.g.*, Chrysanthos Dellarocas, *The Digitization of Word of Mouth: Promise and Challenges of Online Feedback Mechanisms*, 49 MGMT. SCI. 1407 (2003); Qiang Ye et al., *The Impact of Online User Reviews on Hotel Room Sales*, 28 INT'L J. HOSPITALITY MGMT. 180 (2009).

258. Dellarocas, *supra* note 257, at 1407.

259. *See* Goldman, *supra* note 257, at 411.

mandatory regulation.[260] Norms play a strong role in this area, as they help determine good and bad ratings.

As discussed in Part III, 3D printing technology raises some unique concerns in areas such as product safety because it empowers millions of everyday people to become designers, manufacturers, and distributors. Online ratings provide a mechanism to reduce—though not eliminate—concerns about fraudulent or unsafe products. Online users who see or use an unsafe product can provide feedback directly to the original designer to help improve the product. Further, the online community can rate the product much like users rate smart phone apps and Amazon.com products. Products with low ratings and poor reviews are unlikely to sell or be downloaded.[261] Finally, the online community can rate and review the individual who posted the file—via the person's online identity. Buyers will likely avoid products and users with poor ratings.

Naturally, online feedback will not eliminate all harm. At least some consumers may be hurt before they know to rate a product negatively. Malicious users can constantly change their online identity to proliferate their abuses. And finally, online feedback can be faked, leading to false impressions of quality.[262] But overall, online word of mouth presents a powerful private regulatory tool that can reduce risks.

### 5. *Limits to Private Ordering*

Several limits to private ordering exist. Where significant externalities invoke the interests of parties outside of the contracts, private legal ordering will not be sufficient. A CAD file uploaded by a user may infringe another's trademark, patent, copyright or may represent a danger to the public—a gun, a bomb, or a defective device. Further, norms in the 3D printing ecosystem may not have developed sufficiently to direct behavior. Alternatively, various groups may hold competing norms, thus necessitating line drawing.

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260. *See* Shmuel I. Becher & Tal Z. Zarsky, *E-Contract Doctrine 2.0: Standard Form Contracting in the Age of Online User Participation*, 14 MICH. TELECOMM. & TECH. L. REV. 303, 322–32 (2008).

261. *See* Ye et al., *supra* note 257, at 181 (finding that in the hotel review context, negative online reviews affect online sales).

262. *See, e.g.*, Michael Learmonth, *As Fake Reviews Rise, Yelp, Others Crack Down on Fraudsters*, ADVER. AGE (Oct. 30, 2012), http://adage.com/article/digital/fake-reviews-rise-yelp-crack-fraudsters/237486.

When private ordering does not achieve the desired results, perhaps because of externalities or conflicting norms, governments often turn to positive laws.[263]

### *B. Legal Regulation*

As opposed to relatively spontaneous and flexible private ordering, regulation can happen through formal processes, such as the adoption of positive law. This subpart focuses largely on "legal" regulation, meaning regulation embodied primarily in federal and state codes and regulations, common law, and treaties—as opposed to private contracts, although these are heavily influenced by legal regulation.[264] Many times, norms, private ordering, and positive law interrelate in complex ways.[265] Regulation is complex in large part because in any given society—not to mention a collection of societies—different groups have different norms, different powers, and different goals.

For example, a utilitarian theory of tort law seeks to optimize the number of accidents by minimizing the sum of the costs of accidental harm and the costs of preventing the harm.[266] True, the law could further lower the number of accidents, but the costs of doing so might be too great from a utilitarian view.[267] One reoccurring difficulty with utilitarian views arises when obtaining the data regarding costs and benefits is difficult or impossible.[268] This difficulty does not demand that the society give up all pursuits of efficiency, only that it may not be able to completely explain or shape the law on efficiency grounds.[269] Other groups have different

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263. *See* Niva Elkin-Koren, *What Contracts Cannot Do: The Limits of Private Ordering in Facilitating a Creative Commons*, 74 FORDHAM L. REV. 375, 407–22 (2005).

264. Goldsmith, *supra* note 6, at 1216; *see also* U.C.C. § 1-304 (2012) (imposing an obligation of "good faith" in the performance and enforcement of each contract under the code); RESTATEMENT (SECOND) OF CONTRACTS § 205 (1981) (imposing a "duty of good faith and fair dealing" in the performance and enforcement of each contract).

265. *See, e.g.*, Timothy R. Holbrook, *The Expressive Impact of Patents*, 84 WASH. U. L. REV. 573, 591–93 (2006) (discussing how legal regimes express social norms); Hubbard, *supra* note 249, at 390–98 (same).

266. *See, e.g.*, Guido Calabresi, *The Decision for Accidents: An Approach to Nonfault Allocation of Costs*, 78 HARV. L. REV. 713, 717 (1965).

267. *See id.* at 716 (describing accident law as, in part, a "decision balancing lives against money or convenience"). This view must of course place a value on things, such as human life and is not without critics. *See, e.g.*, Charles Fried, *The Value of Life*, 82 HARV. L. REV. 1415, 1416, 1418–19 (1969). Similarly, the economic theory of criminal law seeks not to reduce crime to zero but rather to minimize the sum of the costs of crime and its prevention. *See* Richard A. Posner, *An Economic Theory of the Criminal Law*, 85 COLUM. L. REV. 1193, 1195 (1985).

268. *See* ROBERT P. MERGES, JUSTIFYING INTELLECTUAL PROPERTY 2–3 (2011).

269. *Id.* at 5–6.

foundations and may view aspects of the law through a lens of natural rights—religious or secular—deontology, and virtue ethics, to name only a few.[270]

This Article's goal is to avoid entering normative debates on the superiority of any particular foundation. Rather, the Author acknowledges that these differing views and notes will affect one's approach to regulation. Regardless of the foundation used, laws can be divided into two primary categories: default laws and mandatory laws. Default laws are those that operate as defaults unless the parties agree otherwise.[271] Parties may choose to contract around them, though sometimes the law requires parties to do so very clearly. Mandatory laws, on the other hand, may not be contracted around.[272]

### *1. Default Rules*

The law often creates default rules in an effort to achieve some normative goal, such as to supply terms that the parties would—or perhaps the law thinks *should*—have agreed to had they taken the time to think about it.[273] Default rules are most widely studied in the contract law context, where many such rules abound.[274] Sometimes legislatures create "penalty default rules," which are rules that are not necessarily what the parties would have chosen but are rules that the legislature believes will have some

270. *See e.g.*, Chapin F. Cimino, *Virtue and Contract Law*, 88 OR. L. REV. 703 (2009); A. John Simmons, *Liberties and Markets*, 92 VA. L. REV. 1625 (2006).

271. *See infra* Part IV.B.1.

272. *See infra* Part IV.B.2.

273. *See* Ian Ayres & Robert Gertner, *Filling Gaps in Incomplete Contracts: An Economic Theory of Default Rules*, 99 YALE L.J. 87, 87, 89–91 (1989). Default rules could have other goals, such as achieving an efficient result or pursuing distributive justice. *See, e.g.*, Ofer Grosskopf, *Dividing the Surplus upon Termination: The Case of Relational Contracts*, 48 AM. BUS. L.J. 1, 25 (2011).

274. *See, e.g.*, U.C.C. § 2-305 (2012) (providing a "reasonable price" default if the parties do not specify a price); *id.* § 2-306(2) (pronouncing that a party must use "best efforts" in exclusive dealing contracts unless otherwise agreed); *id.* § 2-309(1) (providing a "reasonable time" default for delivery if the parties do not specify one); *id.* § 2-314(1) (implying a warranty of merchantability in a sale by a merchant unless excluded or modified); *id.* § 2-315 (implying a warranty of fitness for a particular purpose unless excluded or modified).

perceived salutary effect, such as addressing paternalistic concerns[275] or forcing parties to share information.[276]

Default rules in contract law can have important consequences for the 3D printing ecosystem where many amateurs may outline only the most basic contract terms and fail to provide for contingencies. Moreover, as previously discussed, the UCC implies warranties of merchantability and against infringement when the seller is a merchant with respect to goods of the kind.[277] Unless specifically disclaimed, these default warranties place increased risk on the seller. Other significant default rules include those governing the recovery of damages.[278]

Default rules appear in other areas of law besides contract law.[279] Tort liability, such as negligence, is a type of default rule around which parties can sometimes contract.[280] This has important consequences in the 3D printing ecosystem, as donors and sellers of CAD files will want to protect themselves from liability. Intellectual property rights represent a type of default rule because the owner of the intellectual property rights may choose to limit the owner's rights in whole or in part. This is an increasingly common phenomenon in open source and Creative Commons licenses, where parties grant limited downstream uses of their intellectual property rights to any who agree to the terms.[281]

The presence of default rules is important for an emerging technology such as 3D printing. Default rules channel behavior and consequences and present a structure around which parties can base their expectations. Yet they also permit parties to craft their own rules when desired. This flexibility is paramount in the fast-changing and uncharted world of 3D

275. Colin Camerer et al., *Regulation for Conservatives: Behavioral Economics and the Case for "Asymmetric Paternalism,"* 151 U. PA. L. REV. 1211, 1224–30 (2003).

276. Ayres & Gertner, *supra* note 273, at 91. *But see* Eric A. Posner, *There Are No Penalty Default Rules in Contract Law*, 33 FLA. ST. U. L. REV. 563 (2006) (arguing that there are no true penalty default rules in contract law).

277. *See supra* notes 123–28 and accompanying text.

278. Section 2-719(1) of the UCC provides that parties "may provide for remedies in addition to or in substitution for those provided in this Article and may limit or alter the measure of damages recoverable under this Article." U.C.C. § 2-719(1) (2013). But section 2-719(3) restricts any attempted limitations of damages that are "unconscionable" and specifically states that any limitation of "consequential damages for injury to the person in the case of consumer goods is prima facie unconscionable." U.C.C. § 2-719(3) (2013).

279. For a discussion of default rules in statutory interpretation, see Einer Elhauge, *Preference-Eliciting Statutory Default Rules*, 102 COLUM. L. REV. 2162 (2002).

280. *See, e.g.*, Kelly v. United States, 809 F. Supp. 2d 429, 437–38 (E.D.N.C. 2011) (holding that a waiver of liability by a parent of a minor Navy Junior Reserve Officer Training Corps cadet was effective in releasing the United States from liability for the minor's injuries sustained during a visit to a marine base).

281. *See supra* note 255 and accompanying text.

printing. Permitting the parties to craft their own rules and expectations will allow this technology to grow and mature.

Flexibility is important, but parties cannot circumvent all the rules, even if they want to. Some rules will trump the intent of the parties. The next subpart explores these mandatory rules.

### *2. Mandatory Rules*

The law creates mandatory rules for reasons similar to default rules: paternalistic instincts, concerns for third parties—externalities—and international obligations.[282] Lawmakers will need to determine which of the existing mandatory rules should apply to 3D printing and whether they need to create additional rules to govern 3D printing. These determinations will affect the rate at which 3D printing can evolve.

Some mandatory rules are so woven into the law's fabric that they will clearly apply without modification to the world of 3D printing. For example, contract law includes requirements for contractual age of majority,[283] the obligation of good faith in the performance and enforcement of contracts,[284] and the doctrine of unconscionability.[285] There is no apparent reason to modify these rules for the sake of 3D printing.[286]

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282. Ayres & Gertner, *supra* note 273, at 88; *see also* Migratory Bird Treaty Act of 1918 (codified at 16 U.S.C. §§ 703–712 (2012)) (mandating conservation measures for certain migratory bird species in accordance with international treaty).

283. *See* RESTATEMENT (SECOND) OF CONTRACTS § 14 (1981).

284. U.C.C. § 1-304 (2013) (good faith generally); *see also id.* § 1-302 ("Except as otherwise provided . . . , the effect of provisions of [the UCC] may be varied by agreement . . . . The obligations of good faith, diligence, reasonableness, and care . . . may not be disclaimed by agreement.").

285. Terms of a contract may be invalid because they are unconscionable. For example, the doctrine of unconscionability can prevent some waivers of liability. *Id.* § 2-719(3) ("Consequential damages may be limited or excluded unless the limitation or exclusion is unconscionable. Limitation of consequential damages for injury to the person in the case of consumer goods is prima facie unconscionable but limitation of damages where the loss is commercial is not.").

286. Some of the mandatory rules are actually flexible. A parent can sign on behalf of a minor. *E.g.*, Hohe v. San Diego Unified Sch. Dist., 274 Cal. Rptr. 647, 649 (Ct. App. 1990). And, although parties cannot disclaim the obligation of good faith, "[t]he parties, by agreement, may determine the standards by which the performance of [good faith] is to be measured if those standards are not manifestly unreasonable." U.C.C. § 1-302(b) (2013).

Other mandatory rules, if applied to 3D printing, may have a more direct impact on its growth. Strict products liability is such a rule.[287] By shifting risk to the seller, strict products liability may have a chilling effect on the millions of individuals who would otherwise design and share CAD files.[288] Their creativity and ingenuity would be lost for fear of crushing liability. On the other hand, some may welcome this chilling effect, arguing that a liberal imposition of strict products liability will instill a culture of safety and wise circumspection in an otherwise reckless frontier. Whichever argument is believed might determine whether a CAD file should be a product under strict products liability doctrine.[289]

The ability of 3D printers to manufacture guns creates significant external effects, thus inviting mandatory rules. Existing rules, such as those prohibiting the sale or transfer of firearms to convicted felons,[290] would apply equally to 3D printed guns. But as discussed in Part III.D, the law may require additional default rules to cope with the reality of CAD files that can print weapons.

In the regulation of guns, as with any area of law, lawmakers must be careful to tailor mandatory rules to limit unintended consequences. To the extent lawmakers' paternalistic instincts and understandings of externalities are accurate, carefully crafted mandatory rules will benefit society as a whole.[291] But the uncertainties attending an evolving technology increase the likelihood that their instincts and understandings will be inaccurate, leading to unforeseen results.[292]

Thus, lawmakers and judges must exhibit proportionally more care when adopting mandatory rules because such rules have the enhanced potential to stifle innovation.

### *C. Code as Regulation*

In addition to laws, computer architecture and software—collectively referred to as "code" by theorists—operate in a regulatory fashion as a substitute for the legal regime.[293] At a fundamental level, the technological limits of machinery, for example, the inability of a 3D printer to print a Rolex watch, are a form of code.[294] More pertinently, code-based regulation

287. A party cannot contract around strict products liability. *See supra* note 86.
288. *See* Shepherd, *supra* note 78, at 289.
289. *See supra* Part III.B.1.
290. *See supra* note 165 and accompanying text.
291. *See* Omar M. Dajani, *Contractualism in the Law of Treaties*, 34 MICH. J. INT'L L. 1, 17–25 (2012).
292. *See supra* note 249 and accompanying text.
293. LAWRENCE LESSIG, CODE AND OTHER LAWS OF CYBERSPACE 89 (1999).
294. *See id.* (describing code as "a set of constraints on how you can behave").

can come in the form of self-help.[295] Consider the cell phone carriers that did not want their customers taking a proprietary phone, such as an iPhone, to another carrier. Rather than lobbying for a law preventing the act, the carriers relied on code to "lock" cell phones into working with only a single carrier.[296] An additional example comes from the music industry's use of Digital Rights Management (DRM) to prevent the copying and transferring of MP3 files.[297] DRM served as a substitute for—and extension of—copyright law.[298]

Groups can use code for regulatory purposes in the 3D printing context. Intellectual property rights holders can embed CAD files to prevent their copying, modification, and distribution. 3D printers can contain software that prevents certain files from being printed, such as those containing—or lacking—a certain identification code. Further, code may be used to monitor or spy on the activities of 3D printers or online users.[299]

In addition to acting as law, code can be used to circumvent regulations, such as when a hacker anonymously circulates a copyrighted song or cracks DRM. Of course, rights holders do not like it when others circumvent their code, and thus, the rights holders will upgrade their technology

295. *See, e.g.*, Tom W. Bell, *Escape from Copyright: Market Success vs. Statutory Failure in the Protection of Expressive Works*, 69 U. CIN. L. REV. 741 (2001); Kenneth W. Dam, *Self-Help in the Digital Jungle*, 28 J. LEGAL STUD. 393 (1999); Jane C. Ginsburg, *Authors and Users in Copyright*, 45 J. COPYRIGHT SOC'Y 1 (1997).

296. Steven Musil, *Apple Sued over Deal Locking iPhone to AT&T Network*, CNET (Oct. 21, 2012, 2:00 PM), http://news.cnet.com/8301-13579_3-57536889-37/apple-sued-over-deal-locking-iphone-to-at-t-network/.

297. *See* Peter K. Yu, *Anticircumvention and Anti-anticircumvention*, 84 DENV. U. L. REV. 13, 14 (2006); Daniel James, *Digital Rights Management & Music: A Barrier to Creativity?*, SOUND ON SOUND (Aug. 2003), http://www.soundonsound.com/sos/aug03/articles/drm.htm. DRM can prevent or limit certain actions, such as copying a CD or file. *See id.* Concerns about DRM include constraints on free speech, upsetting the balance provided in the copyright regime, and harm to computers. *See* Yu, *supra*, at 19–22, 24 n.48, 61–62.

298. DRM is more strict than copyright law. For instance, it does not have an exception for fair use. *See* Yu, *supra* note 297, at 19–22.

299. *See, e.g.*, Megan M. LaBelle, *The "Rootkit Debacle": The Latest Chapter in the Story of the Recording Industry and the War on Music Piracy*, 84 DENV. U. L. REV. 79 (2006) (analyzing the legal implications of Sony's DRM regime, including the covert installation of a "rootkit" on a user's computer that created a potential for security breaches and spying).

or enlist the legal machinery to protect them further.[300] I discuss this and other regulatory competition phenomena in more detail in the next subpart.

### *D. Responses to Regulation*

Norms, contracts, online feedback, default and mandatory rules, and code can all act in a regulatory manner. But what about when people do not like a regulation? They can choose to respond by obeying, changing, or breaking the regulation. If they break the regulation, they usually seek to avoid sanctions.

#### *1. Obedience*

Why might someone choose to obey the law or other regulation? An oversimplified utilitarian model of the law suggests that groups obey laws when the expected costs of the remedy or punishment—calculated based on the likelihood of being searched for, caught, and prosecuted or sued and the actual remedy or punishment rendered—outweigh the expected benefits of the prohibited behavior.[301] The model predicts that a criminal will steal if the criminal thinks the money is worth the risk of a fine or jail time and a manufacturer will not invest in safety precautions if the costs of doing so are higher than the expected tort remedy.

But it is clear that the utilitarian model does not account for all obedience to the law; normative issues matter. Indeed, as Professor Tom R. Tyler concluded in his seminal book, "People obey the law because they believe that it is proper to do so."[302] People obey laws for a variety of reasons, such as internalized ethics, fear of nonlegal sanctions, and signaling purposes.[303]

300. *See infra* notes 306–309 and accompanying text. This is what happened with the anticircumvention provisions of the DMCA. *See* 17 U.S.C. § 1201 (2012); YiJun Tian, *Problems of Anti-Circumvention Rules in the DMCA & More Heterogeneous Solutions*, 15 FORDHAM INTELL. PROP. MEDIA & ENT. L.J. 749, 762 (2005) ("It seems that Hollywood and its allies won this battle when they successfully persuaded Congress to pass the broad anti-circumvention rules.").

301. *See, e.g.*, RICHARD A. POSNER, ECONOMIC ANALYSIS OF LAW 242 (5th ed. 1998).

302. TOM R. TYLER, WHY PEOPLE OBEY THE LAW 178 (2006). Numerous theorists have explored the role of norms in compliance. *See, e.g.*, Robert C. Ellickson, *Law and Economics Discovers Social Norms*, 27 J. LEGAL STUD. 537 (1998); Steven Hetcher, *Creating Safe Social Norms in a Dangerous World*, 73 S. CAL. L. REV. 1 (1999); Richard H. McAdams, *The Origin, Development, and Regulation of Norms*, 96 MICH. L. REV. 338 (1997); Eric A. Posner, *Law and Social Norms: The Case of Tax Compliance*, 86 VA. L. REV. 1781 (2000).

303. *See* Wu, *supra* note 15, at 723 (citing ELLICKSON, *supra* note 244, at 124–26; Robert D. Cooter, *Decentralized Law for a Complex Economy: The Structural Approach to Adjudicating the New Law Merchant*, 144 U. PA. L. REV. 1643, 1661–66 (1996); Eric

If people perceive a law as immoral or illegitimate, they are less likely to follow it.[304] For example, a "Robin Hood" norm suggests that when groups strongly dislike the beneficiary of a given law, or think the beneficiary undeserving, they will be more willing to break the law. A familiar example from the copyright wars demonstrates this principle: many people saw the recording industry as greedy, dishonest, and bullying and thus, saw less legitimacy in laws benefiting the industry.[305]

In essence, because a jurisdiction's population holds varied norms and self-interests, they will sometimes disagree with regulations or want additional regulations. Sometimes the disagreement results in nothing more than grumbling conformity. At other times, the disagreement results in breaking a law with impunity. Usually, however, the population will choose more subtle paths: One method is to change the regulation. Another is to break the rule but to try to avoid sanctions.

### *2. Change and Avoidance*

When groups are faced with regulatory environments they do not like, they can try to change them. Two primary ways to effect change are litigation and lobbying.[306] For example, groups can use litigation to challenge laws they believe are unconstitutional. Or they can lobby lawmakers to change or adapt the law. But lobbying and litigation require a lot of time and money, and groups can suffer from collective action problems, as demonstrated by the public choice literature.[307] Assuming sufficient resources, small but focused groups can often change the law in ways disproportionate to their size because they can overcome the collective action problems.[308] Larger, more diffuse groups often struggle to effect change because they are often less motivated per capita and each member may try to free ride off others' efforts.[309]

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A. Posner, *Symbols, Signals, and Social Norms in Politics and the Law*, 27 J. LEGAL STUD. 765, 766–77 (1998)).

304. *See* TYLER, *supra* note 302, at 178.

305. *See* Peter K. Yu, *P2P and the Future of Private Copying*, 76 U. COLO. L. REV. 653, 668–69 (2005).

306. Einer R. Elhauge, *Does Interest Group Theory Justify More Intrusive Judicial Review?*, 101 YALE L.J. 31, 35–44 (1991).

307. *See id.* at 36.

308. *Id.* at 35–39.

309. *Id.*

However, groups may feel they are unable to change a law because they lack the resources to lobby or cannot organize members of the group effectively. In these situations, groups may choose to circumvent the regulation and engage in avoidance strategies. Laws often get in the way of what self-interested people want. For example, laws against theft prevent me from taking DVDs without paying for them. If I do not want to obey the law and I do not think I can change the law, I can break the law and seek to avoid punishment.

Two methods of avoidance are avoision and evasion. Avoision is exploiting some loophole in the law by engaging in behavior that is contrary to the law's intent but is not unlawful, such as convincing my teacher to show the DVD in class as an educational experience when it is not truly educational.[310]

Evasion, on the other hand, is when I attempt to avoid punishment after breaking the law.[311] If I really value the DVD, perhaps I am willing to steal it and try to avoid punishment by lowering the chances of detection, by wearing a large coat to conceal the purloined DVD, or lowering the chance of enforcement if I am detected, by offering bribes or intimidating witnesses.[312]

Avoidance strategies do not suffer from the collective action problem posed by change mechanisms. When someone uses a mask to rob a bank, only that person benefits. Hence, individuals can unilaterally employ avoidance strategies without others free riding on the benefits.[313] The ability to overcome collective action problems has significant impacts in areas where people can use technology—code—as a means of evasion, not least because third parties can sell avoidance mechanisms to diffuse groups who can then employ them.[314]

Code helps with evasion in several ways. At a basic level, the fact that much illegal activity can be done in the home using computers lowers the threat of detection, at least when compared with stealing from a store or purchasing from a counterfeit store. At a more technical level, code can be used to hide a person's identity on the Internet[315] or to crack code-

310. Wu, *supra* note 15, at 692 (quoting Ronald Turner, *Reactions of the Regulated: A Federal Labor Law Example*, 17 LAB. LAW. 479, 479 (2002)). A familiar example is exploiting tax loopholes.

311. *Id.*

312. *See id.*

313. *Id.* at 698.

314. *Id.* at 699.

315. Yu, *supra* note 305, at 677.

based regulations employed by others, such as DRM.[316] In response, the code-based regulators develop new code to control their products, which consumers then avoid, and so on in a regulatory arms race.[317]

To summarize, Part IV has outlined a regulatory approach and situated it in the context of 3D printing. The next Part applies the framework to 3D printing, providing insight into ways forward and highlighting regulatory battles to come.

## V. REGULATING BITS AND ATOMS

At the outset, policymakers should recognize that regulating the 3D printing ecosystem will be a complex undertaking because the technology affects so many industries, laws, and policies. Despite the complexity of the task, policymakers should decide early on whether they believe 3D printing is, on the whole, positive or negative. That high-level determination should then guide regulation, helping to determine how to structure the regulation and what to do at the margins when competing policies obfuscate the way forward.

This Article has looked at many of 3D printing's potential benefits and risks, though it is impossible to foresee them all. Recall that the leading technology companies in the 1960s could not fathom what use a home computer would have—the best they came up with was that computers might be used for recipe management.[318] In the same way, 3D printing will have uses we cannot imagine today.

Nevertheless, some potential benefits are fairly certain. Just to review a few, the technology should lead to (1) the "reshoring" of some manufacturing from abroad; (2) increases in creativity and innovation as individuals and small businesses have in-house manufacturing and design capabilities; (3) medical and high-technology advances; (4) improved consumer experiences from product customization; and (5) positive environmental effects from local production, efficient manufacturing, and lighter weight products.[319] Against these benefits must be considered

316. *E.g.*, Susana Polo, *Ubisoft's* Assassin's Creed 2 *DRM Has Been Cracked*, GEEKOSYSTEM (Apr. 23, 2010, 12:57 PM), http://www.geekosystem.com/assassins-creed-2-drm-crack-ubisoft.

317. *See* Yu, *supra* note 305, at 721–24. Regarding the technological arms race, see also Raymond Shih Ray Ku, *The Creative Destruction of Copyright: Napster and the New Economics of Digital Technology*, 69 U. CHI. L. REV. 263, 319–20 (2002).

318. ANDERSON, *supra* note 10, at 56.

319. *See supra* Part II.B.

the potential negative impacts. These include, but are not limited to, (1) harmful environmental effects from chemicals used in 3D printing processes; (2) jobs lost to increasing automation; (3) trafficking of guns and other arms; (4) injuries from unsafe products; and (5) piracy of intellectual property.[320]

It is this Author's estimation that 3D printing's potential benefits outweigh its costs, in part because some of the costs can be controlled. This does not counsel for a headlong rush toward developing the industry at all costs, but it does suggest that lawmakers should be guided by an overall principle of encouraging 3D printing technology. This principle would exclude voices that might call for moratoriums or overburdensome regulations.

If it is accepted that 3D printing brings net benefits, two other aspects of 3D printing should inform regulation. First, the technology is changing fast. When an industry is rapidly evolving, a top-down regulatory framework is undesirable.[321] By the time the regulations are issued, they will be obsolete. Therefore, flexible forms of regulation, such as private ordering, should be preferred to default laws, and default laws to mandatory laws. In addition, the common law iterative approach should generally predominate over legislative pronouncements.[322]

Second, regulation should be guided by the realization that 3D printing technology cuts across numerous industries and laws. 3D printing's broad impact means that a universal set of 3D printing legislation is unfeasible.[323] It follows that any legislation that is adopted should, in general, be narrowly tailored and flexible, targeting specific problems and minimizing other consequences. This will prevent a singular concern, such as printing unregistered weapons or intellectual property piracy, from handcuffing the entire industry.

In summary, 3D printing policy should be guided by three overarching principles: First, on the whole, regulators should encourage the technology. Second, regulators should generally favor flexible, low-level solutions, such as private ordering instead of rigid top-down legislation. Finally,

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320. *See supra* Part III.

321. Hardy, *supra* note 248, at 1025 (noting that the rapid growth of cyberspace counseled against inflexible and uniform regulation).

322. There will always be exceptions to these guidelines. For one, legislative action might be preferable to address a significant, identifiable harm. Moreover, legislative action might be needed if the common law system seems to be impeding rather than fostering the technology.

323. *See* Gregory Mandel, *Nanotechnology Governance*, 59 ALA. L. REV. 1323, 1363 (2008) (arguing that one-size-fits-all regulation would be infeasible for nanotechnology because it cuts across many industries and sciences).

any legislation should be narrowly tailored, targeting specific problems while leaving the remainder of the industry free to grow.

### *A. The Political Economy of 3D Printing*

An understanding of the regulatory forces that will act on the 3D printing ecosystem would benefit from detailed applications of public interest and private interest regulatory theories.[324] On the private interest side, it is helpful to identify and understand the political economy of 3D printing. Studies of political economy, a branch of public choice theory,[325] look at regulation through the lens of supply and demand and assume the participants are self-interested.[326] A full study of the political economy of 3D printing cannot be undertaken here. Rather, this Article outlines the major interest groups to shed light on regulatory strategy.

At a first level, the theory predicts that those who will be harmed—or think they will be harmed—by 3D printing will seek to oppose or limit 3D printing, while those who benefit will do the opposite. Groups who see either no effect or balanced effects will tend to be indifferent. In addition, the magnitude of the benefits or harms matters. Those who incur greater benefits or harms will be correspondingly more motivated to act. Finally, each group's ability to organize plays a role in the theory: unified and well-organized groups will be more effective lobbyists than fractured and unorganized groups.

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324. Interest group theory involves two primary branches. Private interest theory—more often referred to, somewhat confusingly, as public choice theory—uses economic tools to model the political process, assuming the relevant groups act in their own self-interest. *E.g.*, Anne O. Krueger, *The Political Economy of the Rent-Seeking Society*, 64 AM. ECON. REV. 291 (1974); George J. Stigler, *The Theory of Economic Regulation*, 2 BELL J. ECON. & MGMT. SCI. 3 (1971). Public interest theory generally explains regulation as a means to achieve collective goals, such as wealth redistribution, justice, or other group concerns. *E.g.*, CASS R. SUNSTEIN, AFTER THE RIGHTS REVOLUTION: RECONCEIVING THE REGULATORY STATE (1990); Edward L. Rubin, *Beyond Public Choice: Comprehensive Rationality in the Writing and Reading of Statutes*, 66 N.Y.U. L. REV. 1 (1991).

325. Recall from Rubin, *supra* note 324, at 1, that "public choice" theory is actually a private interest theory. Its confusing name comes from the conception of public actors, such as members of Congress, acting in their own private interest to get reelected.

326. Under the theory, regulation is likely to be adopted when pushed by—but not opposed by—a concentrated, and wealthy, interest group that will benefit greatly from the legislation. Opposition to the legislation is likely to fail if the costs of the regulation are small per capita or are imposed on groups that are widely dispersed and unable to organize. WILLIAM M. LANDES & RICHARD A. POSNER, THE POLITICAL ECONOMY OF INTELLECTUAL PROPERTY LAW 10–11 (2004).

Because 3D printing affects so many industries, there are likely to be several groups on each side of the benefit-harm divide. Many of these groups, depending on the intensity of their interest, may cancel each other out. For example, certain groups, such as law enforcement officials and gun opponents, will fear 3D printing's potential for gun proliferation.[327] This rather intense set of interest groups will likely be countered by an equally passionate set of groups, such as advocates for gun rights.[328]

Some camps may be internally divided on the issue. Even the National Rifle Association (NRA) and other progun groups may be unsure how to respond to 3D printing. Gun manufacturers may fear losing sales to 3D printed guns. The NRA may face an internal battle: it has consistently been an advocate for gun rights, but gun manufacturers largely fund the organization.[329] Likewise, environmental groups may be unsure whether to embrace the potential benefits of local and efficient manufacturing—and the corresponding lower environmental impact—or whether to oppose the risks of printer emissions and numerous throwaway printed objects. Labor groups may be divided on whether 3D printing should be opposed on the basis of increased automation or embraced in hopes of new software, design, and 3D printer repair jobs.

One strongly organized group will be intensely intimidated by 3D printing: net producers of intellectual property—at least those who produce 3D goods.[330] A net intellectual property producer is a company that, on the whole, makes more money from selling intellectual property rights, either as products or as licenses to rights, than it spends obtaining intellectual property rights from third parties.[331] Movie companies, record labels, and luxury goods manufacturers represent net intellectual property producers. Although they may sometimes consume intellectual property, such as a movie company paying to obtain rights to make a movie from

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327. *See* Christopher J. Ferguson, *3-D Printed Guns Are a Boon for Criminals*, CNN, http://www.cnn.com/2013/05/07/opinion/ferguson-printable-gun (last updated May 7, 2013, 7:28 AM).

328. *See infra* Part V.C.3.

329. Walter Hickey, *How the Gun Industry Funnels Tens of Millions of Dollars to the NRA*, BUS. INSIDER (Jan. 16, 2013, 1:25 PM), http://www.businessinsider.com/gun-industry-funds-nra-2013-1.

330. Some net producers may not feel threatened by 3D printing. Pharmaceutical companies, for example, may think their products are safe from 3D printing competition. But even they should be wary: Many predict 3D printers will eventually "print" pharmaceutical compounds. *See DIY Drugstores in Development at the University of Glasgow*, UNIV. GLASGOW (Apr. 16, 2012, 9:20 AM), http://www.gla.ac.uk/news/headline_230503_en.html.

331. *See, e.g.*, Gregory N. Mandel, *Proxy Signals: Capturing Private Information for Public Benefit*, 90 WASH. U. L. REV. 1, 19–33 (2012); Lucas Osborn, *Foreword: Globalization, Intellectual Property, and Prosperity*, 34 CAMPBELL L. REV. 517, 520–21 (2012).

a book, on the whole they make money based on having strong intellectual property protection.[332]

Intellectual property producers likely to fear 3D printing are those whose goods might be pirated by 3D printers. These include luxury brand makers; entertainment and toy companies whose products are protected by copyright and trademark; patent holders whose goods—or key components thereof—are simple enough to be 3D printed; and replacement part manufacturers. These groups will want to protect themselves by slowing the development of 3D printing or controlling it to minimize their exposure.

On the other side from those who fear 3D printing, several groups will work together to promote 3D printing. The most intensely interested groups will be the 3D printing manufacturers themselves. Joining them will be companies whose business models center on 3D printing, such as rapid prototyping companies and open design companies. Although these groups will match the intellectual property producers' intensity, they are unlikely as yet to match their economic might. In 2012, the 3D printing industry's revenues were around $1 billion.[333] By comparison, the luxury goods market—just one of the net intellectual property producers—was worth approximately $273 billion in 2012.[334]

Joining the 3D printing companies will be several groups that have somewhat milder economic incentives to promote 3D printing, milder because it is not a core technology for them. These groups will include the scientific and medical industries, including researchers, which foresee many applications for 3D printing.[335] Various Internet-based companies may join in: they tend to oppose overzealous intellectual property regulation because it can impose costs on them in the form of secondary liability or monitoring costs.[336]

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332. Other companies are more balanced in their consumption and production of intellectual property. These companies will have less intense interests in technologies that affect intellectual property. *See* Mandel, *supra* note 331, at 32–33.

333. *3D Printing: Industrial Revolution or Renovation?*, AZOM (June 13, 2013) (citing WENDY KNEISSL, IDTECHEX, 3D PRINTING 2013–2025: TECHNOLOGIES, MARKETS, PLAYERS (2013)), http://www.azom.com/article.aspx?ArticleID=9204.

334. Astrid Wendlandt & Isla Binnie, *Global Luxury Goods Market To Cool in 2013: Bain*, REUTERS (May 16, 2013, 9:26 AM), http://uk.reuters.com/article/2013/05/16/luxury-bain-idUKL6N0DX2E420130516.

335. *See, e.g.*, LIPSON & KURMAN, *supra* note 9, at 127–28 (describing several opportunities for "bioprinting").

336. Marc Andreesen et al., *An Open Letter to Washington*, SCRIBD, http://www.scribd.com/doc/75746065/Open-Letter-to-Washington-SOPA-and-PIPA (last visited Apr.

Finally, individual 3D printer users, including those in the "Maker Movement" and do-it-yourself (DIY) movement,[337] will oppose anything that will hinder 3D printing's development. Although they are a disparate group, and therefore typically not effective lobbyists, they are a smaller and more organized group than the huge group of music listeners—many of whom were teenagers—who battled the copyright industries in the Napster era.[338] Further, they use the Internet and code effectively and thus, can either organize well to lobby for change or use code to effect change.

Having outlined who the powerful and well-organized interest groups are, the next subpart looks at how those groups might attempt to use change mechanisms to achieve their interests.

### *B. Regulatory Competition*

Because net intellectual property producers are one of the groups most intensely threatened by 3D printing, strong parallels exist between the likely future battles in 3D printing and the previous battles of the copyright industry against duplication technologies, such as the VHS machine and peer-to-peer networks.[339] The copyright industry reacted vigorously to duplication technologies, but not all were successful.[340] Opponents of 3D printing should use a page of copyright history to substitute for a volume of logic.

The first lesson that the intellectual property producers should draw from history is that they cannot block 3D printing technology.[341] Litigation to enjoin production of 3D printers will fail just like efforts to stop sales of VHS machines failed in the 1980s.[342] The recording industry failed to obtain an injunction against VHS machines because the machines had

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28, 2014) (letter from Internet-based entrepreneurs and business founders encouraging Congress to vote down the Stop Online Piracy Act and the Protect IP Act).

337. Maker and DIY movements refer to groups of people using tools, digital or otherwise, who like to make things themselves rather than having others do it for them. ANDERSON, *supra* note 10, at 20–21. Chris Anderson describes the Maker Movement as a group of people who use digital tools, such as 3D printers, to create new products, have a culture of sharing and collaborating regarding those products, and use common design file standards. *Id.* at 21.

338. *See RIAA v. The People: Five Years Later*, *supra* note 219.

339. *See* Sony Corp. of Am. v. Universal City Studios, Inc., 464 U.S. 417 (1984); Nieva, *supra* note 192.

340. *E.g.*, *Sony Corp.*, 464 U.S. at 456 (finding that home use of a VHS player for "time-shifting" of television broadcasts did not constitute copyright infringement).

341. *See* Jane C. Ginsburg, *Copyright and Control over New Technologies of Dissemination*, 101 COLUM. L. REV. 1613, 1619 (2001) (noting copyright holders were unsuccessful when they attempted to block, rather than adapt to, a new technology).

342. *E.g.*, *Sony Corp.*, 464 U.S. at 420, 442, 456.

substantial noninfringing uses.[343] 3D printers, much more so than even VHS machines, have substantial noninfringing uses. These include making any public domain object and any original works of art. Hence, even opponents of 3D printing technology should realize the many noninfringing uses for 3D printers.[344]

Rather than trying to block a new technology completely, intellectual property producers may have better luck if they seek changes that will allow them some compensation or partial protection from the new technology.[345] In this regard, the music industry's fight against digital piracy gives insight into the regulatory battles to come. The peer-to-peer copyright battles have special salience for 3D printing because the technological advances that catalyzed them—digitization, the Internet, and peer-to-peer networks—are also highly relevant to 3D printing.

Copyright holders responded to digital piracy with code, lobbying, and litigation. Code-based mechanisms took the form of DRM measures that attempted to control how individuals could use their copyrighted digital files.[346] But these code-based mechanisms largely failed because consumers circumvented the DRM.[347] Undeterred, the music industry successfully lobbied to gain protections against the circumvention of DRM, as well as other protections, with the passage of the DMCA.[348] When the DMCA failed to handle newly developed peer-to-peer networks, the music industry turned to litigation efforts, suing hundreds of individuals who had downloaded copyrighted music without permission.[349]

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343. *Id.*

344. The same is true for those afraid of gun proliferation: 3D printers have a myriad of uses beyond printing guns, so courts would almost certainly not enjoin all 3D printers based on the fear of guns.

345. Ginsburg, *supra* note 341, at 1619–20, 1630.

346. See *supra* note 297 for a discussion of DRM.

347. *See* Andrew V. Moshirnia, *Giant Pink Scorpions: Fighting Piracy with Novel Digital Rights Management Technology*, 23 DEPAUL J. ART TECH. & INTELL. PROP. L. 1, 6 (2012) (citing Polo, *supra* note 316).

348. Digital Millennium Copyright Act, Pub. L. No. 105-304, 112 Stat. 2860 (1998) (codified as amended at 17 U.S.C. §§ 1201–1205 (2012)); Tian, *supra* note 300, at 762. Anticircumvention provisions are codified in 17 U.S.C. § 1201 (2012).

349. David Kravets, *Copyright Lawsuits Plummet in Aftermath of RIAA Campaign*, WIRED (May 18, 2010, 1:24 PM), http://www.wired.com/threatlevel/2010/05/riaa-bump.

For a while, it seemed that consumers could find no effective change mechanisms to match those of the content industry.[350] Without an effective change mechanism, music listeners relied largely on avoidance mechanisms, as discussed in the next subpart. Recently, however, the disparate groups of consumers have found new ways to battle the rights holders in the arena of regulatory change.

First, they have found allies in new, wealthy, well-organized Internet-based businesses such as Google. Among other results, this partnership resulted in the stunning roadblock to the passage of the Stop Online Piracy Act (SOPA) and the Protect IP Act (PIPA) in January 2012.[351] Technology companies and user-driven websites alike, such as Google, Reddit, and the English-language version of Wikipedia, feared harms to the Internet structure and free speech that SOPA and PIPA would bring—not to mention the increased costs of compliance.[352] To combat these laws, they used their vast social reach to encourage ordinary individuals to protest against SOPA, and some participants engaged in a "blackout" of their own sites, quickly stopping the bills in their tracks.[353]

Second, copyright consumers have used code to help them lobby for change. Technology allows even lone individuals to create online petitions and messages that can go viral, bringing public awareness to otherwise unseen political maneuvers.[354] Of course, not every rant or plea will go viral, and the net may sometimes engender weak efforts at activism, so-called slacktivism.[355] Nevertheless, technology gives individuals an improved means of advocating for change by lowering coordination costs and providing access to a wide audience.

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350. Opponents of copyright term extensions took cases all the way to the Supreme Court, but lost. *See* Golan v. Holder, 132 S. Ct. 873, 892–94 (2012); Eldred v. Ashcroft, 537 U.S. 186, 187 (2003).

351. David A. Fahrenthold, *SOPA Protests Shut Down Web Sites*, WASH. POST (Jan. 18, 2012, 6:00 AM), http://articles.washingtonpost.com/2012-01-17/politics/35439450_1_web-sites-english-wikipedia-reddit ("In the back offices of the Senate, many longtime aides were amazed at how quickly a new lobbying force had managed to outmaneuver experienced heavyweights.").

352. *Id.*

353. *Id.*

354. *See, e.g.*, Gregory Ferenstein, *How a Fired Republican Staffer Became a Powerful Martyr for Internet Activists*, TECHCRUNCH (Mar. 8, 2013), http://techcrunch.com/2013/03/08/how-a-fired-republican-staffer-became-a-powerful-martyr-for-open-internet/.

355. *E.g.*, Matthew Lasar, *Ralph Nader: Internet Not So Hot at "Motivating Action*,*"* ARS TECHNICA (May 12 2009, 7:55 AM), http://arstechnica.com/tech-policy/2009/05/ralph-nader-internet-not-so-hot-at-motivating-action/; Ethan Zuckerman, *Overcoming Apathy Through Participation?—(Not) My Talk at Personal Democracy Forum*, ETHAN ZUCKERMAN BLOG (June 3, 2010), http://www.ethanzuckerman.com/blog/2010/06/03/overcoming-apathy-through-participation-not-my-talk-at-personal-democracy-forum/.

In sum, the past copyright battles suggest that the intellectual property industry will seek to influence the law to protect its interests, but the 3D printing industry, together with its allies, will be able to employ change mechanisms of its own. Unlike the digital piracy battles, which involved mostly individuals against a wealthy, well-organized music industry, the 3D printing battles will include a well-organized, determined, and increasingly wealthy 3D printing industry. Hence, efforts by intellectual property producers to change the regulatory framework will be fiercely opposed at every turn.

Besides change mechanisms, however, avoidance mechanisms will be an important part of the 3D printing story, just as it was for the digital music story. The next subpart discusses these avoidance mechanisms.

### *C. Vulnerabilities to Code-Based Avoidance Mechanisms*

When change mechanisms are infeasible or undesirable, groups can participate in avoidance mechanisms. Recall that avoidance mechanisms do not suffer from the collective action problems that plague change mechanisms.[356] Thus, even the disparate individual users of 3D printing technology can employ avoidance mechanisms.

As discussed before, avoidance mechanisms include avoision and evasion.[357] Avoision, which is basically taking advantage of legal ambiguities,[358] can be accomplished utilizing the same strategies used in non-3D printing contexts. Illustrative examples include claiming fair use when using copyrighted material,[359] avoiding laws governing sales by structuring the transaction as a license,[360] framing a particular CAD file transaction as a service instead of a product to avoid strict products liability laws,[361] and structuring a transaction such that it occurs outside of the United States and in a jurisdiction where it is not illegal.[362]

356. Wu, *supra* note 15, at 698.
357. *See supra* notes 310–11 and accompanying text.
358. *See supra* note 310 and accompanying text.
359. *See* 17 U.S.C. § 107 (2012) (governing fair use).
360. Such laws include Article 2 of the UCC—governing the sale of goods—and intellectual property law's first sale doctrines, also referred to as exhaustion doctrines. *See, e.g.*, 17 U.S.C. § 109 (2012).
361. *See supra* note 311 and accompanying text.
362. For example, current law states that an unauthorized "offer to sell" a patented invention violates 35 U.S.C. § 271 only if the sale contemplated by the offer would occur in the United States. Transocean Offshore Deepwater Drilling, Inc. v. Maersk Contractors

But avoision is not likely to have as large an impact on 3D printing as evasion. Evasive techniques may be as simple as doing something you should not do in the privacy of your home to protect against detection. This is an important point when 3D printers become ubiquitous. The prohibited act may be printing an illegal gun or a copyrighted, patented, or trademarked file a user downloaded from the Internet. Alternatively, a user may upload an illicit file to the Internet that the user designed or scanned at home. Although detecting what individuals do on their 3D printers in the privacy of their homes is not impossible—electronic monitoring of Internet and 3D printer usage come to mind—it is difficult.

In addition to relying on the physical walls of their houses to avoid detection, users may attempt to utilize code-based avoidance strategies.[363] These include employing Internet anonymity—proxy servers or Internet aliases, to name a few—and circumventing digital rights management. But the success of code-based avoidance strategies will vary across different areas of the law. Determining where they might succeed in the 3D printing era would demonstrate areas for possible reform. For insight, one can again turn to the copyright battles against digital piracy.

Professor Wu highlighted that the success of code-based avoidance strategies against the copyright regime rested on two of the regime's weaknesses.[364] First, it depended on a gatekeeper enforcement mechanism in which copyright holders enforced the laws primarily against high-level intermediaries that engaged in massive copying.[365] This gatekeeper model proved impotent against massive decentralized copying ushered in by digitization and Internet-based, peer-to-peer networks such as Napster.[366] Second, the copyright regime suffered from a lack of normative support for laws against home-based, noncommercial copying for friends and family.[367] These structural and normative weaknesses facilitated massive infringement.

By following Professor Wu's model, one can attempt to predict whether 3D printing code-based campaigns might be successful against other legal regimes by looking for similar weaknesses in those laws.[368]

USA, Inc., 617 F.3d 1296, 1309 (Fed. Cir. 2010). Thus, companies can specify that their offers for sale will be consummated only outside of the United States.

363. Wu, *supra* note 15, at 707–08.

364. *Id.* at 711.

365. *Id.* at 711–13.

366. *Id.* at 716–17.

367. *Id.* at 713–15, 722–26.

368. It should be noted that the copyright regime remains susceptible to code-based attacks in the digital music context. *See supra* note 250. The same will be true in the 3D printing context.

### *1. Trademark Law Vulnerabilities to Code*

Trademark law relies on a gatekeeper enforcement mechanism in much the same way copyright does. Historically, creating counterfeit goods required investment in manufacturing equipment, the expense of which attracted only those who wanted to make numerous infringing goods to sell in stores and flea markets. Trademark owners have focused enforcement efforts on these manufacturers and the sellers, warehouses, and importers, rather than on the individual customer who bought the fake Louis Vuitton handbag.[369]

In addition to its gatekeeper weakness, trademark law will be vulnerable to code-based avoidance because it suffers from a normative weakness: many people do not think it is wrong to buy counterfeit goods, especially in the area of luxury goods.[370] How else can we explain the persistence of counterfeit sales that amount to as much as $600 billion annually worldwide?[371] Though studies vary, one study indicated that the primary reasons for not buying counterfeit goods are poor quality or lack of availability—neither of which would be true with 3D printing.[372] The study also indicated that personal values played only a strong role in avoiding the purchase of counterfeit goods in between twenty-two and forty-eight percent of people.[373] Moreover, normative arguments against counterfeit

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369. *See, e.g.*, *Anti-Counterfeiting Legal Strategies, Enforcement and Remedies*, GREER, BURNS & CRAIN, LTD., http://gbclaw.net/practiceareas/anti-counterfeiting (last visited Apr. 28, 2014) (describing enforcement procedures against counterfeiters).

370. *See, e.g.*, Susannah Edelbaum, *Dan Ariely Explains the Problem with Fake Fashion: Part One*, HIGH LOW (July 3, 2012, 9:55 AM) http://thehighlow.com/2012/07/dan-ariely-explains-the-particular-problem-with-fake-fashion-part-one/ ("I think for most people the intuitive definition of a cheater would not include someone wearing fakes.").

371. Meg Tirrell, *Fake Louis Vuitton Bags Look Fake Without a Tony Aura*, BLOOMBERG (Dec. 2, 2009, 4:12 PM), http://www.bloomberg.com/apps/news?pid=newsarchive&sid=a2goSFXqnqiw (stating $600 billion figure). Estimating the monetary effects of counterfeit goods is difficult, and the number could be lower. *See* U.S. GOV'T ACCOUNTABILITY OFFICE, GAO-10-423, INTELLECTUAL PROPERTY: OBSERVATIONS ON EFFORTS TO QUANTIFY THE ECONOMIC EFFECTS OF COUNTERFEIT AND PIRATED GOODS 19–26 (2010), *available at* http://www.gao.gov/new.items/d10423.pdf.

372. THORSTEN STAAKE & ELGAR FLEISCH, COUNTERING COUNTERFEIT TRADE 54 (2008).

373. *Id.*

luxury products—that they are made by exploited labor[374]—would have no force in a world of 3D printing, where the labor is not a person but a printer. Though current normative views toward counterfeiting may be somewhat more balanced than those toward downloading songs were in the Napster era, it remains to be seen how views will shift when anyone can print the goods for themselves in the comfort of their home.

Trademark law's gatekeeper enforcement mechanism and its lack of normative support for laws against purchasing counterfeit goods substantially mirror the weaknesses in the copyright regime in the Napster era. Decentralized peer-to-peer networks will allow individuals to obtain unlimited design files for luxury goods and even to make their own files. Based on these weaknesses, it is likely that trademark owners will face battles similar to those of the music industry once 3D printers can print quality counterfeit goods.

### *2. Patent Law Vulnerabilities to Code*

Patent law represents another regime that might have weaknesses code-based attackers can exploit. Patent owners often, but not always, rely on gatekeeper enforcement. When the patented good has a massive market, infringers will look to make large numbers of copies to recoup the manufacturing costs.[375] In such cases, patent holders will focus enforcement on the manufacturers and sellers, not the purchasers. Consider the smart phone patent battles: Millions of consumers use potentially infringing cell phones, but the patent holders have yet to sue the consumers. Rather, they sue the manufacturers, which are their competitors as well as the source of the alleged infringement.[376]

Whether patent law suffers from a normative weakness akin to that of copyright and trademark law is unclear. This Author is not aware of any studies indicating whether consumers would knowingly purchase counterfeit patented goods. Whereas consumers of trademarked goods are generally aware they are paying for a brand name, it is unlikely consumers of patented products pay significant attention to whether the goods are patented. Similarly, unlike with fake luxury goods, purchasers of patent-infringing consumer products are unlikely to be aware the goods are infringing.

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374. Dana Thomas, *Fight Against Fake Designer Goods Isn't Frivolous*, TODAY, http://www.today.com/id/28571321/ns/today-today_style/t/fight-against-fake-designer-goods-isnt-frivolous/#.UffVPxarjww (last updated Jan. 9, 2009, 9:38 AM).

375. Some patented goods are large and complex. Infringers still copy these products but generally not on a massive scale.

376. Sascha Segan, *Infographic: Smartphone Patent Wars Explained*, PC MAG (Jan. 19, 2012, 2:46 PM), http://www.pcmag.com/article2/0,2817,2399098,00.asp.

Although the patent regime suffers from a gatekeeper enforcement weakness in the case of mass-produced, patented goods, it is not clear whether it suffers from a normative weakness. To the extent it does not suffer from a normative weakness, 3D printing will pose less of a piracy threat to the patent regime than to the copyright and trademark regimes. Additional research into consumers' normative views on patented products and counterfeits would shed light on this issue.

### *3. Gun Control Vulnerabilities to Code*

Code-based attackers will also seek out vulnerabilities in the criminal law regime. Criminal law does not rely heavily on gatekeeper enforcement mechanisms the way trademark law and copyright law do. Although police are certainly happy to find a large shipment or a warehouse containing illegal weapons, authorities will not hesitate to pursue individuals—unlike in the intellectual property world, the individuals are not the customers. But the U.S. criminal law system has several weaknesses opening it up to code-based avoidance strategies.

The largest potential vulnerability involves domestic firearms manufacturing and distribution. Unlike import and export-based laws, which regulate schematics and the like, domestic manufacturing and distribution laws regulate only physical firearms.[377] By failing to regulate schematics, most domestic-based laws will not apply to CAD files at all. This leaves a gigantic loophole in a world where bits and atoms are interchangeable.

The U.S. firearm-control system's additional weakness is that its laws designed to facilitate firearm tracing[378] require manufacturers[379] only to engrave a serial number on the "receiver or frame" of any firearm.[380] The receiver, also referred to as the frame, houses the firearm's operating parts, such as the trigger. It can be made of 3D printable plastic, whereas

377. *See supra* Part III.D.1.

378. Serial number tracing helps authorities to prove a gun has been a part of a prohibited action, such as travelling across state lines—an element in many federal gun offenses. *See, e.g.*, 18 U.S.C. § 922(g) (2012) (prohibiting certain people with criminal records from possessing any firearm that has traveled in interstate commerce). It is illegal to deface a serial number and to knowingly transfer in weapons with a defaced serial number. *Id.* § 922(k).

379. Recall that the federal licensing and serial-marking requirements do not cover an individual making a gun for personal use. *See supra* note 158 and accompanying text.

380. 18 U.S.C. § 923(i) (2012).

parts that need to withstand high pressures and temperatures, such as the barrel, are harder to make in plastic.[381] Other parts of the gun, such as a barrel, can be sold or transferred without restriction.[382] Thus, even a felon can freely acquire firearm parts other than the receiver. If a felon then obtains a CAD file for a receiver, the felon can print it in privacy—or can buy a printed receiver from someone else who is willing to break the law—and combine the parts personally.

On the normative side, laws against making and transferring illegal guns will not impress most criminals—almost by definition. In addition to criminals, many law-abiding citizens feel strongly about the Second Amendment right to bear arms and may support many aspects of 3D printed weapons.[383] Those who feel strongly about the issue may be willing to circumvent laws governing firearm manufacturing and distribution even if they do not contemplate additional crimes.

Hence, domestic firearm regulations suffer from weaknesses that expose them to code-based attacks. The facility with which people can exchange CAD files of gun parts and 3D print an untraceable gun may dramatically increase the number of illicit guns. Certain groups will seek to exploit these weaknesses. A regulatory battle is all but certain.

## VI. CONCLUSION

One defining characteristic of 3D printing will challenge many areas of the law: 3D printing causes the worlds of bits and atoms to overlap further. As the technology proliferates and improves, CAD files for many products will become equivalent to their physical counterparts. Regulating these files will be the chief challenge for the legal system as it seeks to adapt to a world with 3D printing. Concerns about intellectual property piracy or gun proliferation, even though legitimate, should not control the technology. The political economy of 3D printing suggests that those issues will not drive regulation because well-organized groups will lobby in favor of 3D printing.

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381. Jensen-Haxel, *supra* note 152, at 455–56. Of course, 3D printers can print in metal as well as plastic, but plastic is cheaper.

382. *See* 18 U.S.C. § 921 (2012) (defining only "the frame or receiver" of a gun as a "firearm"); Adam Clark Estes, *The ATF Has Yet To Be Convinced that 3D-Printed Guns Compare to the Real Thing*, MOTHERBOARD (Mar. 25, 2013, 11:55 AM), http://motherboard.vice.com/blog/the-atf-is-unconvinced-3d-guns-compare-to-real-thing.

383. *See, e.g.*, *Making Guns at Home: Ready, Print, Fire*, ECONOMIST, Feb. 16, 2013, at 34 (discussing Cody Wilson, founder of Defense Distributed and his goal to "expand a free sphere of action in contradistinction to a planned regulatory scheme").

But theory is no substitute for action. Lawmakers and courts have their work cut out for them. So do academics and other policymakers. This Article has touched on many issues that warrant in-depth study from a variety of theoretical, normative, and disciplinary approaches. The world of 3D printing is here.