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The WAKE FOREST JOURNAL OF BUSINESS AND INTELLECTUAL PROPERTY LAW is a student organization sponsored by Wake Forest University School of Law dedicated to the examination of intellectual property in the legal context. Originally established as the Wake Forest Intellectual Property Law Journal in 2001, the new focus and form of the Journal, adopted in 2010, provides a forum for the exploration of business law and intellectual property issues generally, as well as the points of intersection between the two, primarily through the publication of legal scholarship. The Journal publishes four print issues annually. Additionally, the Journal sponsors an annual symposium dedicated to the implications of intellectual property law in a specific context. In 2009, the Journal launched an academic blog for the advancement of professional discourse on relevant issues, with content generated by both staff members and practitioners, which is open to comment from the legal community. The Journal's student staff members are selected for membership based upon academic achievement, performance in an annual writing competition, or extensive experience in the field of intellectual property or business.

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TRADEMARKS & BRANDS IN 3D PRINTING

Tabrez Y. Ebrahim[†]

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I. INTRODUCTION

“If you build it, he will come.”¹ In the movie “Field of Dreams,” Iowa farmer Ray Kinsella heard a voice whispering this phrase and also saw a vision of a baseball diamond in his field.² He interpreted this voice and the vision as an instruction to build a baseball diamond in his field.³ After Ray built the baseball diamond, several deceased baseball players appeared and played on it.⁴

This model of utilizing the action of making something to entice the action of bringing customers has been utilized in traditional manufacturing.⁵ The traditional model of delivering goods to customers has been focused on building and delivering goods to consumers at retail stores, online, or by direct delivery. This model is centered around manufacturers making, distributing, and marketing goods. Traditional manufacturers⁶ have produced the goods on their own, filed trademarks to indicate the source of origin of those goods, and built globally linked manufacturing facilities with complex supply chains to deliver goods to retail channels and consumers. This model of “if you build it, then the consumer will come” has been utilized by traditional manufacturers.

However, 3D printing changes and redefines this model. In a 3D printing world, the consumer can become both the producer and the end customer.⁷ Since 3D printing enables consumers to customize goods, marketers need to revise marketing, trademark, and branding strategies to cater to a new localized production model. Marketers should consider revising the application of the “Field of Dreams” voice to implement a new phrase of, “if *they* build it, *they* will come.” In other words, traditional manufacturers of goods should seek to find new ways to engage a consumer who will also become the producer.

Traditional manufacturers of goods and the marketers they employ

¹ FIELD OF DREAMS (Gordon Company 1989).

² *Id.*

³ *Id.*

⁴ *Id.*

⁵ David M. Anderson, *The End of the Line for Mass Production: No Time for Batches & Queues*, BUILT-TO-ORDER CONSULTING, <http://build-to-order-consulting.com/Mass%20Production.htm> (last visited Sept. 14, 2016).

⁶ This paper utilizes “traditional manufacturing” to refer to the production of goods where 3D printing is not implemented. In other words, the term “traditional manufacturers” is utilized throughout to refer to a party that produces goods without the use of 3D printing technology.

⁷ This paper focuses on a type of manufacturing where the goods will be used by a consumer or where the consumer will personalize the goods. This paper does not investigate 3D printing for prototyping, pre-production, production, industrial, or bioprinting uses.

have begun to learn about the 3D printing revolution. Some are concerned about loss of sales due to counterfeit products produced from 3D printing. Others are unfamiliar with either the technology, are unaware of the complex intellectual property (“IP”) issues, or are concerned about the impact of 3D printing on their business models and branding strategies. Yet others have not thought of a business strategy to address, capture, and grow adoption of 3D printing. This paper discusses each of these concerns, by providing an overview of 3D printing technologies, trademark law doctrine, and branding strategies.

In addressing these concerns, this paper focuses on trademarks and brands in the disruptive 3D printing world. The purpose of this paper is to introduce the reader to 3D printing, provide context to the concerns about trademarks and brands in 3D printing, and analyze the underlying trademark law doctrine in the lens of 3D printing. A suggestion is made that trademarks will be deemphasized in a 3D printing world, and therefore, traditional manufacturers and marketers should instead focus on building brand value. Traditional manufacturers and marketers should adopt new branding strategies in order to retain existing customers, engage new 3D printing enthusiast market segments, and align existing consumer engagement models to include new 3D printing applications. The strategic branding recommendations provided herein are a response to doctrinal IP legal analysis and are also grounded on business frameworks in the context of emerging 3D printing technologies that disrupt traditional models of manufacturing of goods.

Part II of this paper provides a brief introduction to 3D printing technology, new business entities, new business models, and markets segments.⁸ In doing so, this section addresses new technological innovation and barriers to adoption in 3D printing to give readers who may be new to 3D printing an overview. This section delves into the reasons why certain market segments have ignored or been slow to adopt 3D printing. A discussion of the diminishing importance of IP and its impact on reducing the adoption gap among market segments is also provided.

Part III of this paper focuses on one form of IP—trademarks⁹—and provides an analysis of the interplay between 3D printing and trademark doctrine and policy. It analyzes trademark law issues from

⁸ A reader who has a sufficient knowledge of the basics of 3D printing should feel free to skip ahead to Part II and Part III.

⁹ The focus of this paper is on trademark and brands. This paper does not discuss 3D printing’s effect on other forms of IP, such as copyrights, patents, and trade secrets.

the context of traditional manufacturers of goods, and suggests that trademarks are deemphasized in the era of 3D printing. This section seeks to advance Professor Mark Lemley's thesis that IP artificially imposes scarcity when digitization technologies (such as 3D printing, which digitizes physical goods into digital design files) enable zero marginal cost production.¹⁰ As 3D printing develops, it is conceivable that traditional manufacturers' initial response will be to adopt protectionist strategies to protect their R&D investments, which may be jeopardized as 3D printing trends towards zero marginal cost production. Thus, traditional manufacturers will be inclined to pursue enforcement of their trademarks against 3D printing uses via infringement, dilution, and counterfeiting actions. The downsides to such protectionist strategies in the context of 3D printing are discussed, and a call is made to traditional manufacturers to focus instead on customer engagement and brand development strategies.¹¹

Part IV of this paper provides a distinction between trademarks as property rights and brands as strategic business assets. A discussion of the de-emphasis of trademarks and the need for a re-emphasis of brands in the context of 3D printing is provided. This section suggests that traditional manufacturers deemphasize their trademark enforcement strategies and refocus on branding strategies in an era of 3D printing. Brand building (not the artificial scarcity created by IP) is proposed for encouraging creative activity through personal customization by consumers in a 3D printing world. The psychological principles underlying brands in traditional manufacturing economies and the changes needed for marketers in 3D printing are mentioned, and a proposal is made to traditional manufacturers to utilize brands' emotional and symbolic appeal in conjunction with 3D printing's ability of enabling consumers to become producers. Moreover branding via quality in digital design files is suggested to replace IP as a strategic business asset to distinguish among competitors in a post-scarcity world. This section applies Professor Deven Desai's observation¹² that brands, not trademarks, drive demand to generate equity.

¹⁰ Mark Lemley, *IP in a World Without Scarcity* (Stanford Pub. Law, Working Paper No. 2413974, 2014).

¹¹ Neil Wilkof, *Trademarks and Brands in the Competitive Landscape of the 3D Printing Ecosystem*, 104 THE TRADEMARK REP. 817, 820 (2014) (citing David Teece, who argued that when innovation is not protected by strong IP regimes, then complementary assets such as trademarks and brands determine economic returns from the innovation (citation omitted)).

¹² Deven R. Desai, *From Trademarks to Brands*, 64 FLA. L. REV. 981, 981 (2012).

II. INTRODUCTION TO 3D PRINTING TECHNOLOGIES & BUSINESS

Projections show a rapid growth for the 3D printing industry, with a Compound Annual Growth Rate (“CAGR”) in the near term of nearly 35%¹³ and an economic impact in the range of \$230 to \$550 billion by the year 2025.¹⁴ Much of the expected growth of 3D printing stems from customers who will benefit from 3D printing’s ability to enable them to create the physical goods, thereby eliminating the previous high cost-to-entry barrier in producing goods and eliminating the need to wait for the distribution function.¹⁵

However, there are some barriers that might keep 3D printing from attaining such rapid growth numbers. First, the physical processes of 3D printing are complex and time consuming and do not yield as high quality or precise subtractive manufacturing processes. While 3D printing hardware prices are dropping,¹⁶ there is still a need for improvements and innovation in printing technologies involved to reach better quality print outputs. This section provides a brief introduction to the physical printing processes of 3D printing, and highlights new innovations, new business entities, and new business models that have arisen in 3D printing to capture and deliver the value to 3D printing customers.

Second, while 3D printing hands the ability to produce to the consumer, this very benefit is also a limitation. Some potential customers are hesitant to utilize 3D printing because it does not produce as high grade of a product or a prototype as performed by a traditional manufacturing process.¹⁷ Others, who might still value the

¹³ TJ McCue, *\$4.1 Billion Industry Forecast in Crazy 3D Printing Stock Market*, FORBES: TECH (July 30, 2015), <http://www.forbes.com/sites/tjmccue/2015/07/30/4-1-billion-industry-forecast-in-crazy-3d-printing-stock-market/#52c2a51125df> (discussing that market for additive manufacturing grew at a CAGR of 35.2% in 2014, had a CAGR from 2012 to 2014 of 33.8%, and expanded by over \$1 billion in 2014 alone, including with 49 new manufacturers producing and selling industrial grade additive manufacturing machines).

¹⁴ JAMES MANYIKA ET AL., *Disruptive Technologies: Advances That Will Transform Life, Business, and the Global Economy*, 2013 MCKINSEY GLOBAL INSTITUTE 105.

¹⁵ *Id.* at 105, 110–11.

¹⁶ Elizabeth Matias & Bharat Rao, *3D Printing: On Its Historical Evolution and the Implication for Business* PROCEEDINGS OF PICMET ’15: MANAGEMENT OF THE TECHNOLOGY AGE, 551, 551-52 (2015), <http://faculty.poly.edu/~brao/3dppicmet.pdf>.

¹⁷ Matthew Timms, *3D Printing Cannot Completely Replace Traditional Manufacturing, Say Experts*, WORLD FINANCE, (July 16, 2014), <http://www.worldfinance.com/infrastructure-investment/3d-printing-cannot-completely-replace-traditional-manufacturing-say-experts>.

lower cost and ease of access to 3D printing, are simply hesitant or unfamiliar with this emerging technology. This section analyzes the gaps, or chasms, in adoption that have arisen with 3D printing among specific market segments. The analysis suggests that a reduction in importance of IP in the 3D printing ecosystem also enables a quicker closing of market segment adoption gaps.

A. 3D Printing Technologies, Entities, & Business Models

3D printing utilizes an “additive manufacturing” process to build products by adding many very thin layers of material, layer on top of layer.¹⁸ The brain of a 3D printing operation is an electronic Computer Aided Design (“CAD”) file, which serves as a digital blueprint model for producing the output product.¹⁹ This CAD file can be created from 3D modeling software, from scanning a 3D object, or from tweaking in modeling software a scanned object.²⁰ 3D printing offers the ability to make a physical object using an electronic file, which contains the printing instructions. In essence, a 3D printing machines enable users to turn a digital blueprint into a physical object with the press of a button.²¹ There are multiple methods to achieve such conversion of digital to physical, and the major additive manufacturing processes that enable 3D printing are discussed herein.

1. Additive Manufacturing (“AM”) Methods

Additive Manufacturing (“AM”) is the formalized term for 3D printing, and its basic principle is that a model is initially generated using a three-dimensional CAD system and then fabricated directly without the need for process planning.²² AM adds material in layers, with each layer being a cross-section of the part that is produced from

¹⁸ See Matias, *supra* note 16, at 551.

¹⁹ Michael Weinberg, *It Will Be Awesome if They Don't Screw Up: 3D Printing, Intellectual Property, and the Fight Over the Next Great Disruptive Technology*, PUBLIC KNOWLEDGE (Nov. 2010), at 3–4 (explaining that the CAD design process eliminates the need to design physical prototypes out of other materials not needed for the object, and that a designer can use a CAD program to create and manipulate a virtual model that is saved to a file).

²⁰ *Id.* at 3.

²¹ See *id.* at 2.

²² IAN GIBSON ET AL., ADDITIVE MANUFACTURING TECHNOLOGIES: 3D PRINTING, RAPID PROTOTYPING, AND DIRECT DIGITAL MANUFACTURING 1–2 (2d ed. 2015) (describing that AM significantly simplifies the process of producing complex 3D objects directly from CAD data, whereas other manufacturing processes require a more careful and detailed analysis of part geometry, the order in which different features can be fabricated, which tools and processes can be used, and what additional features are required to complete the part).

the CAD file.²³ All AM processes utilize a layer-based approach, but there are differences in how the layers are created and bonded to each other.²⁴ The most common of the AM method utilized in current commercial 3D printing units sold is material extrusion, which is a process by which the object is built in layers by outputting a semi-liquid material from a computer-controlled nozzle.²⁵ This process utilizes the extrusion of thermoplastics, in which a spool of filament material get fed into a heated printhead, which extrudes the then molten filament onto a build platform.²⁶ The thermoplastic material rapidly sets after it exits the printhead. An analogous process is extruding of a cake's icing from an icing nozzle and placing the icing onto the cake.

Another additive manufacturing process is VAT photopolymerization, which uses a light source to solidify successive layers on the surface or base of a liquid photopolymer.²⁷ The most commonly known method of VAT photopolymerization is a StereoLithography Apparatus ("SLA"), which uses a computer-controlled laser beam to build a 3D object within a tank (or "VAT") of a photopolymer.²⁸ In a SLA process, a UV laser beam traces out the shape of the first object layer on the surface of the liquid and then builds more layers by lowering the tank.²⁹ A new method of stereolithography utilizes UV light to solidify the bottom layer of the plastic material to build the eventual 3D object in a precise pattern that is dictated by the object's CAD file. Carbon3D is commercializing this new photopolymerization method,³⁰ and its patents³¹ describe the use of a pool of liquid photopolymer resin, with a bottom that is

²³ Christopher Barnatt, *Future Technologies: 3D Printing*, EXPLAINING THE FUTURE (July 6, 2016), <http://explainingthefuture.com/3dprinting.html>.

²⁴ *Id.*

²⁵ *Id.*

²⁶ *Id.*

²⁷ *Id.*

²⁸ *Id.*

²⁹ *Id.*

³⁰ See John R. Tumbleston et al., *Continuous Liquid Interface Production of 3D Objects*, 347 SCIENCE 1349, 1349 (2015) (stating that a continuous liquid interface production (CLIP) method creates an oxygen-containing "dead zone" of an uncured liquid layer, thereby reducing the problem of oxygen inhibition of free radical polymerization of conventional photopolymerizing UV-curing resins and enabling simpler and faster stereolithography).

³¹ CARBON, <http://carbon3d.com/about/> (last visited Sept. 16, 2016); Aaron Tilley, *How Carbon3D Plans to Transform The Way We Make Stuff*, FORBES (Nov. 4, 2015, 2:30 PM), <http://www.forbes.com/sites/aarontilley/2015/11/04/how-carbon3d-plans-to-transform-manufacturing/#1a6e0c0de56c> (discussing Carbon3D's ability to 3D print one hundred times faster than SLA and at higher resolutions).

transparent to UV light, so that the UV light shines through and illuminates the cross-section of the printed objects, causing the resin to solidify.³²

Another printing process is power bed fusion, which uses the selective application of heat to bond adjacent powder granules.³³ The most common way of achieving this process is by laser sintering, in which a layer of powder is swept across a powder bed followed by a laser beam that traces out the cross-section of the first object layer.³⁴ In the selective laser sintering process, a laser melts particles of powder together.³⁵ One major advantage of this method is that a variety of powdered materials can be used during this process. Another advantage of selective laser sintering is that it provides high resolution in all three dimensions of the object, so that limited, if any, post-production processes are required.³⁶

Yet another printing process is sheet lamination, which sticks together sheets of paper, plastic, or metal foil into object layers by cutting them with a laser or blade.³⁷ In this process, a sheet of built materials is advanced onto a build platform and an adhesive is applied, after which the laser or blade cuts the outline of the object layer into the sheet, and the process repeats. A major advantage of this process is that since no chemicals are used and no chambers are needed, then larger models can be built. However, a downside to this process is that it is difficult to use for printing complex geometries.³⁸

2. *New Business Entities & New Business Models*

The traditional model of producing goods involved entities that conducted R&D, manufacturing, distribution and supply chain operations, and marketing.³⁹ 3D printing democratizes production and provides the ability to print away from control of a traditional

³² Method and Apparatus for Three-Dimensional Fabrication with Feed Through Carrier, WIPO Patent No. WO2014126834 (filed Feb. 10, 2014); Continuous Liquid Interphase Printing, WIPO Patent No. WO2014126837 (filed Feb. 10, 2014).

³³ Barnatt, *supra* note 23.

³⁴ *Id.* at 71.

³⁵ See Winnan, *infra* note 91, at 200.

³⁶ See *id.*

³⁷ See Barnatt, *supra* note 23.

³⁸ GIBSON ET AL., *supra* note 22.

³⁹ MICHAEL E. PORTER, *COMPETITIVE ADVANTAGE: CREATING AND SUSTAINING SUPERIOR PERFORMANCE*, 36–48 (1985) (describing the value chain in traditional manufacturing as a framework that follows the company's internal product processes starting with raw materials and ending with customer purchase and service; the steps of traditional manufacturing's product flow is delineated as going from raw materials to operations to delivery to marketing and sales and to service).

manufacturing firm.⁴⁰ Since 3D printing can enable a new way to mass customize and replace mass production, then new business entities are arising to capture this new way of creating value. Moreover, since traditional product manufacturing and distribution no longer applies in 3D printing, then new business models will arise to provide new ways of delivering value. Thus, new business entities will arise to take advantage of new business models for creating value, capturing value, and serving consumers. There are five fundamental business entity types, some of which are deploying new business models from traditional manufacturing, that are arising in the 3D printing ecosystem:

1. printer and equipment manufacturing,
2. printing intermediaries,
3. software tools,
4. marketplaces, e-commerce sites, and repositories of 3D printable CAD files, and
5. information technology and service oriented solutions utilizing 3D printing.

First, the 3D printer and equipment manufacturing provides capital equipment to be utilized by other businesses and consumers in the 3D printing ecosystem. Such hardware is being deployed for new applications and new markets,⁴¹ and it is conceivable that 3D printing hardware will someday become as commonplace as mobile phones. 3D printers are developing new hardware improvements that provide benefits in printing speed and throughput, material choice, quality and surface finish, end product strength, and printing resolution, but inevitably such hardware improvements are approaching Moore's Law limitations and costs will decrease. While profit margins in hardware manufacturing are often not appealing to investors, new functionality and new capabilities of printing novel materials are creating new life for the printing manufacturing business. Furthermore, novel technology, such as Continuous Liquid Interface Production

⁴⁰ John Hornick, *3D Printing and IP Rights: The Elephant in the Room*, 55 SANTA CLARA L. REV. 801, 803 (2015) (discussing that 3D printing away from control means that an individual can make objects without anyone's knowledge and without any firm being able to control it).

⁴¹ Brian Krassenstein, *Carbon3D Unveils Breakthrough CLIP 3D Printing Technology, 25-100X Faster*, 3DPRINT.COM (Mar. 16, 2015), <https://3dprint.com/51566/carbon3d-clip-3d-printing>, (introducing Carbon3D's game-changing technology that produces prints with consistent mechanical properties and choice of materials required for commercial quality parts, and demonstrating fidelity at micron (μm) resolution under an electron microscope).

(“CLIP”),⁴² is being utilized in 3D printer hardware for end-use customers in prototyping and manufacturing.⁴³ Additionally, new printer manufacturers are attempting to solve the difficult hardware problems with reliability and consistency that has hampered progress in adoption of 3D printers among advanced consumers and 3D printing hubs. R&D advances will enable a more consistent print, smoother surface finishes, greater throughput, and quicker print time; however, inevitably, there are tradeoffs between these parameters and bill of materials (“BOM”) costs for printer manufacturers.⁴⁴

Second, printing intermediaries that print on behalf of others are providing printing services to those who do not own a 3D printer or do not want to purchase a 3D printer.⁴⁵ These intermediaries are platforms that can be in the form of printing service bureaus, printing hubs, Print as a Service (“PaaS”) entities, or print-on-demand services. These entities are either purchasers of 3D printing hardware or are separate production entities that utilize 3D printers. Some offer customizable 3D printed products,⁴⁶ and others ship directly to consumers who post-process and sell to their customers. Others enable customers to personalize their 3D printed object, along with serving a printing function. In effect, printing intermediaries capture value by providing either creation or customization or both on their

⁴² *Id.*

⁴³ Brian Krassenstein, *Ford Is Now Using Carbon3D's CLIP 3D Printers With Astonishing Results While Researching New Materials*, 3DPRINT.COM (June 23, 2015), <https://3dprint.com/75738/ford-is-now-using-carbon3d-clip-3d-printers-with-astonishing-results-while-researching-new-materials/> (discussing the use of the Carbon3D printer for Ford's fabrication of elastomer grommets development in Focus Electric vehicles).

⁴⁴ For example, while greater reliability and consistency can be achieved, the tradeoff will be more components, such as sensors and rigid platforms, thereby increasing BOM cost and shipping cost. However, a more reliable and consistent printer could also reduce maintenance cost and could output better printouts, such that the long run volume cost could be smaller than a cheaper and less consistent printer. 3D printer manufacturers will need to conduct design of experiments studies to optimize performance without running up the BOM cost. Professional-grade and production-specific 3D printers will require more consistent, higher quality, and more reliable prints, thereby necessitating a higher BOM cost, whereas consumer-oriented 3D printers for basic consumer function will continue to be designed with cheaper and cheaper components, so as to decrease BOM cost and increase price-sensitive consumer adoption.

⁴⁵ Tabrez Y. Ebrahim, *3D Printing: Digital Infringement & Digital Regulation*, 14 NW. J. TECH. & INTELL. PROP. 37, 51 (2016).

⁴⁶ Kraftwürx, <http://www.kraftwurx.com/about-our-company> (last visited Sept. 16, 2016) (marketing the ability to empower anybody to create, showcase, buy, and sell customized 3D printing products through a network of worldwide production facilities).

platforms and by reducing the complexity and cost of delivery, transportation, logistics, and supply chain of 3D printed goods.

Third, some entities' businesses are focused on developing and selling software tools that make it easier to capture, create, or modify 3D printing content.⁴⁷ These entities focus on the R&D of software that creates or modifies the electronic blueprint, or CAD file, of the 3D printer. In essence, these companies are involved with promoting the ease-of-use and ease-of-transfer of 3D CAD files. They provide modelers the ability to design a new object for 3D printing. New innovations are arising in software development, including simpler meshing capabilities for 3D model generation and co-creation development platforms.⁴⁸

Fourth, marketplaces, e-commerce sites, and repositories of 3D printable CAD files are offering ways to store information content in CAD files, modify and share modified CAD files, and transact services associated with CAD files.⁴⁹ Some allow designers to monetize their creative works, whereas others are completely free and do not allow designers to monetize their designs.⁵⁰ Each of these online platforms is aimed at consumer 3D printing applications, and some offer add on services, such as design services, interactive 3D model visualizations, and manufacturability checks.⁵¹ Others offer e-commerce options, such as selling designs, and yet others offer cloud storage capabilities. Similar to other Internet-based business-to-consumer ("B2C") business models, Internet-based 3D websites allow direct interaction with the consumer.

Fifth, 3D printing is starting to utilize information technology and service-oriented solutions. Some new businesses are utilizing technologies and business models from the information technology industry to develop 3D printing platforms aimed at cost reduction, increased production speeds, and big data analytics to enable customers to cope with dynamic changes in 3D printing

⁴⁷ *3D Design Programs: Tools for Your Trade*, KRAFTWURX, <http://www.kraftwurx.com/3d-design-programs> (last visited Sept. 16, 2016).

⁴⁸ Ebrahim, *supra* note 45, at 39.

⁴⁹ *See id.*; see also Tesh W. Dagne, *The Left Shark, Thrones, Sculptures and Unprintable Triangle: 3D Printing and its Intersections with IP*, 25 ALB. L.J. SCI. & TECH. 573, 583 (2015).

⁵⁰ *See* Kyle Dolinsky, *CAD's Cradle: Untangling Copyrightability Derivative Works, and Fair Use in 3D Printing*, 71 WASH. & LEE L. REV. 591, 616–17 (2014).

⁵¹ *See, e.g., Digital Factory*, KRAFTWURX, <http://www.kraftwurx.com/online-3d-printing-dfretail> (last visited Sept. 15, 2016) (describing the many options available, such as an "online customization system [that] offers real-time product visualization for what-you-see-is-what-you-get personalization. Real-time pricing, intuitive controls and an industry-leading selection of more than eighty-five 3D Printing materials and finishes").

environments.⁵² Enterprise solutions are enabling e-procurement, supplier tracking, and report generation-functions that information technology companies have serviced. Other service-oriented businesses are utilizing 3D printing through support services within their own business processes and providing repair operations and replacement part services.⁵³

B. 3D Printing in the Context of the Technology Adoption Life Cycle

3D printing is generating a tremendous amount of interest. The term “3D printing” has experienced a drastic increase in online searching,⁵⁴ in media interest,⁵⁵ in patent applications filings,⁵⁶ and in legal scholarship.⁵⁷ Moreover, 3D printing is arising in litigation⁵⁸ and

⁵² See, e.g., *id.* (offering a one-stop-shop where customers can create products, purchase professional consulting, and set up e-commerce websites).

⁵³ Gail Brooks et al., *3D Printing As a Consumer Technology Business Model*, 18 INT’L J. MGMT & INFO. SYS. 271, 274–75 (2014) (describing the advent of support services within existing business models, so as to provide replacement parts with the same capabilities, enable customers to cut costs by not having to order parts from a third party supplier, repairing parts, and redesigning original parts that are no longer available, each via the use of a 3D printer).

⁵⁴ UK INTELLECTUAL PROP. OFFICE PATENT INFORMATICS TEAM, *3D Printing: A Patent Overview* 6, 6 (2013), https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/445232/3D_Printing_Report.pdf (showing at Fig. 1, a plot of the number of times the search term “3D printing” has been inputted into the Google search engine, which shows an exponential rise in 3D printing in search engine usage from the years 2011 to 2013).

⁵⁵ *Id.* at 8 (showing in Fig. 2, a plot of the usage of the term “Reprap” in the Google search engine and the co-occurrence of news articles mentioning 3D printing which shows a linear rise in such a trend from the years 2007 to 2013).

⁵⁶ Gridlocks Technologies Pvt Ltd, *3D Printing: Technology Insight Report 1*, 29 (2014), <http://www.patentinsightpro.com/techreports/0214/Tech%20Insight%20Report%20-%203D%20Printing.pdf> (utilizing Patent iNSIGHT Pro and PatSeer research tools to generate a chart of patent publications of 3D printing technologies, in which displayed is a gradual linear rise in patent applications in 3D printing technologies from 1961 to 2008 and an exponential rise in 3D printing technologies in patent applications from 2009 to 2013).

⁵⁷ Jasper L. Tran, *The Law and 3D Printing*, 31 J. OF INFO. TECH. AND PRIVACY LAW 505, 505 (2015) (outlining a bibliography of over 100 entries of the emerging field of 3D printing law, the historical growth pattern of law, 3D printing legal scholarship, and the publications and cases related to 3D printing).

⁵⁸ Robert E. Yoches & Shaobin Zhu, *IP Strategies for Chinese 3D Printing Companies*, FINNEGAN (Sept. 2014), <http://www.finnegan.com/resources/articles/articlesdetail.aspx?news=3d9f9b27-f552-440c-a8b7-82c06c218e4f> (discussing recent U.S. IP litigation in 3D printing, and noting that two leaders in 3D-printing in the U.S., Stratasys, Ltd. and 3D

in enforcement orders at the International Trade Commission.⁵⁹ 3D printing is among the disruptive technologies that has been included in the latest Hype Cycle for Emerging Technologies' report.⁶⁰ The hype cycle⁶¹ perspective of an emerging technology, such as 3D printing, follows a progression of interest that can qualitatively be described as going from a rise, to a peak, to sliding into a trough, to climbing a slope, and finally to entering a plateau. Since there are different applications and different market segments for 3D printing, then the hype cycle expectations vary with 3D printing applications as a function of time.⁶²

Systems, Inc, have sued competitors offering low-cost printers; specifying that 3D Systems has sued Formlabs, a U.S. startup 3D printer manufacturer and Kickstarter, Formlabs' crowdsource funder, for infringing a stereolithography patent; and detailing that Stratasy's has sued Afinia for patent infringement of four patents relating to fused deposition modeling).

⁵⁹ *ClearCorrect Operating, LLC v. Int'l Trade Comm'n.*, 810 F.3d 1283, 1290 (Fed. Cir. 2015) (regarding a dispute based on the use of 3D printing technology to produce invisible braces and including infringement of digital files containing digital scans of patients' teeth, the case centers on the importation of patented articles and violation of Section 337 of the Tariff Act).

⁶⁰ Betsy Burton & Mike J. Walker, *Hype Cycle for Emerging Technologies, 2015*, GARTNER (July 27, 2015), <https://www.gartner.com/doc/3100227/hype-cycle-emerging-technologies-> (providing a cross-industry perspective on the technologies and trends that business strategists, chief innovation officers, R&D leaders, entrepreneurs, global market developers, and emerging technology teams utilize and evaluate).

⁶¹ See *Gartner Hype Cycle*, GARTNER, (2016), <http://www.gartner.com/technology/research/methodologies/hype-cycle.jsp>. The research firm Gartner has long promoted an analytical concept of technology's life cycle called the "hype cycle," which is based on the notion that in the world of technology, people follow-up a process of getting over-excited about emerging technological developments, then disappointed when such developments do not gain traction as expected, and finally a plateauing effect of those developments mature and start to gain adoption and traction. This process has been graphically shown in phases of increasing maturity with time and are titled, "innovation trigger," "peak of inflated expectations," "trough of disillusionment," "slope of enlightenment", and "plateaus of productivity." See *id.*

⁶² Michael Molitch-Hou, *Consumer 3D Printing More than 5 Years Away from Mainstream Adoption, Says Gartner*, 3D PRINTING INDUSTRY (Aug. 20, 2014), <https://3dprintingindustry.com/news/consumer-3d-printing-5-years-away-mainstream-adoption-says-gartner-31677/> (showing a graphical hype cycle representation of 3D printing in which the following applications are displayed in the respective five hype cycle phases: 1) Technology Trigger phase: IP protection, macro 3D printing, 3D bioprinting systems, classroom 3D printing, 3D printing and supply chain, 3D printing for oil and gas, retail 3D printing, and industrial 3D printing, 2) Peak of Inflated Expectations phase: 3D printing of medical devices, consumer 3D printing, and 3D printing in manufacturing operations, 3) Trough of Disillusionment: n/a, 4) Scope of Enlightenment: 3D print creation software, enterprise 3D printing, 3D printing service bureau, and 3D scanner, and 5) Plateau of

continued . . .

3D printing's hype cycle raises questions of why certain segments are gaining traction while others are not and also what affects the rate of adoption. While there is a growing rise of industrial applications for 3D printing,⁶³ the hype of 3D printing has barely touched the consumer population. The current largest market segment embracing 3D printing is for industrial applications, such as for rapid prototyping⁶⁴ and for molds and other tooling applications, whereas the final consumer products usage is a significantly less mature market segment.⁶⁵ There are a number of barriers to entry with 3D printing for the average consumer, such as software for 3D printing being difficult to use and a lack of understanding of the design process associated with 3D printing.⁶⁶

A chasm has developed in the 3D printing consumer space due to varying experiences and knowledge with respect to hardware functionality, software familiarity, cost, and interest in customization. Just as in high technology adoption of new products, there have been early market wins, but there seems to be a need to undertake an immense effort to make a transition into serving the mainstream market.⁶⁷ 3D printing adoption mirrors other high technology adoption models where market penetration of any new technology production leads to gaps symbolizing dissociation between groups in accepting a new product or a new technology.⁶⁸

There have been early adopters who have embraced 3D printing for personal fabrication.⁶⁹ But there is a mainstream consumer market

Productivity: 3D printing for prototyping).

⁶³ *See id.*

⁶⁴ ALI K. KAMRANI & EMAD ABOUEL NASR, RAPID PROTOTYPING 295 (2006) (defining rapid prototyping as a process of selectively depositing a gas, liquid, powder, or sheet material in layers, with the purpose of producing solid three-dimensional parts directly from CAD models).

⁶⁵ *See* Barnatt, *supra* note 23, at 13 (showing technology S-curves adoption among various market segments by graphing 3D printing adoption percentage versus time and displaying in order of highest adoption per given year the following: rapid prototyping, mold & tooling, digital manufacturing, and personal fabrication).

⁶⁶ *See* Matias, *supra* note 16, at 556 (demonstrating, via a research survey, that a knowledge gap exists with 3D printing and that an opportunity exists for software companies to design a user-friendly package to educate consumers, who unlike designers and engineers that have regularly utilized 3D printing technology at work or school, are not educated about the 3D printing process of having an idea, designing a 3D model in CAD, converting the design file to an appropriate file type, and then printing the model).

⁶⁷ Regis McKenna, *Foreword* to GEOFFREY A. MOORE, CROSSING THE CHASM X, XI (HarperCollins Publishers rev. ed. 2001).

⁶⁸ *See* GEOFFREY A. MOORE, CROSSING THE CHASM 12 (HarperCollins Publishers rev. ed. 2001).

⁶⁹ *See* Matias, *supra* note 16, at 554 (remarking on how three consumers have

that has been unaware of or slow to adopt 3D printing.⁷⁰ The adoption of 3D printing seems to have developed a chasm between the early adopters and the mainstream market akin to the Technology Adoption Life Cycle model proposed by Geoffrey Moore.⁷¹ A segmentation⁷² based on psychographic profiles consists of groups characterized as being innovators,⁷³ early adopters,⁷⁴ early majority⁷⁵ (which is followed by a major chasm⁷⁶), late majority,⁷⁷ and laggards⁷⁸ (wherein

become quite savvy in their overall understanding of 3D printing and one of their uses is for personal manufacturing).

⁷⁰ See *id.* (discussing that only a small fraction of roughly 10% of consumers has used a 3D printer).

⁷¹ See MOORE, *supra* note 68, at 8–10 (where Moore’s model describes a response to a discontinuous innovation based on a new technology, wherein each group represents a unique psychographic profile that is a combination of psychology and demographics that makes its marketing responses different from other groups and where the distribution in the model follows a bell curve shape with divisions in the curve roughly equivalent to standard deviations; further describing that technology is absorbed into any given community in stages corresponding to the psychological and social profiles of various segments in a process that can be thought of as a continuum with definable stages, each that is associated with a group; characterizing success for a company within the context of the High Technology Marketing Model as gaining traction from the left to the right of the curve and capturing each group as a reference base in order to market to the next group).

⁷² CLAYTON M. CHRISTENSEN & MICHAEL E. RAYNOR, *THE INNOVATOR’S SOLUTION: CREATING AND SUSTAINING SUCCESSFUL GROWTH* 75 (2003) (cautioning that delineations based on attributes of products and customers only reveal correlations between attributes and outcomes, and suggesting that only when marketing theory provides causality built on circumstance-based segmentation schemes that assert what causes customers to buy a product results in predictable marketing; in other words, critical segmentation analysis is based on the circumstance, and not the actual customer, and requires observation of the circumstances of certain circumstances).

⁷³ See MOORE, *supra* note 68, at 9 (where innovators are defined as ones pursuing new technology products aggressively even before a formal marketing program has been launched since the technology is a central interest in their life and since they often make a technology purchase simply for the pleasure of exploring the new device’s properties).

⁷⁴ *Id.* (where early adopters are defined as not being technologists, but rather people who find it easy to imagine, understand, and appreciate the benefits of a new technology, can relate potential benefits of the new technology to their concerns, and rely on their own intuition regarding the new technology in making purchasing decisions for particular reasons).

⁷⁵ *Id.* (where early majority is defined as a group driven by a strong sense of practicality and wanting to see how other people are making out before they buy in themselves and wanting to see well-established references before investing substantially; further describing that roughly one-third of the whole technology adoption life cycle is comprised of this group, and therefore, winning their business is key to any substantial growth).

⁷⁶ See CHRISTENSEN, *supra* note 72, at 83 (emphasizing that one’s view of a

continued . . .

each is characterized by the degree of adoption of 3D printing).

One challenge for 3D printing to attain a greater adoption and develop a greater market penetration is the need for endorsement of a particular earlier responsive group before developing credibility with a subsequent adoption group.⁷⁹ Thus, for example, the support of innovators is needed before reaching early adopters. Another challenge for 3D printing is the difficulty with neatly defining the psychographic profiles associated with 3D printing users and would-be users. An initial characterization utilizing the Technology Adoption Life Cycle model based on observations of 3D printing uses can be: Do-It-Yourselfers (“DIY”) as Innovators, Tinkerers as early adopters, “Prosumers” as the early majority, consumers as the late majority, and Skeptics at laggards.

The DIY community has been defined by creating, modifying, or repairing objects without the aid of a paid professional and without being motivated by commercial gain.⁸⁰ DIYers are driven by the intrinsic enjoyment of creating and customizing objects, and 3D printing has served as a tool to enable them to pursue making objects. The DIY community fits the psychographic profile of innovators since creative desires are already a central interest in their lives and they find 3D printing an enjoyable outlet for their already existing creative visions. Marketers do not need a formal marketing program to attract DIYs to 3D printing, since DIYers would utilize 3D printing simply to explore 3D printing’s properties for creation.

The Tinkerer community is comprised of those who specifically seek out 3D printing technology to make their own products, but unlike DIYers, have particular problems they are solving in the absence of marketplace choices.⁸¹ Tinkerers have been referred to as

market for a certain technology determines what product features are relevant) (therefore, characterizing the 3D printing ecosystem as having segments comprising a chasm in adoption also presupposes that certain 3D printing features are relevant to certain segments).

⁷⁷ See MOORE, *supra* note 68, at 10 (where late majority is defined as sharing the same characteristics as the early majority plus also requiring that an established standard from large well-established companies; further describing that also roughly one-third of the whole technology adoption life cycle is comprised of this group, and also that gaining traction with this group is especially profitable because all R&D costs have been amortized).

⁷⁸ *Id.* (where laggards is defined as a group that simply does not want anything to do with new technology for any reason where it be personal or economic).

⁷⁹ *Id.*

⁸⁰ Stacey Kuznetsov & Eric Paulos, *Rise of the Expert Amateur: DIY Projects, Communities, and Cultures*, 6TH NORDIC CONF. ON HUMAN-COMPUTER INTERACTION, 1 (2010).

⁸¹ Matias, *supra* note 16, at 552.

Lead Users, who develop and modify products for their own use and anticipate relatively high benefits from obtaining a solution to their needs.⁸² The Tinkerer community fits the psychographic profile of early adopters since they can readily imagine, understand, and appreciate the benefits of 3D printing technology and can relate the potential benefits of 3D printing technology to their concerns and needs. In many cases, tinkerers are sophisticated consumers who are trying to fashion solutions to their own particular problems, in the absence of marketplace choices.⁸³ In essence, tinkerers specifically seek out 3D printers as substitute tools or mechanisms for making their own products, designs, and outputs at home.

While DIYers are utilizing 3D printing for their existing creative desires and Tinkerers find 3D printing as useful solutions for their particular needs, others have even greater sophistication and expectations of 3D printing and fit the psychographic profile for the Early Majority. The label “Prosumer” in the context of 3D printing refers to either: 1) consumers who need higher-grade printing than a hobbyist,⁸⁴ or alternatively, 2) a 3D printing populace that is a strong voice or influencer in 3D printing.⁸⁵ Both of these characterizations of “Prosumer” are applicable to the Early Majority, since each would need to witness others’ usage before investing in 3D printing for themselves.⁸⁶ In the first case, a 3D printing user for a high-grade application will need to see 3D printing demonstrated to their satisfaction before putting at risk their high cost or high value project; this is unlike, for example, a DIYer, whose project cost is minimal or can be easily replaced. In the second case, an individual who becomes a strong voice or influencer by blogging, social networking, or spreading messages would first need a point of comparison to provide support or critique for a 3D printing tool or service. However, in either case, each requires a reference point before investing in the emerging technology, and winning over this Early Majority would

⁸² ERIC VON HIPPEL, *DEMOCRATIZING INNOVATION* 19, 22 (The MIT Press 2005).

⁸³ See Matias, *supra* note 16, at 552.

⁸⁴ CHARLES BELL, *MAINTAINING AND TROUBLESHOOTING YOUR 3D PRINTER* 54 (2014).

⁸⁵ Susan Gunelius, *The Shift from CONsumers to PROsumers*, FORBES.COM (July 3, 2010, 11:34 AM), <http://www.forbes.com/sites/work-in-progress/2010/07/03/the-shift-from-consumers-to-prosumers/#3161e490543f> (describing that the term “prosumer” no longer means a “professional consumer” who simply “consumes” products, but instead refers to consumers who are the voices and influencers of products via the social web, such as by blogging, microblogging, social networking, and spreading messages in general about the product).

⁸⁶ EVERETT M. ROGERS, *DIFFUSION OF INNOVATIONS* 249 (3d ed. 1962).

