Additive Manufacturing and the 3-D Opportunity

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Contents

[VI. Political and Legal Influences 3](#_Toc422002226)

[A. Political Influence Needed To Make Technology Widespread 3](#_Toc422002227)

[B. Security and Safety Concerns 4](#_Toc422002228)

[1. Gun control loopholes. 4](#_Toc422002229)

[C. Creation and Reform of Laws 5](#_Toc422002230)

[1. How will new technology be governed? 5](#_Toc422002231)

[D. Intellectual Property Issues 7](#_Toc422002232)

[1. Ownership of ideas and patent system.. 7](#_Toc422002233)

[VII. Economic Questions and Considerations 8](#_Toc422002234)

[A. Effect on Industry/Manufacturing 9](#_Toc422002235)

[1. Shift in world’s manufacturing centers. 10](#_Toc422002236)

[B. Associated Cost of Technology 11](#_Toc422002237)

[1. RepRap and implications for operating cost. 11](#_Toc422002238)

[C. Future Economy and Automate Manufacturing 12](#_Toc422002239)

[References 14](#_Toc422002240)

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**VI. Political and Legal Influences**

3-D printing has had many private and lesser known applications over the last 30 years, mostly in the context of “additive manufacturing” as a whole. With the recent advent of consumer-grade 3-D printers and the popularization of the technology by virtue of more affordable computer-processing technologies, it is only natural that the vast expanse and limitless potential these technologies offer is going to resonate with the natural creativity and curiosity of human-kind. As with anything else, a large amount of people using or participating in something – anything – often requires governance and regulation to ensure that society and the quality of life of all people is not negatively affected. It is important to consider how a new technology with such extensive applications, some even unknown or undiscovered at this point in time, may impact the political and legal realms.

**A. Political Influence Needed To Make Technology Widespread**

With additive manufacturing technologies quickly becoming popular via applications such as consumer 3-D printing come challenges to the status quo of society and it’s perception of technological change and the impact these changes may have. Baase (2013) states that “most new technologies are not safe when first developed… if the death rate from commercial airline accidents in the United States were the same now as 50 years ago, 8,000 people would die in place crashes each year” (p. 394). Most of these safety issues are assessed over time and along the way many laws and regulations are developed that challenge the issues head-on, because after all laws are created with the intent to protect the safety and well-being of society. The legislative processes involved with this creation and reform of laws is critical to the success or failure of the technology, particularly with society’s ability to adapt to and accept the technology. Consideration of how a technological innovation impacts a society, for better and worse, must be at the forefront of lawmaker’s agendas. Engstrom (2013) poses three important questions for these lawmakers to consider: “Will it fit? What must change? Where are the pitfalls and opportunities?” (p. 36).

**B. Security and Safety Concerns**

In addition to the large number of policy issues posed by a new technology, security and safety concerns are also paramount in ushering in the widespread use of the technology. Engstrom (2013) indicates that inevitably there will be “complex, sophisticated, and dangerous” (p. 37) products that are created via 3-D printing.

**1. Gun control loopholes.**

The most publicized case of safety-concern pertaining to 3-D printing is that of the 3-D printed gun. In 2012, the Wiki Weapon Project began work on creating a working pistol created by a 3-D printer; The Liberator, as it was named, almost instantly received backlash from the U.S. Department of State when it was successfully developed and its ensuing CAD files were made available to the public via the Internet (Bryans, 2015, p. 901). The files were subsequently removed, but this raised the profound question of how regulation would need to be applied to many 3-D printed items, especially those that directly affect the public’s safety. The ability to bypass traditional processes used when purchasing a firearm were in essence completely bypassed when CAD files for a firearm were released over the Internet, allowing anyone with a 3-D printer to get a working gun into their hands with minimal effort. I think a majority of us would understand the decision to disallow items like guns to be so easily shared and produced, but it raises the important question, that with such an advanced capability to create and produce where do we draw the line and who decides how it is drawn? Ultimately we need to keep in mind that while we do need to be protected, we also cannot hinder the prospect of technological advancement.

**C. Creation and Reform of Laws**

One of the major hurdles with instantiating any new technological revolution (think, the Internet) are the regulatory challenges that are ultimately presented any time the scope of a technology is so potentially widespread, as is the case with 3-D printing. Osborn (2014) sums this up in his statement that “the difficult part, as always, is maximizing the benefits and minimizing the problems of the new technology” (p. 593). There are a number of critical points regarding regulation and law that must be addressed, and ultimately we rely on government policy-making to provide a large part of this. We must explore the potential challenges a government’s legislative bodies may face, and even pose on the technology, when attempting to define regulations for a new technology of this scale.

**1. How will new technology be governed?**

There are a large number of factors and approaches that must be addressed when ushering in a new technological age. Environmental law, product liability law, contract law, and even criminal law are just a few of the areas that must be considered and defined. Of course some of these areas are too engrossing to detail at length in this research section, but understanding the sheer size of the challenges involved is necessary to begin the discussion of how a technology as limitless as 3-D printing can potentially be governed and regulated. There are multiple avenues to attempt to govern, including heavy government regulation and conversely minimizing government intervention in the sense that none, or not many, new regulations would be created that apply directly to the new technology.

Essentially it could be decided that we let the technology fall under the guidelines of preexisting laws and regulations and only deal with new or unforeseen circumstances on a case-by-case basis. This could be classified as a “private ordering” governance in which we apply known definitions or “norms” to the use of the technology and by doing so enact self-governing practices (Osborn, 2014, p. 593). The issue with self-governance and development of norms is the fact that ultimately the government bodies are called to action when paramount legal issues arise.

The alternative is a hands-on governmental approach that attempts to reform or reestablish laws with the context of the new technology in mind. This is a difficult task when the technology is still in its infancy stage in terms of creation and application potential. How can laws be created when their application is still vastly unknown? A good reference point is the United States Constitution. We can create laws (or regulations) that pertain broadly to the technology in the context that we understand it today, and then amend these laws over time as applications develop and change. Regardless of which option is ultimately adopted when it comes to governance of 3-D printing, government involvement is inevitable whether in the form of proactive or reactive approach.

While it may not be possible to avoid government regulation, as it will be part of any processes in some form, it is important to minimize and limit government interference. We must prefer administrative action over traditional legislation in order to aid this next technological revolution. Nielson (2015) indicates that we can achieve this by continuing “to involve the 3-D printing industry before seeking to regulate” (p. 621), and also mentioning that it’s best to involve the courts if necessary rather than rely on the slow-acting legislative body. It is paramount in this new technological revolution to encourage progress and innovation in any way rather than stifle it.

**D. Intellectual Property Issues**

When considering all policy and regulation challenges involved with additive manufacturing, probably none is as widespread as the effects the technology may have on intellectual property law. Patent infringement, copyright concerns, trademark law, and even counterfeiting are some of the hot topic issues that are frequently referenced when discussing 3-D printing. The issue can be easily summarized when you think about it in the context that due to 3-D printers quickly becoming much more affordable and popular, many more people will have access to creating a wide range of products from their home. The power to create also leads to the ability to sell, and it is at this point the lines begin to blur between hobbyist and commercial-producer.

**1. Ownership of ideas and patent system.**

The heart of 3-D printing lies in open-source, freely-shared computer-aided design (CAD) files that serve as the blueprint for products to be made out of raw materials (Grace, 2014, p. 264), the fundamental principle in additive manufacturing. The issue with open-source distribution of CAD files then becomes allegations of infringement when someone at home has the ability to produce products that have already been patented. Not only is the home-creator liable in being implicated in this, but also the file distributors and even the makers of the 3-D printers. As of right now it remains to be seen how new circumstances introduced by widespread home-use of 3-D printing machines will be handled in the legal system, but as it stands 3-D printing encroaches on a number of current patent law provisions.

The most obvious response to intellectual property concerns as they apply to the 3-D printing revolution is to have the industry giants who claim ownership to many of these product patents and copyrights produce and sell the CAD files directly to the public. In addition, in order to avoid much of the detailed legal provisions that deal with specific patent issues, different mechanisms and technology can be incorporated into the 3-D printing machines that alter the way they actually perform their additive manufacturing techniques. Selective sintering, which Lewis (2014) describes as “the process by which a laser heats powder and fuses it into the desired shape” (p. 317), could be one of these processes that helps the 3-D printing revolution overcome any substantial infringement concerns primarily due to the fact it’s patent expired in 2014. As we move into a new era of technological innovation, using patent expiration to explore alternative methods of creation as well as encourage the open-source (even if paid) spirit that 3-D printing provides will help move us into what could possibly be the next great Industrial Age.

**VII. Economic Questions and Considerations**

Additive manufacturing over the years has grown from its original application in rapid prototyping into being able to do the actual manufacturing of the objects themselves via 3-D printing in the context we know it today. As one can imagine, any time a new technology has the ability to alter manufacturing and production, such is the case with 3-D printing, there will inevitably be a shift in not only social connotations but also will have profound economic implications. Just as the industrial revolution of the last 200 years brought about significant changes to manufacturing processes and ultimately set forth the economy we know today, many of the changes and opportunities the 3-D printing technology can offer will end up revolutionizing production standards and spark a new economic structure. This structure is one that sees a shift and a rebalance between traditional economies of scale and that now of economies of one. It is important to understand the effects that this shift will have on the global economy as a whole as well as consider what is in store for the future revolution this technology may ultimately bring.

**A. Effect on Industry/Manufacturing**

It is estimated that the worldwide market for additive manufacturing will see an increase of 390% over the next seven years (Jenkins, 2015, p. 20). While this is an astonishing projection in itself, the notion that 3-D printing empowers the individual to design and create is the most important point of contention. From this we can begin to see how a change in economic structure is potentially brewing should the projected success of the technology be achieved or even exceeded. 3-D printing gives the individual the ability to create and customize and ultimately fosters the notion of “do it yourself” which leads many to believe that it directly challenges and disrupts the traditional patterns of mass-production (Hansen, 2015, p. 120).

With 3-D printing and what it offers to the individual, the creator, and the inventor, we begin to reshape the idea of mass production. A shift from highly manual labor and production to more high-tech thought processes and design is what’s creating this separation between traditional manufacturing and the manufacturing capability that 3-D printing affords the individual. This “economics of one” approach is not, however, one that replaces mass production but rather supplements many of the traditional manufacturing processes. Large volume production is not something 3-D printing can yet sufficiently achieve due to issues with production speed, level of accuracy, as well as repeatability and reliability concerns of additive-manufactured technologies (Mahamood, 2014, p. 171). This means that big industry is still able to flourish as it excels at large scale manufacturing and quick production, while additive manufacturing can help supplement the product market with unique, highly customized products as well as helping to create many of the raw materials, such as plastic parts, that are widely used in many of the modern production machines used today in mass production (Bargelis, 2014, p. 20).

**1. Shift in world’s manufacturing centers.**

“Think globally, produce locally” (Martin, 2014, p. 35) is one of the key thought processes that fuels the spirit of 3-D printing and serves as a statement that attempts to summarize the effects that the technology will ultimately have on the world’s manufacturing processes.Additive manufacturing has the potential to change the ways business currently manufacture and operate. An example of this is the ability for an aircraft company to produce spare parts on demand and consequently doing so not only reduces the reliance on outside production but also reduces holding stock, which increases profitability and efficiency all around (Atzeni, 2012, p. 1147). This example is that which illustrates the highly technical nature and application of additive manufacturing technologies. Presumably a highly skilled engineer and equipment operator work in tandem to design and manufacture these aircraft parts in-house.

Additive manufacturing ushers in a significant alternative to how products and materials can be created. We see a shift from highly manual labor where workers break down materials (traditional manufacturing) using tools to a much more calculated and technical method of production. The fact that engineers can create designs, put them in file format, and then an operator can load the files and supply the appropriate raw materials to a 3-D printing machine helps illustrate the technical power and progress that new additive manufacturing technologies introduce. As one can imagine, using a 3-D printer both to design and produce requires much more technical knowledge and application than a manual laborer who uses tools to manipulate materials. What this likely means is that with a rise in additive manufacturing comes a rise in a highly technical, trained workforce needed to design for and operate the machines. The idea that 3-D printing allows an operator (per machine) to manipulate and create from raw materials aims to rebalance the world’s established manufacturing centers.

**B. Associated Cost of Technology**

The innate nature of 3-D printing being design-focused is critical to its ability to serve as a highly influential product in manufacturing. Eliminating many of the issues common to traditional manufacturing helps the valuation and potential of the technology as a whole. To start, the cost of 3-D printers have recently begun to become much more affordable, with prices of notable consumer-grade models ranging from $1100 to nearly $25,000 with key cost variation based on max printable area, printing technology, and whether the device comes assembled or not (Martin, 2014, p. 31). Due to the open-source nature that fuels the 3-D printing community, the hardware itself becomes the largest cost in a startup-venture. Of course that still leaves the cost of raw materials, but this is static to any production/manufacturing method. Jenkins (2015) proposes that “if machines get faster and less expensive, and that is coupled with low-cost fee-stock, the markets will boom” (p. 22).

**1. RepRap and implications for operating cost.**

The RepRap project is a revolutionary display of what 3-D printing can potentially offer. With its first model released in 2007, what makes the RepRap a unique 3-D printing device is its ability to completely print the components used to create itself (Bogue, 2013, p. 311). This is monumental not just in technological achievement terms, but also in what it implies for operating costs of 3-D technologies. Not only is the RepRap one of the most affordable 3-D printers currently on the market at ~$1100, it also allows for a generous “max printable area” of 210x190x140 mm (Martin, 2014, p. 31) which shows that it is also highly functional. This is primarily achievable because of the fact it can replicate itself which helps lower production costs and increase distribution of the machines dramatically. In addition, the RepRap is a forerunner in using recyclable materials which is another pinnacle in 3-D printing because often the raw materials used or created from additive manufacturing are plastics. An important principle of additive manufacturing in general is the fact that material is added and not subtracted (such is the case in traditional manufacturing) which helps foster an idea of “maximum material savings” (Petrovic, 2011, p. 1063). With raw materials being a static piece of manufacturing, the ability to so greatly minimize waste and reduce/reuse materials is one glistening point in favor of additive manufacturing.

The RepRap and all of its innovative methods of operation are monumental in bringing 3-D printing to the masses without the need for a costly infrastructure. Self-sustainability and low entry and operation costs are landmark in the additive manufacturing process and the release of the RepRap has since inspired many more 3-D printer makers to produce models with similar specifications, which is good news for the prospects of the industry overall. RepRap as an example of a self-replicating machine indicates just how impactful 3-D printing technologies may in fact be to manufacturing and transitively the world economy, and perhaps gives most credence to the notion that additive manufacturing by way of 3-D printing is in fact the next industrial revolution.

**C. Future Economy and Automate Manufacturing**

A qualitative and quantitative analysis can be applied to 3-D printing and its effects on industry, manufacturing, and the economy. When performing this analysis, we can begin to see that 3-D printing, still in its infancy stages, may still be somewhat under-developed quantitatively, as it is still very niche and the average consumer has probably not yet had experience with one, let alone used one for manufacturing. For this reason, we must understand and emphasize the qualitative properties inherent to the technology. 3-D printing at its root presents an alternative to traditional manufacturing processes and by doing so opens avenues for the consumer to become the creator. Petrick (2013) states that **“**bursts of innovation happen when an emerging technology removes a once prohibitive barrier of cost, distance, or time” (p. 15). This statement can be illustrated by highlighting the customization, material savings, reduced human error, and reduced time-to-market as just some of the potential advantages that the technology offers (Petrovic, 2011, p. 1063).

In this discussion of 3-D printing the capability of production and potential for the technology has been stated many times. As of right now, “potential” is a word that resonates deeply with the technology as a whole. The reality is 3-D printers have primarily been used for prototype purposes thus far. In the future, if many of the aspects discussed pan out and reach their full potential, production on a much larger scale *will* be achieved. Ultimately it is the qualitative advantages additive manufacturing offers over traditional manufacturing that makes it so appealing economically, and one day may also allow it to ultimately achieve superior quantitative standards. With the technology being so highly technical in nature, it is probable that we will see a shift away from manual labor (the technology itself encourages this) and instead will see much more automation in terms of letting the device do the work which, again, promotes many of its qualitative standards (Bargelis, 2014, p. 21). Overall, 3-D printing’s potential value and importance is being further shaped and defined each and every day as we head into the future, and the shape that is ultimately formed aims to have a significant impact on not only the economy, but also society as a whole.

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