

Symposium: The Legal Dimension of 3D Printing

The New Steam: On Digitization, Decentralization, and Disruption

DEVEN R. DESAI*

Digitization is the new steam. Steam allowed us to leverage like never before and spawned a series of new offerings and new needs. The steam era started with many competitors and inventors and ended with only a few concentrated winners. The winners contributed vast amounts to society and spawned a need for new laws, from antitrust to product liability to intellectual property to securities, and more. Just as steam disrupted old industries and fostered new ones, digitization is providing the same changes today. Digitization opens the door to decentralized production, lower costs, and disruption of incumbents, but digitization does not mean perpetual disruption is at hand.

In this essay, I begin to set out why new, centralized winners will emerge. Digitization spawns an abundance of person-to-person transactions but with the problems of impersonal transactions. Copyright industries were some of the first to experience the change from few to many producers. Technologies such as 3D printing, synthetic biology, and nanotechnology further the shift from centralized to small and local production. Although some champion disruption and new businesses, a paradox of centralized production and markets with fewer players is that such sectors are easier to regulate. The ability of almost anyone to make guns, sell harmful software, or produce other sophisticated offerings removes that easy pressure point. Put differently, even though digitization enables decentralized, lower-cost production, economic questions will remain. We must understand what they are and why they persist to see what the future may be.

* Associate Professor of Law and Ethics, Georgia Institute of Technology, Scheller College of Business; J.D. Yale Law School. This Article has benefitted from the input of Brett Frischmann, the attendees of The Legal Dimension of 3D Printing Symposium at the University of California, Hastings College of the Law, and the *Hastings Law Journal* editors. I thank all for their help.

In simplest terms, transactions costs related to safety, quality, property rights, contracting, and knowledge may be more acute in a digitized, decentralized world. I offer that companies such as Uber, Lyft, Airbnb, Google, Apple, Amazon, and eBay, have thrived, in part because they have enabled decentralized production to operate at scale. In addition, as established players understand digitization and network technology better, they have adapted to the new marketplace. For example, rather than giving consumers a music or video file, part of the copyright industry has shifted to streaming music and video. Consumers have access to the content with no fear of malware but lose the ability to manipulate that content. This strategy could be used to limit 3D printing and other creative technologies. Instead of having design files that can be altered, consumers will stream a file for the specific design. Many may welcome this shift, because they are not tinkerers but instead are simply consumers who want a safe, stable product or service. But that stability flows from centralized players. In short, this era of disruption and decentralization will likely pass and new winners, who will look much like firms of old, will emerge, if they have not already.

The explosion of decentralized production challenges core, unstated presumptions in the law. Of late, 3D printing has caught the attention of business and academia. 3D printing fascinates us as a potential Star Trek replicator, but it is not there yet. Given the ever-increasing ease of making physical things at home, however, 3D printing promises to unleash creativity and challenge incumbent industries much the way digitization challenged and reordered the music, book, and film industries. It is easy to think that this technology relates mainly to intellectual property (“IP”). But the *Hastings Law Journal* has smartly put together a symposium to look at this technology in a broad context. As the symposium’s sessions reveal, not only IP law, but also tort and sector specific laws such as gun and food and drug law, struggle once digitization takes hold. I am honored to write this Introduction because it provides the opportunity to begin engaging with the larger implications of digitization and society.

Much of our current system rests on an unacknowledged equilibrium. Our system assumes that specialization, division of labor, and large markets work in a certain way, or at least that the system is somewhat static regarding these matters. Digitization and networking technology alter that balance in every industry they touch. One way to think about these effects is whether the way we regulate an activity scales. That is: what happens once digitization takes a practice that was once limited to a few actors, and allows almost anyone to engage in it? The answer is that our premises and systems are disrupted. I offer that the simplified story—that much of our legal system flows from the rise and nature of industry in the steam and railroad era—is both accurate and flawed. It is accurate in that our laws tend to operate well when dealing with limited numbers of actors. Those actors tend to be firms, and they are often large ones. It is flawed, because when technology changes those premises, the system falters.¹ The claims that emerged to explain or justify the old system do not work as well as they used to, and the fights over government policy are fierce. The task is to set out why these fights occur and how to identify questions for policy going forward.

Although digitization affects more than IP law, the first area where digitization began to show cracks in the system, IP is instructive regarding digitization, decentralization, and disruption. Intellectual property tells a story. The tale is one of public goods.² The cost to develop a patent,

1. Cf. Douglass C. North, *Capitalism and Economic Growth*, in *THE ECONOMIC SOCIOLOGY OF CAPITALISM* 41, 45 (Victor Nee & Richard Swedberg, eds., 2005) (“[W]e are evolving political/economic/social structures that are radically different and more complex than any in our past and therefore the evolving human environment has no historical precedent from which to derive theoretical inspiration.”).

2. Many authors have documented and explained this point. For an insightful exploration of the problems with the relationship among public goods, natural monopoly, and IP policy, see Shubha

make an album, or write a book is high; the cost to make many copies afterwards is low. The cost to infringe is low, because the developer incurs risk and costs while others can appropriate the work once it is publicly available. Without structures in place to protect that initial investment, why would anyone produce these goods? Yet the fights over music copyright ownership and distribution revealed that the music business and the policies around it assumed that costs to make and distribute copyrighted goods would be high forever. With digitization, those costs dropped. A flood of infringement followed. But a flood of new works followed as well. Digital tools that had allowed garage bands to record and mix music at home improved to the point that expensive studio production was not necessary except for highly sophisticated work. Digital distribution meant that refined and widespread creation was no longer limited. The claim that music would stop being produced was proven false.³ The incumbents had to retool their business models. High cost intermediaries and distribution networks changed. A world of four or five major labels controlling close to eighty percent of the market shifted, and a host of smaller labels produced more music. Artists sold their work directly to consumers. Apple's iTunes, Amazon, and Google Play began selling singles at ninety-nine cents to a dollar and thirty cents. Rhapsody and Spotify developed subscription services. Concerts became a major source of income. After some legal fights, YouTube came up with a system to allow rights holders to identify potentially infringing works, and offer ways to make money for uses previously too expensive to negotiate, even through rights collectives such as the American Society of Composers, Authors and Publishers, or Broadcast Music, Inc. In sum, digitization and network technology shifted the way music is created, sold, and monetized.

The market changed, but it was not destroyed. The specialization, division of labor, and type of market that accompanied early forms of music production were less necessary. Key transaction costs relating to quality and production went down. At the same time, protecting rights, enforcing agreements, and integrating dispersed knowledge in society posed new challenges.⁴ Some of those were met. Some incumbents were unhappy as new entrants rose to dominance, but that is not a legal problem. That is competition in a market.

This history makes it easy to think that digitization and networking affect only IP. That is a mistake. These shifts are just the beginning of a full overhaul of our economic and related legal structures. 3D printing is

Ghosh, *Decoding and Recoding Natural Monopoly, Deregulation, and Intellectual Property*, 2008 U. ILL. L. REV. 1125, 1157–58.

3. See generally Julie E. Cohen, *Copyright as Property in the Post-Industrial Economy: A Research Agenda*, 2011 WIS. L. REV. 141 (discussing other incentives to create copyrighted works).

4. See North, *supra* note 1, at 47.

an excellent example of technology that opens the door to both desired and feared outcomes, and challenges assumptions in our legal and economic systems. Although the technology has important implications for IP, it also reveals the larger disruptions fostered by digitization. To reiterate, the need for specialization and division of labor decreases, which alters the analysis of what the law is and should do.

Technology always poses opportunities and problems for businesses, as well as the laws that inform and shape business practices. At certain times, these laws seem to support a wide range of activities. At other times, these laws seem to hinder a wide range of activities. The ability to use 3D printing technology to make guns provides but one example of the way technology can shift commercial activity and our understanding of what is and is not permissible. As Rory K. Little argues, the technology distracts from the core issues about gun regulation.⁵ Yet the shift in technology calls into question how much our society wants to embrace ubiquitous gun ownership. It also rubs against the myth and reality of an individual being able to design and make items for personal use.

Under federal law, anyone can make a gun at home. This rule may stem from deference to certain views about the Second Amendment. It may also have been unexamined, because until recently, the cost and skill needed to make a gun at home was high. Using lathes and milling tools, understanding material science, and so on, is not simple. In the parlance of computers, making a gun at home is not plug and play. Even that barrier is, however, dropping. For example, a company called Carbide 3D LLC is developing a home milling machine that it hopes to sell for two thousand dollars. As they put it, a Computer Numerical Control (“CNC”) mill can make the perfect prototype and is a tool “at the heart of the manufacturing industry.”⁶ Carbide’s mill can be used to cut a variety of materials, including plastics, wood, aluminum, brass, bronze, tooling boards, wax, and foam.⁷ Carbide has not yet tested the mill’s ability to cut hard metals.⁸ The shift to lower-cost, home ready CNC machines, combined with 3D printing’s rapid advances, shows that the number of people who can make a complicated and potentially dangerous item at home is limited only by the cost of the machine and the materials—both of which are becoming less of an obstacle. But, there is still some skill involved in assembling the parts. As with buying furniture from IKEA, there will likely be instructions on how to deal

5. *SEE GENERALLY* RORY K. LITTLE, *Guns Don’t Kill People, 3D Printing Does? Why the Technology is a Distraction from Effective Gun Controls*, 65 HASTINGS L.J. 1505 (2014).

6. *See* Carbide 3D LLC, *The Nomad CNC Mill*, KICKSTARTER, <https://www.kickstarter.com/projects/178590870/the-nomad-cnc-mill> (last visited Aug. 1, 2014).

7. *Id.*

8. *Id.*

with “some assembly required.” A relatively unskilled person can now make a sophisticated, dangerous item. Thus, the legality and ideal of a rugged individualist making a gun at home was less of an issue, because so few could plausibly do it.

Automobiles raise similar issues, and show why firms play a special, underappreciated role in regulation. If one buys a kit and assembles a car, the normal safety requirements do not apply. This fits the industrious home inventor image. Yet, with 3D printing, groups are making cars with a crowd-sourcing approach. Designers who may not have had a chance to design cars for Ford or Toyota join together online and design a car to specific cost goals. Car parts are digitized and shared for enthusiasts and repair shops to use in vehicles already on the road. As more people design cars and car parts for personal manufacture, the effect of little to no safety regulation will go up. The ability to regulate those practices will go down. The same applies to guns. A commercial-level gun manufacturer is easier to identify and license than a home one. In short, digitization democratizes almost any sector it touches. There is an irony here. Any technology that opens the door to large-scale experimentation and invention by garage inventors or home hobbyists—or that offers even simpler beneficial effects like sharing books and music so others can learn—reduces, if not removes, the need for a centralized manufacturer or distributor. Therefore the ability to have centralized control and regulation of the sector is lower as well. Widely distributed practices are more difficult to regulate. That is not new, but it is more acute with digitization.⁹

The key lesson is not that a given technology causes the problem. As Little argues, the issue should turn on the practice we wish to regulate and not the technology.¹⁰ If we want to prevent unlawful possession and use of guns, certain cars on the road, or any item that poses a problem for society, trying to limit the technology is a mistake. The issues should turn on the products of technology and their disfavored uses. At the

9. As discussed below, another irony is that digitization can also be used to increase the amount of control and regulation possible. Thus, another mistake is to assume that information wants to be free or cannot be governed. Privacy and surveillance literature regarding state and private sector monitoring have developed this critique at length. *See, e.g.*, Deven R. Desai, *Beyond Location: Data Security in the 21st Century*, 56 *COMMS. OF THE ACM* 34, 36 (2013) (explaining that increased ability to track data for security reasons allows for increased surveillance); Julie E. Cohen, *What is Privacy For?*, 126 *HARV. L. REV.* 1904, 1912 (2013) (“A society that permits the unchecked ascendancy of surveillance infrastructures cannot hope to remain a liberal democracy. Under such conditions, liberal democracy as a form of government is replaced, gradually but surely, by a different form of government that I will call modulated democracy because it relies on a form of surveillance that operates by modulation. Modulation and modulated democracy are emerging as networked surveillance technologies take root within democratic societies characterized by advanced systems of informational capitalism.”).

10. *See generally* Little, *supra* note 5.

same time, as Ben Depoorter shows, digitization “creates unique practical, as well as normative obstacles that render all forms of property rights enforcement troublesome.”¹¹ It is the tension between a given outcome—such as the ability to produce a gun or living tissue at home—and the general questions of regulation and property rights that denies easy answers for how to address increased digitization. Intellectual property again provides insights about the problem.

Ambiguity about what is allowed can open the door for new businesses, or it can deter and even defeat a new entrant. The problem is that one cannot know how the law will perceive issues raised by new technology.¹² In addition, the potential benefits to incumbents, new entrants who increase competition, and consumers are not clear. As Depoorter has explained, “[t]he initial ambiguity of the socioeconomic implications of a new technology can be illustrated, for example, by peer-to-peer music exchanges. The music industry discovered that huge profits could be made by delivering music in a compressed format (MP3) only after such exchanges were already relatively common.”¹³ Even before that moment in copyright history, one could argue that the music industry was blind or missed the importance of digitization until deep shifts in the market had already taken hold.¹⁴ The deeper irony is that the music industry thought it understood digitization. It was at the table and negotiated for significant limits on one type of digitization during the drafting of the Audio Home Recording Act. The carve out for recordable CDs and the use of a computer to record music probably seemed innocuous, because everyone was thinking about recording onto audiocassette, the next step in the dominant medium for home copying. The audiocassette was the source of copying feared by the industry, so the standard move was to limit the future of the technology. Of course, that shift did not work. Nonetheless the music industry did not vanish. It reoriented its practices, and new leaders emerged.

Some take these changes to mean the end of scarcity or creation of a world of overabundance, but that interpretation misses the rise of new firms and market demands that remain even in a digitized world. Nonetheless, Jeremy Rifkin has argued that we are approaching zero marginal cost:

11. Ben Depoorter, *Intellectual Property Infringements & 3D Printing: Decentralized Piracy*, 65 HASTINGS L.J. 1483, 1486 (2014).

12. *Id.*

13. Ben Depoorter, *Technology & Uncertainty: The Shaping Effect on Copyright Law*, 157 U. PA. L. REV. 1830, 1841–42 (2009).

14. See Peter S. Menell, *Envisioning Copyright Law's Digital Future*, 46 N.Y.L. SCH. L. REV. 63, 99 (2002) (“Even with the introduction and rapid popularity of digitally-encoded compact disks (CDs) and the proliferation of microcomputers beginning in the early 1980s, the record industry did not appreciate the dramatic changes that would be brought about by the emerging digital technologies.”).

At the heart of capitalism there lies a contradiction in the driving mechanism that has propelled it ever upward to commanding heights, but now is speeding it to its death: the inherent dynamism of competitive markets that drives productivity up and marginal costs down, enabling businesses to reduce the price of their goods and services in order to win over consumers and market share. (Marginal cost is the cost of producing additional units of a good or service, if fixed costs are not counted.) While economists have always welcomed a reduction in marginal cost, they never anticipated the possibility of a technological revolution that might bring marginal costs to near zero, making goods and services priceless, nearly free, and abundant, and no longer subject to market forces.¹⁵

Mark A. Lemley has made a similar claim: “Economics is based on scarcity. Things are valuable because they are scarce. The more abundant they become, they cheaper they become. But a series of technological changes is underway that promises to end scarcity as we know it for a wide variety of goods.”¹⁶

The shifts that arise here are not ones of utopian replicators, and they are not truly about scarcity at all levels. As Lemley notes, costs to infringe played a major role in infringement in the music and copyright.¹⁷ As Gerard Magliocca and I offer in our work on 3D printing, costs to infringe have played a large role in keeping the patent system stable.¹⁸ Patent law requires the disclosure of how to make the subject of the patent; yet infringement is not rampant.¹⁹ The costs to infringe—building a factory, buying materials, learning design, and so on—were high; the digitization of things reveals that those costs are dropping. 3D printing, synthetic biology, robotics, nanotechnology, and more do not end scarcity. They erode the need for, or alter the role of, large firms.²⁰ They indicate that fewer firms are needed for specialization and that division of labor becomes rarefied. Thus, if we accept that in some cases, as in movie or pharmaceutical production, there is a public goods and a related IP problem, maybe it is true that there would be an under-

15. See Jeremy Rifkin, *The End of the Capitalist Era, and What Comes Next*, HUFFINGTON POST (Apr. 1, 2014, 4:59 PM), http://www.huffingtonpost.com/jeremy-rifkin/collaborative-commons-zero-marginal-cost-society_b_5064767.html.

16. See Mark A. Lemley, *IP in a World Without Scarcity* 1 (Stanford Pub. Law, Working Paper No. 2413974, 2014), available at <http://ssrn.com/abstract=2413974>.

17. *Id.*; see generally Mark A. Lemley & R. Anthony Reese, *Reducing Digital Copyright Infringement Without Restricting Innovation*, 56 STAN. L. REV. 1345 (2004) (documenting this shift in costs).

18. See generally Deven R. Desai & Gerard Magliocca, *Patents, Meet Napster: 3D Printing and the Digitization of Things*, 102 GEO. L. J. (forthcoming 2014).

19. As Ghosh explains, if public goods or natural monopoly logic is to justify IP, the costs argument faces a problem. Ghosh, *supra* note 2, at 1159 (“Complex chemical and industrial processes protected by patent are not cheap to copy. In these cases, where fixed costs are not high and the costs of copying are not low, arguments for intellectual property protection seem not to parallel natural monopoly arguments at all. Instead, the rationale lies more likely in natural rights or authors’ rights.”).

20. *Cf.* Lemley, *supra* note 16, at 6 (noting that IP is a type of regulation).

production of the goods or services that we think we want. But when a sector demonstrates not just copying, but increased production, new entrants, and new offerings, the scarcity that has disappeared is the scarcity of producers in that sector. Rather than a small number of firms competing and producing, there may be a large, distributed number of machines and/or firms that can produce a good or service. In such sectors, Lemley is correct that we are entering “a world without scarcity,” but it is a specific type of scarcity.²¹ Insofar as a given world or industry relies on IP to sustain it, the justification for that IP becomes difficult to maintain at least on a public goods argument.²² But these changes affect areas beyond those governed by IP and public goods problems. Two business areas, hotels and taxis, help see this point.

The hotel and taxi industries have been stable for years, but now both industries have had to cope with newcomers. Thanks to online exchange services and GPS, barriers, such as the cost of connecting with customers, dispatching cars, and knowing the layout of a city, have gone down.²³ Services like Airbnb, which allow people to turn their homes into small hotels, and Uber or Lyft, which allow people to use their cars as taxi services, are changing the hotel and taxi industries. Some value Airbnb at \$10 billion—more than Hyatt or Wyndham hotels—and one informal taxi service recently raised \$250 million in venture capital funds.²⁴ The incumbent industries have argued that the upstarts are not complying with health, safety, insurance, tax, and other regulations.²⁵ Those regulations are costs that the newcomers currently evade. Yet they still have costs for the rooms, food, cars, and other amenities that customers want. Although lower costs play a role here, these services are less scarce, because the need for specialized offerings and division of labor has gone down. Anyone can be a hotel operator or taxi driver on a part-time basis with an asset that otherwise sits idle, such as an extra bedroom or a car sitting in a garage.

Put differently: even with digitization, economic questions will remain, but we must understand what they are and why they persist to see what the future may be. Douglass North captures a paradox that goes with transaction costs. Greater specialization, division of labor, and a large market increase transaction costs, because the shift to impersonal transactions demands higher costs to: 1) measure the valuable dimensions of a good or service; 2) protect individual property rights;

21. *Id.* at 1.

22. *See id.* at 5–6 n.5.

23. Rifkin is correct that digital networks are a big reason that these new offerings can emerge.

24. *See The Sharing Economy: Remove the Roadblocks*, THE ECONOMIST (Apr. 26, 2014), available at <http://www.economist.com/news/leaders/21601257-too-many-obstacles-are-being-placed-path-people-renting-things-each-other-remove>.

25. *Id.*

3) enforce agreements; and 4) integrate the dispersed knowledge of society.²⁶ Standardized weights and measures, effective laws and enforcement, and institutions and organizations that integrate knowledge emerge, but the “dramatic increase in the overall costs of transacting” is “more than offset by dramatic decreases in production costs.”²⁷ Digitization forces us to revisit these issues.

With digitization, we are seeing an abundance of person-to-person transactions, but with the problems of impersonal transactions.²⁸ In each example of digitization’s challenge to an industry, a pattern emerges. In the early stages, the technology lowers production costs and thus reduces the need for specialization and division of labor. That opens the door to person-to-person transactions and permits evasion of many transaction costs. Music moves freely across the Internet. Homeowners let rooms to tourists. Designs are shared, and physical items such as toys are made at the consumer’s home rather than a factory. Cars are turned into taxis. In each case, laws—including IP, tort, and public safety—may apply. However, in the early phases, these organizations may ignore these laws or believe them inapplicable as to the services they are providing. And, regulators may not demand compliance, in part because the offerings are small or do not fit into easy categories. The lack of regulation and the nature of digitization allow the new offerings to scale quickly. In one way, the shift is a return to face-to-face transactions. And yet the market is now dispersed. Instead of repeat players, we have many buyers and sellers, or purveyors of files, or offerors of rides, or guests in one’s rooms.²⁹ Each case presents middle stage problems as the offerings mature. Without repeat players, these businesses could fail.³⁰ Sellers may rip off consumers; consumers may cost too much to track down and prosecute (think of a guest who destroys an Airbnb room). Taxi drivers may crash and fail to have insurance. Goods made with a 3D printer may choke a child or cut someone. Music, video, or design files may damage a computer. As incumbents start to see threats, they make a range of arguments against the new players—they are committing theft (IP), are unsafe (3D printing, synthetic biology, taxis, Airbnb), or are scofflaws for not paying taxes and complying with regulations. Law and policy makers must be careful not to take the claims at face value.

26. See North, *supra* note 1, at 47.

27. *Id.*

28. See Ko Kuwabara, *Affective Attachment in Electronic Markets A Sociological Study of eBay*, in *THE ECONOMIC SOCIOLOGY OF CAPITALISM*, *supra* note 1, at 269.

29. Cf. North, *supra* note 1, at 46 (noting the problems of “shift[ing] from personal to impersonal exchange” involve “reciprocity, repeat dealings, and the kind of informal norms that that tend to evolve from strong reciprocity relationships”).

30. See *generally* Kuwabara, *supra* note 28, at 268 (studying eBay and how feedback, even if motivated by emotional and gift-giving factors rather than purely rational ones, thrives because it addresses the repeat player problem).

The new options may not fit our current notion of how things should work, but that may be because the new options are just that: new. We have no good point of reference from which to assess them.³¹ And the arguments may be directed more at protecting an incumbent business and rent seeking than at desired outcomes for society and the economy as a whole.³² The outcries of incumbents matter not because lawmakers ought to heed the cries. The outcries let people know something has changed. Poor press, the threat of new regulation, or potential legal action may force private adaptations, such as building reputation systems (eBay), requiring insurance (Uber), developing tools to aid enforcement of rights (YouTube's content ID), or creating a robust, third-party clearinghouse (Amazon Marketplace). Other responses, such as commons-style management or cooperative norms within communities, may also emerge.³³ These responses track North's point about what happens with moves away from face-to-face business, but reveal that there is not one simple solution.

Closer inspection reveals that digitization could easily lead to a new wave of specialization, division of labor, and large markets with a few players controlling much of the market and new modes of regulation and control taking hold.³⁴ The quality problem—dubious music files, potentially poor design files for 3D printers, trust of unknown sellers and

31. This idea is sort of a Kuhnian moment, in that with a true paradigm shift, the incumbents and devotees of the old system will fail to recognize the new way of thinking and instead stay with commonly held beliefs. See, e.g., SERGIO SISMONDO, AN INTRODUCTION TO SCIENCE AND TECHNOLOGY STUDIES 25 (2004). (Kuhn sees scientific education as “authoritarian, militating against skepticism in favor of specific general beliefs.”); cf. North, *supra* note 1, at 46 (“The set of mental models, categories, and classifications of the neural networks that have evolved in our belief system through which the new evidence gets filtered has no existing pattern that can correctly assess the new evidence.”).

32. North, *supra* note 1, at 46.

33. See, e.g., Francis Fukuyama, *Still Disenchanted? The Modernity of Post-Industrial Capitalism*, in THE ECONOMIC SOCIOLOGY OF CAPITALISM, *supra* note 1, at 79.

34. Cf. Lemley, *supra* note 16, at 41 (noting a possible “dystopian” future where “a few large companies get the right to decide what sorts of innovation are permissible”). I am not sure that these groups will get to decide what is possible directly, but insofar as Lemley is pointing out that just as previously powerful, incumbent industries shaped rules and practices for their ends, so too can the new ones. The argument shows why we should be cautious about any group's claims over what is required for innovation, especially when an industry demands legal protection or exerts market control. It is not a given that technology always leads to a decrease or increase in the number of firms. See, e.g., Richard N. Langlois, *The Vanishing Hand: The Changing Dynamics of Industrial Capitalism*, 12 INDUS. AND CORP. CHANGE 351, 379 (2003) (arguing that “the managerial revolution—in this interpretation—is a temporary episode that arose in a particular era as the result of uneven development in the Smithian process of the division of labor”); Hal Varian, *A New Economy With No New Economics*, N.Y. TIMES (Jan. 17, 2002), <http://www.nytimes.com/2002/01/17/business/17SCEN.html> (“It just doesn't follow that lower communication costs lead to smaller companies. In fact, Mr. Coase himself said that ‘changes like the telephone and telegraphy, which tend to reduce the cost of organizing spatially, will tend to increase the size of the firm.’”).

buyers on eBay, Amazon, Uber, or Airbnb—means that firms that offer a trust system, enforce rules, protect consumers, or vouch for files can provide extra value. The transaction costs problem persists, but the private offering absorbs that cost, especially if there is a large scale. Monitoring or offering these protections to a few customers might be too expensive, but with millions or billions of transactions, the new central power can provide a marketplace and charge for its ability to manage transaction costs. This change suggests that new oligopolies will emerge. In 3D printing or telecommunications, those who control the inputs—be they materials or data—will exert great power over the provision of the commodities. In other areas, iTunes, Google, Amazon, Netflix, and others may be the new powers, because they can offer solutions to the rights holders' interest problem.

Although incumbents may seek new laws to protect their positions, the irony is that they can exert the same, and perhaps more, power thanks to the very technologies they fight. It is not just the Stop Online Piracy Act, Protect IP Act, or other legislative efforts that threaten a world of easily shared digital content.³⁵ By offering streaming music, video, and ebooks, companies can limit the way a consumer can interact with the content. It is digital rights management in disguise. Any company in the design business could leapfrog the problems of copyright by making their design files available as streams to a networked 3D printer. Instead of relying on a scan and copy of a given auto part, a consumer or auto supply store could order the part, the file would stream to the printer, and the item would be produced. If one wanted ten items, ten purchases (or maybe a bulk discount) would be made, and ten items would be made. Although a dedicated person could hack the stream, that tactic has not yet become rampant. It may be that the offered price, the quality of the service, and the nuisance of hacking the stream explains the new equilibrium. The current state of affairs suggests that streaming design files would work well. This shift indicates that digitization and networking reintroduce the possibility of regulation and centralized control.

At the extreme, the logic of digitization and networking allows the state to impose regulations on all players, not just large firms. I have argued that digitization and related networking technology changes the

35. *Cf. id.* (“The Internet has survived repeated efforts by private parties to lock it down, and it seems unlikely after the dramatic defeat of SOPA that anything so draconian will pass, in the United States at least. But that was never a guaranteed outcome.”). The odds that private parties will give up on trying to lock down the Internet are low. The new force against those habits is the technology sector that benefits from a different set of costs and barriers than IP. As long as they are powerful, attempts by the copyright industry to lock down information technology may fail. But as digitization touches other sectors, such as pharmaceuticals, tourism, and so on, they may band together and outspend the technology sector in Congress.

scale of many aspects of business, explains why IP may not be needed for some industries, and challenges attempts to regulate, because enforcement costs are high when the number of players is high. But this point can be misunderstood; for as soon as digitization offers a method of control, it will be exerted. The domain name industry argued that it could not monitor millions of potentially infringing domain name registrations. Intermediary liability shield laws followed that logic and protected ISPs and host sites, such as eBay and YouTube, from having to police their services for potential violations of the law. And yet, pressure from incumbents with genuine rights concerns has led to counterfeit enforcement systems and YouTube's ContentID system, which aids rights holders in identifying potentially infringing goods. Going forward, one can imagine networked cars that are only licensed for personal use and require another license to be used as a taxi. Once networked, identifying driving patterns to flag suspicious, unlicensed use of a car would be possible. 3D printing could evolve to a world where only authorized designs are allowed on a machine. 3D printers would go from being a general-purpose tool to a dumb box, like a television or DVR. The new centers of power would again control the way we create and the way we do business. This point returns us to a different type of 3D, the 3D of digitization, decentralization, and disruption.

Digitization is the new steam. Steam allowed us to leverage like never before and spawned a series of new offerings and new needs. Steamboats, railroads, steel, refrigeration, kerosene, electricity, gasoline, automobiles, and more followed one after the other, either complementing or competing with a new way to take business to a massive scale. Digitization is providing the same changes today. Circuits, mainframes, pocket calculators, software, hardware, networks, the Internet, the domain name system, search technology, broadband, cellular phones, mobile broadband, smart phones, tablets, distributed computing, big data, and more feed the creation of new businesses and challenge old ones. The steam era started with many competitors and inventors and ended with only a few concentrated winners. The winners contributed vast amounts to society and spawned a need for new laws, from antitrust to product liability to IP to securities, and touched almost every area of law.

Digitization is now in the heady period where all seems possible. Digitization is breaking down cost barriers and opening the doors for newcomers to take on incumbents directly. Digitization also upsets incumbents indirectly with new, unexpected substitutes, such as when digital cameras made the film market a tiny fraction of what it was. This era will likely pass and new winners will emerge, if they have not already. Whether the law will explicitly champion the new business models or try to meter the winners remains to be seen. In some cases, society will

demand laws to manage the problems of new businesses (such as new safety laws for homemade cars or toys sold to others and licensing requirements for personal taxi services). In others, we will face the eternal question of when a market is thriving and offering new, desired outcomes and when it is truly stagnant or harmful and in need of legislative or regulatory action to fix an imbalance. This symposium's willingness to look beyond IP and engage with business leaders who use 3D printing technology, inventors, and scholars from a range of disciplines shows a dedication to broad thinking, gathering the facts, and searching for rich answers to complex problems. That approach should allow us to assess whether digitization promotes decentralization, and disruption continues, or whether the legal system may be setting the balance between stability and instability as correctly as possible. Nonetheless, what exactly that balance is, what laws are needed to maintain it, and what institutions will foster it are ongoing questions. I will continue to pursue them, and I hope many others interested in the future of technology law and policy will join the *Hastings Law Journal*, the authors in this symposium, and me.