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Innovation's Hidden Externalities

Stephanie Plamondon Bair[*]

When commentators discuss innovation's externalities, they often classify them into one of two categories. On the positive externalities, or "spillovers" side, legal and economics scholars often speak of the benefits innovation confers on other innovators. Future innovators profit from past innovation as they "stand on the shoulders of giants" to develop progressively new and better innovation. Discussion of innovation's negative externalities, on the other hand, has mainly focused on social harms not directly related to future innovation that particular advances impose on third parties—the classic example being pollution. Thus, the common understanding is that innovation's spillovers positively impact innovation (among other things), while innovation's negative externalities are only indirectly related to society's collective capacity for further innovation, if at all.

This Article challenges that view, arguing that innovation does impose negative externalities on contemporary and future innovators, thereby making it more difficult for them to innovate. It discusses three mechanisms by which these negative externalities arise. The first is through path dependencies. Path dependencies in innovation can limit the innovative potential of other innovators by effectively foreclosing particular areas of study or by directing innovation along less productive paths. A second mechanism by which innovation imposes negative externalities on other innovators is through the workings of social norms. Social norms that become entrenched in innovative communities can lead innovators to adopt sub-optimal research agendas and methodologies. Third, particular innovations may

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work on those who adopt them at a psychological level, changing their cognition and thought processes in ways that negatively impact their future ability to innovate.

Uncovering innovation's hidden externalities has implications for discussions of innovation policy. Currently, the conventional wisdom holds that innovation's spillovers should be addressed through innovation subsidies, while innovation's negative externalities can be addressed by taxing the externalities directly. Recognizing that innovation has both positive and negative externalities for contemporary and future innovators, however, challenges the view that the conversation about innovation subsidies (like intellectual property, tax breaks, grants, and prizes) should concern itself only with innovation's spillovers, and not with its negative externalities.

CONTENTS

INTRODUCTION

There are few things society celebrates more highly than innovation. Innovation drives economic growth, producing wealth and raising the standard of living.[1] Particular innovations contribute further to the social welfare by reducing disease, prolonging life, increasing leisure time, and providing entertainment, among other things.[2]

Given this, it's not surprising that scholars and policymakers spend significant time and money considering and implementing policies to promote innovation. For example, much attention has been devoted to policy levers like intellectual property (IP) regimes, grants, prizes, and research and development (R&D) tax credits, with the goal of leveraging these mechanisms to generate optimal levels of innovation.

But when innovation does occur, which policymakers hope it will, an important question arises about the downstream effects of this innovation on society's ability to continue to generate yet more socially beneficial innovation. Innovation is not an isolated, one-time event. What, then, are the dynamics of innovation?[3]

The conventional wisdom holds that innovation tends to give rise to more innovation in a positive feedback cycle, as society makes use of new innovation to develop progressively more and better innovation.[4] This idea is often expressed in economic terms as innovation giving rise to spillovers, or positive externalities, for

1. *See, e.g.*, W. BRIAN ARTHUR, THE NATURE OF TECHNOLOGY: WHAT IT IS AND HOW IT EVOLVES 10 (Simon & Schuster 2009); RICHARD R. NELSON, THE SOURCES OF ECONOMIC GROWTH 31 (1996) ("Virtually all scholars of productivity growth now agree on the central role of technological advance."); Paul M. Romer, *Two Strategies for Economic Development: Using Ideas and Producing Ideas*, *in* PROCEEDINGS OF THE WORLD BANK ANNUAL CONFERENCE ON DEVELOPMENT ECONOMICS 1992, at 63–64 (Lawrence H. Summers & Shekhar Shah eds., 1993).

2. ARTHUR, *supra* note 1, at 11.

3. *See* Zachary Liscow & Quentin Karpilow, *Innovation Snowballing and Climate Law*, 95 WASH. U. L. REV. 387, 392 (discussing how conventional views of innovation policy "miss[] the *dynamics* of innovation").

4. Russell Golman & Steven Klepper, *Spinoffs and Clustering*, *in* INNOVATION SYSTEMS, POLICY AND MANAGEMENT (Jorge Niosi ed., 2018); *see also* John Villasenor, *The Future of Innovation: Five Things We Can Learn From Bitcoin*, FORBES (May 12, 2014, 4:29 PM), https://www.forbes.com/sites/johnvillasenor/2014/05/12/the-future-of-innovation-five-things-we-can-learn-from-bitcoin ("Much has been written about how innovation centers such as Silicon Valley, where a high concentration of talent, venture capital, and successful technology companies creates a positive feedback cycle that begets more talent, investment, and success stories.").

third-party innovators, who build on and benefit from the work of earlier innovators.[5]

In terms of the dynamic effects of innovation then, it is understood that innovation gives rise to innovation-promoting positive externalities. But what has been largely overlooked is the possibility that innovation may give rise to innovation-inhibiting negative externalities as well. Instead, the discussion of innovation's negative externalities has focused for the most part on social harms, largely unrelated to future impacts on the collective capacity for innovation, that arise from the use of specific innovations—harms like pollution, for example.[6] Due to this oversight, discussions concerned with addressing innovation's externalities have centered mainly on how best to approach innovation spillovers so as to properly incentivize the optimal amount of innovation through innovation subsidies,[7] while employing other policies (primarily taxation) to mitigate the negative, non-innovation-related externalities these innovations produce. But this discussion would shift dramatically if it were recognized that innovation gives rise to both positive and negative externalities borne by other innovators.

This Article argues that innovation does in fact trigger negative externalities for innovators and outlines three mechanisms by which it may do so. The first is through path dependencies.

5. *See, e.g.*, Suzanne Scotchmer & Jerry Green, *Novelty and Disclosure in Patent Law*, 21 RAND J. ECON. 131, 132 (1990) ("Disclosing technical information confers a positive externality on a firm's competitors[.]"); Adam B. Jaffe, Richard G. Newell & Robert N. Stavins, *Technology Policy for Energy and the Environment*, *in* 4 INNOVATION POLICY AND THE ECONOMY 35, 39 (Adam B. Jaffe, Josh Lerner & Scott Stern eds., 2004) ("[I]nnovation creates positive externalities in the form of knowledge spillovers for other firms[.]"); Lisa Grow Sun & Brigham Daniels, *Mirrored Externalities*, 90 NOTRE DAME L. REV. 135, 146 (2014) ("Individuals who exercise and share their creativity . . . generate innumerable positive externalities. In the case of inventions, for instance . . . other inventors may build on the initial innovation to create new and different products."); Gregory N. Mandel, *Proxy Signals: Capturing Private Information for Private Benefit*, 90 WASH. U. L. REV. 1, 17–18 (2012) ("In the case of innovation, positive externalities are legion. The positive externalities, or spillovers, of innovation include third-party benefits from the chance to improve upon an innovation (and profit thereby), [and] the opportunity for others affiliated with innovation to learn from an innovation and transfer that know-how to other projects[.]").

6. *See, e.g.*, Jaffe et al., *supra* note 5, at 35 ("New technologies may create or facilitate increased pollution[.]").

7. *See, e.g.*, Scotchmer & Green, *supra* note 5, at 132 (stating that "[d]isclosing technical information confers a positive externality on a firm's competitors, which the firm might want to avoid[,]" and discussing how patentability requirements can provide appropriate incentives to firms concerned with these spillovers).

Economists have detailed how innovation's future, like other social phenomena, is subject to its past. For example, Zachary Liscow and Quentin Karpilow have coined the term "innovation snowballing" to refer to economists' finding that past innovation can guide future innovation in particular directions by making certain innovative choices more valuable.[8] As Liscow and Karpilow point out in the context of clean versus dirty energy technologies, the resulting trajectory might not always be the most socially beneficial one.[9] More generally, however, path dependencies in innovation can impact third-party innovators by effectively foreclosing particular areas of innovation or by directing their innovation along less productive paths.

A second, related mechanism by which innovation may limit other innovators is through the workings of "anti-innovation norms."[10] Innovation occurs mainly in communities,[11] and innovative communities are subject to social norms and pressures. These norms can lead innovators to adopt particular research agendas and methodologies based on their social consequences rather than their projected impact on future innovation trajectories.[12] These innovative choices, in turn, could limit other innovators. An example of anti-innovation norms at work can be seen in the results of a recent study finding that the death of a leader in an academic field actually leads to a surge in highly cited contributions from others that "rejuvenates a research field with new . . . ideas."[13] Presumably, the social influence of the leader had a stifling effect on both the quantity and quality of research being produced prior to the leader's death.

Finally, particular innovations may work on those who adopt them at a psychological level, changing their cognition and thought processes in ways that affect their future ability to think creatively

8. Liscow & Karpilow, *supra* note 3, at 389.

9. *Id.* at 404–14.

10. Stephanie Plamondon Bair & Laura G. Pedraza-Fariña, *Anti-Innovation Norms*, 112 NW. U. L. REV. 1069, 1073 (2018).

11. *See, e.g.*, Stephanie Plamondon Bair, *Innovation Inc.*, 32 BERKELEY TECH. L. J. 713, 717 (2017).

12. Bair & Pedraza-Fariña, *supra* note 10, at 1074.

13. Tyler Smith, *Scientific Progress One Funeral at a Time: What Happens to a Research Field When It Loses Its Leader?*, AM. ECON. ASS'N (Sept. 13, 2019), https://www.aeaweb.org/research/scientific-advancement-eminent-deaths (reporting on Pierre Azoulay, Christian Fons-Rosen & Joshua S. Graff Zivin, *Does Science Advance One Funeral at a Time?*, 109 AM. ECON. REV. 2889 (2019)).

and innovate. For example, repeated use of certain types of innovations may alter brain architecture and function in ways that decrease attention span and information filtering capability—cognitive abilities crucial for creative thinking. Engagement with these innovations also seems to interfere with the development and maintenance of emotional intelligence, which is strongly correlated with creativity. Present innovation may thus affect tomorrow's innovators by limiting their creative potential.

Recognizing that innovation gives rise to both positive and negative externalities borne by contemporary and future innovators has implications for discussions of innovation policy. The conventional wisdom holds that treatment of innovation's spillovers and externalities are separable: spillovers can be addressed (if necessary) through innovation subsidies, while innovation's negative externalities are best addressed by taxing these externalities directly.[14] But separating treatment of innovation's positive and negative externalities makes less sense if they are both operating, in oppositional ways, on the same third party—other innovators. In this case, decisions about how to account for innovation's spillovers benefitting other innovators should also account for any countervailing externalities imposed on the same group. For example, if scholars believe that to achieve optimal levels of innovation, IP protection should be sufficiently robust to allow innovators to capture the full social benefit conferred on other innovators, a calculation of this benefit should be offset by whatever harms those innovators are also imposing on other innovators.

The rest of this Article proceeds as follows. Part I examines how innovation scholars think about innovation externalities and the dynamics of innovation. The dominant view is that innovation gives rise to spillovers for other innovators, who build on past advances to perpetuate a positive feedback cycle of innovation,[15] while the negative externalities generated by innovation are not directly related to the collective capacity for innovation. Part II challenges this view by exploring the various ways in which innovation may give rise to negative externalities that impact other innovators. Part III explores the implications of this insight. Among

14. Liscow & Karpilow, *supra* note 3, at 390.

15. Suzanne Scotchmer, *Standing on the Shoulders of Giants: Cumulative Research and the Patent Law*, 5 J. ECON. PERSPS. 29 (1991).

other things, it suggests that innovation's spillovers and externalities should be considered together when designing innovation policy, at least to the extent that they both impact other innovators. It also explores what these findings may mean for philosophical conceptions of innovation and the types of innovation society should focus on promoting.

I. INNOVATION EXTERNALITIES: CURRENT UNDERSTANDINGS

Innovation is an iterative process.[16] Today's innovation builds on any number of past innovations. Uber, for example, exists in part because of the prior development of GPS, while the electric car depends on pre-existing battery technology.[17]

The cumulative nature of innovation has led to a common understanding among innovation scholars that innovation begets further innovation, as past creations create future innovative opportunities.[18] As economist and innovation theorist W. Brian Arthur put it in his book *The Nature of Technology*, "the collective of technology builds up from itself with the agency of human inventors and developers much as a coral reef builds itself from itself from the activities of small organisms."[19] In other words, as more innovations emerge, humans make use of these innovations to develop progressively more and better additional innovations—and the virtuous cycle continues.[20]

In economic terms, scholars refer to these cumulative benefits as innovation spillovers, or positive externalities.[21] Present innovators appropriate the spillovers from past innovation as they "stand on the shoulders of giants" and build on a foundation created by others.[22] There are multiple ways in which they do this.

16. *See, e.g.*, *id.* at 29 ("Most innovators stand on the shoulders of giants, and never more so than in the current evolution of high technologies, where almost all technical progress builds on a foundation provided by earlier innovators.").

17. Liscow & Karpilow, *supra* note 3, at 405.

18. *See, e.g.*, Golman & Klepper, *supra* note 4, at 342 ("Innovation begets more innovation in a positive feedback cycle[.]"); Villasenor, *supra* note 4; Liscow & Karpilow, *supra* note 3, at 405 ("Innovation therefore begets more innovation[.]").

19. Arthur, *supra* note 1, at 169.

20. Troy Camplin & Euel Elliott, *Innovation, Complex Systems and Computation: Technological Space and Speculations on the Future*, 7 STUD. EMERGENT ORD. 184, 201–02 (2014).

21. *See, e.g.*, Daron Acemoglu, *Directed Technical Change*, 69 REV. ECON. STUD. 781, 793 (2002); Liscow & Karpilow, *supra* note 3, at 397; Brett M. Frischmann & Mark A. Lemley, *Spillovers*, 107 COLUM. L. REV. 257, 257–58 (2007).

22. *See, e.g.*, Acemoglu, *supra* note 21, at 793; Scotchmer, *supra* note 15, at 29.

Third-party innovators might benefit from spillovers at the research and development stage as research scientists move between firms or laboratories, bringing their knowledge with them.[23] They might benefit at later stages of research when they gain information from other innovators in academic journals, at scientific conferences, or by reverse engineering completed innovations.[24] Or they might benefit as they attempt to commercialize or otherwise put past innovations into practice.[25]

Of course, underlying this assumption is an understanding that innovation, like many other endeavors, is stochastic. Not every innovative advance will give rise to immediate and valuable future innovative returns. But in general, scholars believe in the spillover benefits of present innovation for future innovation.

Innovation thus produces spillovers for other innovators, benefitting them in ways not fully internalized by those producing that innovation. For this reason, some economists and innovation scholars believe that some form of innovation subsidy is required to incentivize optimal levels of innovation—otherwise, innovators unable to capture the full value of their efforts will choose not to innovate.[26]

But does innovation also produce negative externalities? Scholars have acknowledged that particular innovations do, indeed, impose negative externalities on third parties. A classic example of such an externality is pollution.[27] Another is the increased capacity for warfare and violence certain innovations enable.[28] These externalities, as the categorization suggests, involve

23. Liscow & Karpilow, *supra* note 3, at 398.

24. *Id.*

25. *Id.*

26. *See, e.g.*, Amy Kapczynski & Talha Syed, *The Continuum of Excludability and the Limits of Patents*, 122 YALE L.J. 1900, 1905–06 (2013) (discussing IP's "appropriability" problem, wherein IP under incentivizes creations whose value cannot be fully appropriated by the creator); Liscow & Karpilow, *supra* note 3, at 399. *But see* Frischmann & Lemley, *supra* note 21, at 258 (arguing that it is not necessary to fully compensate innovators for spillovers in order to achieve optimal levels of innovation).

27. Liscow & Karpilow, *supra* note 3, at 390.

28. Estelle Derclaye, *Eudemonic Intellectual Property: Patents and Related Rights As Engines of Happiness, Peace, and Sustainability*, 14 VAND. J. ENT. & TECH. L. 495, 498 (2012) ("The simple examples of the two World Wars, pollution, and global warming are enough to prove the point: knowledge, science, and technological progress have both positive and negative consequences."). Other negative externalities posed by particular innovations include the harms innovation in antibiotics imposes on consumers in the form of increased cross-

social harms largely borne by third parties. But what is interesting to note about these identified externalities is that unlike innovation's spillovers, the third parties are not necessarily other innovators. The harms are related only indirectly, if at all, to future innovation. In part because of this, the conventional wisdom suggests that policymakers address these externalities via taxation rather than through innovation policy. Fewer scholars, however, have considered the possibility that innovation may also give rise to negative externalities that directly affect other innovators and their collective capacity to innovate.[29] The next Part explores that possibility.

II. INNOVATION'S HIDDEN EXTERNALITIES

How might innovation produce negative externalities for other innovators? There are at least three mechanisms by which this might occur: path dependencies, anti-innovation norms, and long-lasting detrimental cognitive effects of particular innovations on creativity.

A. Path Dependencies

Innovation, like other dynamic processes, gives rise to path dependencies, wherein the future of innovation is dictated at least

resistance, Ankur Sood & Vardaan Ahluwalia, *Questioning the Justifiability of Innovation Protection in Antimicrobial Drugs: A Law and Economics Perspective*, 6 NW. J. TECH. & INTELL. PROP. 181, 184 (2008) ("consumption of [antibiotic] drugs and the consequent development of resistance in pathogens due to cross-resistance impose a negative externality upon . . . society"), the negative externalities innovation imposes on consumers as a result of reduced access to the innovations due to the innovations being patented, Mandel, *supra* note 5, at 18, or the firms passing on the R&D costs of the innovations onto consumers, Erik Dietzenbacher & Bart Los, *Externalities of R & D Expenditures*, 14 ECON. SYS. RSCH. 407, 408 (2002). *See also* J.J. Voeten & W.A. Naudé, *Regulating the Negative Externalities of Enterprise Cluster Innovations: Lessons from Vietnam*, 4 INNOVATION & DEV. 203, 206 (2014) ("[Negative externalities of particular innovations] include unfavourable or even dangerous working conditions (e.g. in recycling of heavy metals used in ICT), [and] jobless growth (e.g. through the automation of services)[.]").

29. A notable exception is Glynn Lunney, who has argued that innovation in developed countries can impose negative externalities on developing countries by disincentivizing them from engaging in further innovation due to their reliance on foreign IP. Glynn S. Lunney, Jr., *Patents and Growth: Empirical Evidence from the States*, 87 N.C. L. REV. 1467, 1490–91 (2009) ("If . . . a state's ability to undertake future innovation . . . depends upon a state's active role in past innovation in the field, then licensing external patents may impair the state's ability to undertake future innovation in the field. . . . [A]ny one domestic firm is unlikely to bear the full costs of the state's dependence on external patenting, suggesting that licensing of external patents will often entail a negative externality.").

in part by its past. In fact, the conventional wisdom that innovation tends to give rise to more innovation in a positive feedback cycle is itself an example of path dependency in innovation.[30]

Although many scholars have noted this positive aspect of path dependency for innovation, few have explored whether innovation's path dependencies could lead to less favorable innovation outcomes. A notable exception is the work of Zachary Liscow and Quentin Karpilow, who have explored how a path-dependency phenomenon they term "innovation snowballing"[31] could exacerbate a classic innovation externality: pollution. In innovation snowballing, past innovation directs future innovation by rendering certain innovative choices more valuable. Innovators choose to pursue innovations with the greatest knowledge base, because these innovations have the highest expected returns.[32] In the context of clean energy versus polluting technologies like fossil fuels, Liscow and Karpilow argue that because dirty tech has had a head start of many decades, innovation snowballing will prompt innovators to disproportionately choose to innovate in this field.[33] These path-dependent innovation decisions have consequences for innovation externalities, leading to the generation of greater pollution than might otherwise occur.[34]

Liscow and Karpilow have recognized that path dependency in innovation has consequences for the well-documented innovation externality of pollution. But path dependencies in innovation could also lead to additional, under-studied externalities. Specifically, innovation path dependencies could lead to negative consequences for third-party innovators.

How might this occur? Precisely because innovation is an iterative process, innovative choices of present innovators will affect the innovative choices of future innovators[35]—and they

30. Liscow & Karpilow, *supra* note 3, at 389 ("[I]nnovation builds on itself over time, developing path dependencies in which past innovations make present ones more valuable . . . .").

31. *Id.*

32. *Id.* at 405.

33. *Id.* at 407–08.

34. *See id.* at 394 ("Innovation snowballing undercuts the benefits of patents by reducing the utility of market valuation, since markets reflect an uneven playing field created by a century of untaxed greenhouse gas externalities.").

35. As explained, the way innovation scholars usually think of these effects is in the language of spillovers—or positive impacts on the decisions of future innovators. Innovation spillovers can occur in various ways and on various time scales. For example, future

might do so in ways that stifle future innovation. In fact, the phenomenon of innovation snowballing, which makes certain innovative choices more valuable, and therefore more likely, offers a prime example. Snowballing occurs because it is easier and cheaper to innovate in an area with a greater knowledge base; as these individual innovation decisions accumulate, the snowball grows in size. But as innovation proliferates in one field, the knowledge base of other, unchosen fields remains anemic.

These research roads not taken could represent a blow to the progression of innovation in a number of ways. First, the process by which a particular area of research becomes the subject of snowballing is often somewhat arbitrary. For example, in the 1980s, VHS technology won out over Betamax technology due in large part to snowballing effects, though neither technology was inherently superior to the other.[36] Because of this, there is no guarantee that the snowballing field is the one that offers the most productive innovation opportunities. Of course, the snowballing field eventually becomes relatively more productive than other, unchosen fields simply because the process of snowballing makes it so. But if another field had instead, for idiosyncratic reasons (as occurred with VHS technology), become the target of snowballing, it might have offered even greater opportunities for productive research and innovation. Because snowballing usually occurs without any explicit consideration of these factors, there is often no way to know whether a particular path-dependent innovation trajectory was the best and most productive use of scarce innovation-generating resources like human and financial capital.

Second, it is well known that the most groundbreaking and productive innovation is often innovation that combines insights from disparate fields.[37] But the phenomenon of snowballing limits

innovators learn and build on information disclosed at scientific conferences and in academic journals and learn from co-workers who have migrated from other firms, bringing their knowledge with them. *See, e.g.*, William Nordhaus, *Designing a Friendly Space for Technological Change to Slow Global Warming*, 33 ENERGY ECON. 665, 666 (2011); Mika Maliranta, Pierre Mohnen & Petri Rouvinen, *Is Inter-Firm Labor Mobility a Channel of Knowledge Spillovers? Evidence from a Linked Employer-Employee Panel*, 18 INDUS. & CORP. CHANGE 1161, 1161–62 (2009); Paul Almeida & Bruce Kogut, *Localization of Knowledge and the Mobility of Engineers in Regional Networks*, 45 MGMT. SCI. 905, 905–07 (1999).

36. Liscow & Karpilow, *supra* note 3, at 406; Michael A. Cusumano, Yiorgos Mylonadis & Richard S. Rosenbloom, *Strategic Maneuvering and Mass-Market Dynamics: The Triumph of VHS over Beta*, 66 BUS. HIST. REV. 51, 51 (1992).

37. Bair & Pedraza-Fariña, *supra* note 10, at 1091–95 (discussing the research).

the potential for this to occur. When the knowledge base is robust in one area but limited in other related fields due to snowballing, there will be fewer opportunities for researchers and innovators to look to these other fields for insights that could be combined with their own expertise to produce novel and innovative solutions. For example, clean tech and dirty tech are disparate, yet sufficiently related fields that insights from clean tech could—and often do—benefit dirty tech researchers.[38] But because snowballing has led to a choice of disproportionate investment in dirty tech over clean tech, the opportunities for this cross-pollination are limited. If, on the other hand, both fields experienced more proportionate levels of investment and growth, innovators would benefit as they drew from the robust pool of insights made available by researchers in the other field.

Finally, the phenomenon of snowballing increases the likelihood of wasteful and duplicative research. If innovation is largely concentrated in particular fields while other promising areas go unexplored, the likelihood of duplication of effort increases accordingly. This concern should be a familiar one to those acquainted with the prospect theory of patents. According to prospect theory, an innovator should be granted a broad patent early in the lifetime of the innovation.[39] Doing so, theoretically, should help prevent so-called "patent races," which impose a negative congestion externality on innovation.[40] The externality arises because a patent diverts researchers into a particular area of study as they race to get the patent prize.[41] This area becomes congested with researchers, and because only a single entity or group can hold a patent on a particular innovation, the success rate of the average researcher goes down as other researchers abandon their efforts once someone succeeds and a patent is granted.[42] The broad and early patents prescribed by prospect theory arguably

38. Liscow & Karpilow, *supra* note 3, at 433 ("Evidence suggests that research into some types of clean energy benefits dirtytech as much as cleantech . . . .").

39. Edmund Kitch, *The Nature and Function of the Patent System,* 20 J. L. & ECON. 265, 265–90 (1977).

40. Udayan Roy, *Economic Growth with Negative Externalities in Innovation*, 19 J. MACROECONOMICS 155, 156–57 (1997).

41. *Id.*

42. *Id.*

avoid this waste and duplication in research.[43] If a single party has a limited monopoly over a particular field, this should ideally (according to the theory) discourage other parties from engaging in duplicative research as they race for a later-granted patent,[44] while at the same time encouraging the party with the patent to efficiently explore and exploit the full extent of the field.[45]

The phenomenon of innovation snowballing raises a concern similar to the one prospect theory seeks to address. Like the valuable prospect of obtaining a patent, innovation snowballing diverts researchers into particular areas of study, leading to potential congestion externalities as large numbers of innovators pursue the same or similar lines of research.[46]

Of course, those familiar with prospect theory also know that its premise is controversial. There are many reasons to believe that a party with a broad patent will not in fact conduct the most efficient exploration of the patented field.[47] More relevant to the theory's application here, however, is the idea that patent races, wherein multiple parties engage in overlapping research, might not be as wasteful as one might expect. Specifically, because innovation is a stochastic process, it is possible (and in fact likely) that even researchers working in similar fields and on similar projects will adopt different approaches that will lead to unique contributions,[48] thereby reducing the congestion concern.[49] At first glance, this criticism of prospect theory, if accepted, might seem to allay any

43. Edmund W. Kitch, *The Nature and Function of the Patent System*, 20 J.L. & ECON. 265, 266–71 (1977); Roberto Mazzoleni & Richard R. Nelson, *Economic Theories About the Benefits and Costs of Patents*, 32 J. ECON. ISSUES 1031, 1042 (1998).

44. Mark F. Grady & Jay I. Alexander, *Patent Law and Rent Dissipation*, 78 VA. L. REV. 305, 307–08 (1992) (discussing how the patent system is set up to grant protection broad enough to serve the system's purposes, but not so broad as to encourage wasteful patent races); *see also* Kitch, *supra* note 43, at 269–71.

45. Mark A. Lemley, *The Myth of the Sole Inventor*, 110 MICH. L. REV. 709, 738–39 (2012).

46. In the absence of an explicit race to obtain a patent, the congestion concern is perhaps not quite as salient as it is in the patent-racing context. In a patent race, the assumption is that all those who fail to obtain the patent will abandon their research once a patent application is filed (leading to waste). In the absence of such a race, there may be less of a basis for such an assumption. But the reality is that even outside the patent-theory context, innovators are often competing to get a patent and so may abandon their efforts once a patent is achieved. There are other additional "goalposts" that, though not strictly exclusionary in the same sense as a patent, might similarly cause competing researchers to abandon their efforts—a product to market, for example.

47. Lemley, *supra* note 45, at 740–41.

48. *Id.* at 753–54.

49. Roy, *supra* note 40, at 157.

concern of congestion externalities posed by innovation snowballing. However, even if one grants that all those exploring similar research questions will make *some* individual contributions to the collective endeavor of innovation, it is still inevitable, given the concentration of researchers pursuing the same topics, that there will be some congestion and duplication of effort, which imposes a negative externality on innovation.

Additional path dependencies related to, but distinct from, innovation snowballing could pose similar concerns for future innovation. For example, in addition to making certain innovation paths more valuable (as snowballing does), past innovation also dictates to some extent what tools are available for particular research endeavors going forward. When research becomes concentrated in particular fields, research tools will be developed with these areas of interest and high activity in mind. Even if researchers are interested in pursuing questions outside of these areas, they may lack the capacity to do so because the tools and infrastructure necessary to explore these questions are simply unavailable. This can lead to an iteration of the so-called "streetlight effect"[50] in innovation, where researchers engage in whatever inquiries they can with the tools they have available—even if those inquiries may not be the most productive,[51] or might even, in some cases, produce misleading results.[52]

Finally, network effects may sometimes give rise to innovation-inhibiting path dependencies. Network effects occur when the value of an innovation arises as more people adopt it. For instance, the telephone (or, to give a more contemporary example, Facebook)

50. *See, e.g.*, Cullen S. Hendrix, *The Streetlight Effect in Climate Change Research on Africa*, 43 GLOB. ENV'T CHANGE 137, 137 (2017) ("The streetlight effect is the tendency for researchers to focus on particular questions, cases and variables for reasons of convenience or data availability rather than broader relevance, policy import, or construct validity . . . ."). The streetlight effect gets its name from the story, oft told in scientific circles, of the drunk man looking for his wallet under a streetlight. When a police officer offers to help him, the drunk man tells him that he thinks he lost his wallet across the street. In response to the officer's inquiry as to why the man is searching so far from the probable location of the wallet, the man explains that the light is better under the streetlight. David H. Freedman, *Why Scientific Studies Are so Often Wrong: The Streetlight Effect*, DISCOVER (Dec. 9, 2010).

51. *See, e.g.*, Hendrix, *supra* note 50, at 137–38 (describing how a history of colonialism and political instability led to path dependencies and the streetlight effect in climate change science, with the ultimate result that researchers have largely neglected studying climate change in Africa, despite Africa being significantly affected by climate change in terms of population size and territorial size).

52. Freedman, *supra* note 50.

became more valuable to each user as more people adopted it. However, network effects could lead to path dependencies that inhibit innovation.[53] For example, people may be reluctant to adopt a superior social networking site because the network effects of using Facebook have made it so valuable.[54] For similar reasons, innovators may be reluctant to even attempt to improve upon Facebook or other innovations where significant network effects are in play, slowing down the pace of innovation.[55]

All of these potentially negative effects of path dependencies on innovation can be characterized as negative externalities. Present innovators impose costs on contemporary and future innovators as they direct future innovation along less productive paths; concentrate innovation in particular fields, which leads to congestion and prevents opportunities for beneficial cross-pollination; develop tools in particular areas (and fail to develop them in others), which results in streetlight effects that limit future research opportunities; and accumulate network effects that constrict future innovation.

B. Anti-Innovation Norms

Innovation may also impose negative externalities on other innovators through the workings of so-called "anti-innovation" norms. Laura Pedraza-Fariña and I have explored how the social norms that inevitably take hold in innovative communities (and the psychological biases that give rise to them) can cause researchers to pursue research agendas that are sub-optimal from the perspective of the collective project of advancing socially beneficial innovation.[56] In fact, these norms may often mount substantial barriers to creative and innovative activities.[57]

For example, extensive research in both the sociology and psychology literatures suggests that disciplinary boundary crossing is a crucial component in the process of generating novel,

53. Willow A. Sheremata, *Barriers to Innovation: A Monopoly, Network Externalities, and the Speed of Innovation*, ANTITRUST BULL. 937, 955 (1997) (describing how network effects can lead to a "socially excessive reluctance to switch to a superior new standard[,]" with the result that "[v]ariety is reduced" and "[i]nnovation is excessively slow.").

54. *See id.*

55. *Id.*

56. Bair & Pedraza-Fariña, *supra* note 10.

57. *Id.*

creative, and groundbreaking products and ideas.[58] Yet various social norms, common in innovative communities, often prevent researchers from engaging in this cross-pollination process. Research priority norms, for instance, in which a community collectively decides on the questions it will pursue, can lead to an intense focus on particular questions, to the exclusion of other important pursuits.[59] In this exclusionary process, it is most often the questions that fall at the intersection of disparate fields that get overlooked[60]—and yet, these are the very questions that hold the most promise for the advancement of innovation.[61]

Similarly, methodology norms, in which an innovation community adopts particular tools and approaches for solving problems while excluding others, can also mount barriers to innovation.[62] There are at least three ways in which they do so. First, methodology norms can cause a community to overlook particular approaches and tools that might in fact be optimal for solving the problems with which the community is concerned.[63] This dynamic can also feed back into research priority norms, causing a streetlight effect[64] where members of a community select research questions based on which of these questions are amenable to accepted methodologies rather than on more relevant factors, such as which questions are the most pressing or hold the most promise for innovation and advance.[65] Second, as with research priority norms, methodology norms also often lead to a deprioritizing of promising intersectional questions that require a

58. *See, e.g.*, DAVID STARK, THE SENSE OF DISSONANCE: ACCOUNTS OF WORTH IN ECONOMIC LIFE (2009); Mathijs de Vaan, David Stark & Balázs Vedres, *Game Changer: The Topology of Creativity*, 120 AM. J. SOCIO. 1144 (2015); Balázs Vedres & David Stark, *Structural Folds: Generative Disruption in Overlapping Groups*, 115 AM. J. SOCIO. 1150 (2010); RICHARD K. LESTER & MICHAEL J. PIORE, INNOVATION—THE MISSING DIMENSION (2004); Gregory N. Mandel, *To Promote the Creative Process: Intellectual Property Law and the Psychology of Creativity*, 86 NOTRE DAME L. REV. 1999 (2011); Bair & Pedraza-Fariña, *supra* note 10, at 1091–95 (summarizing some of the research).

59. Bair & Pedraza-Fariña, *supra* note 10, at 1096–99.

60. *Id.*

61. *See* cases cited *supra* note 58.

62. Bair & Pedraza-Fariña, *supra* note 10, at 1099–102.

63. *See id.* at 1099–100.

64. *See supra* Section II.A (discussing the streetlight effect).

65. *See* Bair & Pedraza-Fariña, *supra* note 10, at 1101 ("It is not necessarily the most important organizational problems that are being solved. Rather, which problems are prioritized and how they are solved depends on actors' methodological ability to solve them and their power to impose their solution.").

combination of methodologies.[66] Finally, methodology norms can lead to duplication of effort and missed opportunities for innovation-enhancing collaboration, due to the community-specific jargon that inevitably arises around a community's chosen methodologies and approaches. Because innovative communities tend to describe their methodologies in idiosyncratic and opaque-to-outsider ways, members of disparate groups may not realize that they are working on similar or even identical problems.[67] This oversight can lead to wasteful duplication and missed opportunities as distinct communities spend significant time pursuing parallel research paths, unaware of the insights and efforts of other innovators.

Finally, evaluation norms, whereby an innovation community decides what work is valuable, can also pose unintended barriers to innovation. For example, an innovation community might adopt evaluation norms deeming work "good" if it is published in a particular journal, is patented, receives grant funding, leads to increased market share of a company, or meets certain productivity standards.[68] These norms can impede truly innovative work in a number of ways. For one thing, researchers will feel pressure to choose research questions based on their ability to produce work that is judged as "good" in conformance with these norms—because it makes money for the company, meets patent eligibility standards, or appeals to peer reviewers—rather than their potential for true creative advance. And again, as with other anti-innovation norms, there might be a deprioritizing of intersectional research. Gatekeepers who subscribe to a particular community's research and methodology norms will be less accepting of transdisciplinary research, making it more difficult for these types of projects to be published or receive funding—that is, to meet the community's evaluation norms—and thereby discouraging or outright preventing researchers from pursuing them.[69]

To be clear, norms in innovation communities, including research priority, methodology, and evaluation norms, can and do

66. *Id.* at 1100–01.

67. *Id.* at 1101–02 (describing how a fifty-year-old mathematics problem was finally solved when mathematicians and computer scientists realized that the problem, which each community had been working on separately and referring to with unique framing and language, was in fact the same problem and joined forces).

68. *Id.* at 1102.

69. *See id.* at 1102–03.

serve important functions in the innovative process. Research priority norms, for example, help community members focus and coordinate their priorities, potentially leading to more collaboration within a community, speedier solutions to chosen problems, and deeper insights into those particular research areas.[70] Methodology norms go hand in hand with research priority norms and also serve important coordinating and focusing functions.[71] Evaluation norms are beneficial for establishing and reinforcing best practices, and, in a world with increasing volumes of research, can also reduce search costs for community members by providing a heuristic for quickly identifying "good" work. [72] It is not the presence of these norms per se, then, that is problematic from an innovation perspective, but the entrenchment and over-enforcement of these norms, which can impede crucial flexibility and creativity in the collective innovative project.[73]

A striking illustration of the potential anti-innovation effects of community norms is provided by a recent study investigating research practices in the life sciences.[74] The study's authors discovered that when an established and prominent leader in the field died, his or her death was followed by a surge in published work from "outsiders"—researchers who were not in the deceased leader's network of collaborators.[75] This outside research was "disproportionately likely to be highly cited,"[76] a measure of its impact and importance in advancing the field. Rather than any evidence that the deceased researcher exerted an overt influence on the field by restricting grant funding or publication, the authors found instead that the suppression of outside ideas was more likely the consequence of social norms that made community members reluctant to challenge the prevalent way of thinking (as embodied by the deceased).[77] The researcher's death acted as a jolt of sorts, providing a window of opportunity for new entrants; a rethinking of current research priority, methodology, and evaluation norms;

70. *Id.* at 1095.

71. *Id.* at 1100.

72. *Id.* at 1102.

73. *See id.* at 1104.

74. Pierre Azoulay, Christian Fons-Rosen & Joshua S. Graff Zivin, *Does Science Advance One Funeral at a Time?*, 109 AM. ECON. REV. 2889 (2019).

75. *Id.* at 2890.

76. *Id.*

77. *See id.* at 2890–91.

and an introduction of outside ideas into the mix. Indeed, consistent with the theory that anti-innovation norms tend to deprioritize intersectional research, the authors found that the "boost" to a field following a superstar researcher's death came largely from outsiders who "appear[ed] to tackle the mainstream questions within the field but by leveraging newer ideas that [arose] in other domains."[78] And consistent with the idea that intersectional research tends to be disproportionately important for advancing innovation, the authors also found that this research that leveraged ideas from other areas "represent[ed] substantial contributions" to the field.[79]

Though our previous exploration of innovation norms was not framed in the language of externalities, the anti-innovation consequences of the over-enforcement of some of these norms could be characterized as negative externalities. Researchers who make research and innovation decisions in accordance with anti-innovation norms impose negative externalities on other innovators by making it more difficult for them, in turn, to pursue research agendas more likely to lead to innovative and groundbreaking research. For example, research priority norms, as enforced by insiders—including prominent researchers and their network of collaborators[80]—make it more difficult for other innovators to enter a field where they could make a substantial contribution, or to introduce new, cross-disciplinary ideas into the study of accepted questions.[81] Similarly, enforced methodology norms make it more difficult for other innovators to adopt or even have access to the methodologies that might lead to the greatest innovative advances.[82] And evaluation norms can serve a gatekeeping function wherein only certain types of accepted

78. *Id.* at 2915, 2917; *see also* Jay Fitzgerald, *Does Science Advance One Funeral at a Time?*, NAT'L BUREAU ECON. RSCH. (Mar. 2016), https://www.nber.org/digest/mar16/does-science-advance-one-funeral-time (reporting on the study and quoting the study's authors).

79. Azoulay et al., *supra* note 74, at 2917 ("[A]t least as measured by long-run citation impact.").

80. *See id.* at 2890–91 (describing how entry by outsiders to a field is "more anemic when key collaborators of [a deceased star researcher] are in positions that allow them to limit access to funding or publication outlets to those outside the club that once nucleated around the star").

81. Bair & Pedraza-Fariña, *supra* note 10, at 1096–99.

82. *Id.* at 1099–1102.

research—not necessarily the most productive or innovative—are published or receive funding.[83]

Anti-innovation norms are related to, but distinct from, path dependencies. Innovation norms can certainly create path dependencies: as innovative communities adhere to particular research priority and methodology norms, particular areas of focus will become more valuable due to innovation snowballing, and particular methodologies and research tools will become more available and accessible than others.[84] But though anti-innovation norms may contribute to path dependencies, the mechanism by which these norms create negative externalities for innovators is distinct. In the case of anti-innovation norms, innovation creates negative externalities for other innovators because the social structures that arise around innovation exert overt or more subtle social pressures (rooted in psychological biases) on members of innovative communities, driving them to make innovation decisions that are often sub-optimal from an innovation perspective. These pressures, and the psychological drives that give rise to the need to comply with them, exist independent of any path dependencies that might emerge as innovation proceeds along particular trajectories.

C. Cognitive Effects

A third way in which innovation may impose negative externalities on other innovators is through cognitive effects. Specifically, certain innovations may impact the cognition of those who adopt them in ways that interfere with these users' potential to be creative and, ultimately, produce more innovation. Several strains of the psychology and neuroscience literatures are beginning to explore how engagement with particular innovations may be changing innovators' brains and the way they think.

1. Media Innovations, Multitasking, and Cognitive Performance

One particularly well-studied phenomenon on this topic has to do with the way media innovations have encouraged "multitasking" behavior—defined as engaging with simultaneous

83. *Id.* at 1102–03.
84. *See supra* Section II.A.

media streams.[85] Given the technological advances that make it not only possible but exceedingly easy to consume several forms of media—including print media, television, digital video, music, nonmusical audio like podcasts, video games, phone, instant messaging, text messaging, email, digital print, and other computer applications[86]—simultaneously or near simultaneously, it's unsurprising that the incidence of multitasking in daily life has increased markedly.[87]

One might be inclined to assume that the increased ease of multitasking, facilitated by various technological innovations, has made people more productive. But the developing research tells a different story. A review of the literature by Melina Uncapher and Anthony Wagner concludes that heavy multitaskers score poorly on a range of cognitive skills.[88] For example, of all the studies that have pitted high multitaskers against low multitaskers on working memory tasks, approximately half showed that low multitaskers outperformed high multitaskers, and none showed high multitaskers outperforming low multitaskers.[89] High multitaskers also seem to have problems with long-term memory not seen in low multitasking groups.[90]

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85. Melina R. Uncapher & Anthony D. Wagner, *Minds and Brains of Media Multitaskers: Current Findings and Future Directions*, 115 PNAS 9889, 9889 (2018).

86. *Id.*

87. *Id.* ("[M]edia multitasking behavior is increasing in prevalence, almost doubling from 1999 to 2009 (from 16% to 29% of total media time).").

88. *Id.*

89. *Id.* at 9890. The remaining studies failed to show any statistically significant effects.

90. Melina D. Uncapher, Monica K. Thieu & Anthony D. Wagner, *Media Multitasking and Memory: Differences in Working Memory and Long-Term Memory*, 23 PSYCHONOMIC BULL. & REV. 483, 483 (2016); Kathleen S. Edwards & Myoungju Shin, *Media Multitasking and Implicit Learning*, 79 ATTENTION PERCEPTION & PSYCHOPHYSICS 1535, 1535 (2017) (finding deficits in implicit learning (a form of long-term memory) among high multitaskers). One possible explanation for the working memory findings is that heavy multitasking over time may affect attentional processes, making it more difficult for high multitaskers to exert attentional control and increasing the incidence of attentional lapses. Uncapher & Wagner, *supra* note 85, at 9891. In support of this attentional hypothesis, additional studies have found that high multitaskers are less able than low multitaskers to effectively perform a task when confronted with distractions. *See, e.g.*, Eyal Ophir, Clifford Nass & Anthony D. Wagner, *Cognitive Control in Media Multitaskers*, 106 PNAS 15583, 15583 (2009); Pedro Cardoso-Leite, Rachel Kludt, Gianluca Vignola, Wei Ji Ma, C. Shawn Green & Daphne Bavelier, *Technology Consumption and Cognitive Control: Contrasting Action Video Game Experience with Media Multitasking*, 78 ATTENTION PERCEPTION & PSYCHOPHYSICS 218, 218 (2016); Wisnu Wiradhany & Mark R. Nieuwenstein, *Cognitive Control in Media Multitaskers: Two Replication Studies and a Meta-Analysis*, 79 ATTENTION PERCEPTION & PSYCHOPHYSICS 2620, 2620 (2017). Although it

In addition to attentional and working memory deficits, a habit of media multitasking may also impact ability to problem solve. Three experiments that pitted high multitaskers against low multitaskers on a standard task[91] used to evaluate abstract reasoning and fluid intelligence (measures of problem-solving ability)[92] all found that low multitaskers performed significantly better than their high multitasking counterparts.[93]

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is unclear whether these effects arise from an inability to prioritize attention by filtering unwanted information or a more general inability to sustain attention for long periods of time, what is clear is that high multitaskers seem to have increased trouble with attention as compared to those who do not multitask as often. Uncapher & Wagner, *supra* note 85, at 9892. The few studies that have directly addressed the link between multitasking and attention also support this conclusion. *See id.* (discussing Brandon C.W. Ralph, David R. Thomson, Paul Seli, Jonathan S.A. Carriere & Daniel Smilek, *Media Multitasking and Behavioral Measures of Sustained Attention*, 77 ATTENTION PERCEPTION & PSYCHOPHYSICS 390 (2015), and Jit Yong Yap & Stephen Wee Hun Lim, *Media Multitasking Predicts Unitary Versus Splitting Visual Focal Attention*, 25 J. COGNITIVE PSYCH. 889 (2013), and concluding that the studies "report negative effects of media multitasking on measures of attention.").

91. The task, known as the Raven's Standard Progressive Matrices, "is a 60-item test for measuring abstract reasoning [and is] considered a nonverbal estimate of fluid intelligence[.]" Warren B. Bilker, John A. Hansen, Colleen M. Brensinger, Jan Richard, Raquel E. Gur & Ruben C. Gur, *Development of Abbreviated Nine-Item Forms of the Raven's Standard Progressive Matrices Test*, 19 ASSESSMENT 354, 354 (2012).

92. *See, e.g.*, David Huepe & Natalia Salas, *Fluid Intelligence, Social Cognition, and Perspective Changing Abilities as Pointers of Psychosocial Adaptation*, FRONTIERS HUM. NEUROSCIENCE, June 2013, at 1, 1 (defining fluid intelligence as "the ability to think logically and to solve problems in new situations, regardless of the acquisition of knowledge").

93. Meredith Minear, Faith Brasher, Mark McCurdy, Jack Lewis & Andrea Younggren, *Working Memory, Fluid Intelligence, and Impulsiveness in Heavy Media Multitaskers*, 20 PSYCHONOMIC BULL. & REV. 1274, 1276, 1277 (2013) (discussing studies 1 and 2); Uncapher & Wagner, *supra* note 85, at 9893 (discussing Reem Alzahabi, Mark W. Becker & David Z. Hambrick, *Investigating the Relationship Between Media Multitasking and Processes Involved in Task-Switching*, 43 J. EXPERIMENTAL PSYCH. HUM. PERCEPTION & PERFORMANCE 1872 (2017)). The cognitive effects discussed here suggest that there may also be differences in brain structure or function between those who multitask heavily and those who do not. Two studies that addressed this question found that the brains of heavy multitaskers do indeed look and act different. One of these studies found a negative correlation between multitasking behaviors and grey matter (brain cell) volume in an area of the brain responsible for cognitive control. Kep Kee Loh & Ryota Kanai, *Higher Media Multi-Tasking Activity is Associated with Smaller Gray-Matter Density in the Anterior Cingulate Cortex*, PLOS ONE, Sept. 2014, at 1, 1. It also found a negative correlation between multitasking behaviors and connectivity between control areas. *Id.* The second study found that when high multitasking adolescents were distracted during a reading comprehension task, brain areas required for exerting attentional control were more active compared to those of low multitaskers performing the same task under the same conditions. Mona Moisala, V. Salmela, L. Hietajärvi, E. Salo, S. Carlson, O. Salonen, K. Lonka, K. Hakkarainen, K. Salmela-Aro & K. Alho, *Media Multitasking Is Associated with Distractibility and Increased Prefrontal Activity in Adolescents and Young Adults*, 134 NEUROIMAGE 113, 113 (2016). Based on this

These findings are primarily correlational and so do not prove that heavy multitasking negatively impacts cognition and brain function. It could be the case, for example, that those with a preexisting, lower ability to pay attention naturally gravitate towards opportunities to multitask.[94] But the studies are at least consistent with the hypothesis that heavy multitasking behavior does in fact change the brain in ways that affect cognition.[95] And if so, it does so in ways relevant to creativity and innovation. Innovation entails the creation or application of something new,[96] often in an entrepreneurial setting to meet consumer needs.[97] But the cognitive skills one would expect to aid in the process of

finding, the study's authors hypothesized that heavy multitaskers needed to exert more cognitive effort than light multitaskers in order to pay the required attention and effectively complete the task. *Id.*

94. Uncapher & Wagner, *supra* note 85, at 9894–95.

95. *See, e.g.*, *id.* at 9889 ("Even for fully developed brains it is possible that frequent engagement with simultaneous media streams affects cognition, behavior, and neural architecture."); Moisala et al., *supra* note 93, at 120 ("One interpretation of our results is that extensive daily media multitasking directly reinforces task switching behavior and deteriorates the ability to sustain attention on a focal task. Frequent multitasking behaviors enabled by modern technology may, in other words, lead to reduced executive control and greater susceptibility to interference."); Ophir et al., *supra* note 90, at 15583 (hypothesizing that "chronic media multitasking" may be "the cause" of "deficits in cognitive control"); Loh & Kanai, *supra* note 93, at 6 ("Although it is conceivable that individuals with smaller [grey matter volume in control areas] are more susceptible to multitasking due to weaker ability in cognitive control or socio-emotional regulation, it is equally plausible that higher levels of exposure to multitasking situations lead to structural changes in [these brain areas].")

96. *See, e.g.*, PETER DRUCKER, INNOVATION AND ENTREPRENEURSHIP 36 (2015) ("Innovation . . . creates a resource."); *Innovation*, MERRIAM-WEBSTER, https://www.merriam-webster.com/dictionary/innovation (last visited Feb. 13, 2022) ("the introduction of something new"; "a new idea, method, or device").

97. DRUCKER, *supra* note 96, at 36.

innovation—including abstract reasoning,[98] fluid intelligence,[99] and exerting attentional control while completing a creative task[100]—are all skills associated with lower, rather than higher, levels of simultaneous engagement with media streams made possible by modern innovations like cell phones, instant messaging, audio and video streaming, etc. These innovations may therefore be imposing negative externalities on other innovators by interfering with their ability to effectively engage in the mental processes necessary for producing high levels of quality innovation.

2. Smartphones, Cognitive Performance, and Impulse Control

Even in the absence of conscious engagement in multitasking behavior, certain innovations may provide unwanted distractions

98. *See, e.g.*, Adrian Furnham, John Crump & Viren Swami, *Abstract Reasoning and Big Five Personality Correlates of Creativity in a British Occupational Sample*, 28 IMAGINATION COGNITION & PERSONALITY 361, 361 (2009) (finding a modest but significant correlation between abstract reasoning and divergent thinking, a measure of creative potential); Adrian Furnham & Mikael Nederstrom, *Ability, Demographic and Personality Predictors of Creativity*, 48 PERSONALITY & INDIVIDUAL DIFFERENCES 957, 960 (2010) (showing a modest and non-significant correlation between abstract reasoning and divergent thinking. The authors explain the non-significant result on the fact that the divergent thinking measure was a verbal test; they did find a highly significant correlation between divergent thinking and verbal reasoning); Baoguo Shi, Lijing Wang, Jiahui Yang, Mengpin Zhang & Li Xu, *Relationship Between Divergent Thinking and Intelligence: An Empirical Study of the Threshold Hypothesis with Chinese Children*, FRONTIERS PSYCH., Feb. 2017, at 1, 6 (finding a positive relationship between intelligence and divergent thinking in Chinese children); Emanuel Jauk, Mathias Benedek & Aljoscha C. Neubauer, *The Road to Creative Achievement: A Latent Variable Model of Ability and Personality Predictors*, 28 EUR. J. PERSONALITY 95, 95 (2014) (finding that intelligence predicted creative achievement).

99. *See, e.g.*, Emanuel Jauk, Mathias Benedek, Beate Dunst & Aljoscha C. Neubauer, *The Relationship Between Intelligence and Creativity: New Support for the Threshold Hypothesis by Means of Empirical Breakpoint Detection*, 41 INTEL. 212, 212 (2013) (finding evidence for the hypothesis that an intelligence quotient (IQ) of at least 100 is necessary condition for divergent thinking (a measure of creative potential), and that creative achievement is positively correlated with IQ).

100. *See, e.g.*, Darya Zabelina, Arielle Saporta & Mark Beeman, *Flexible or Leaky Attention in Creative People? Distinct Patterns of Attention for Different Types of Creative Thinking*, 44 MEMORY & COGNITION 488, 488 (2016) ("Creativity, like many mental behaviors, requires attention."). Interestingly, this study's authors found that different types of creativity (real-world creative achievement versus divergent thinking, a measure of creative potential) are associated with different types of attentional processes. *Id.* While subjects who were divergent thinkers tended to be better at filtering irrelevant information, subjects with a proven track-record of creative achievement had "leaky" attention filters that let in irrelevant information. *Id.* But because creative achievement still requires attention, the authors hypothesized that creative achievers rely more heavily on cognitive control "to maintain their attention when needed . . . to persist with an idea or behavior that ultimately leads to a new musical composition, or a highly original painting[.]" *Id.* at 497.

that affect cognitive processes. A well-studied example of such a technology is the ubiquitous smartphone. Cognitive scientists have been exploring how the presence of smartphones in people's daily lives affects attention, memory, reward processing, and other cognitive tasks.

What they have found tentatively suggests that smartphones have at least short-term detrimental effects on attention.[101] A common feature of smartphones is their "notification" functionality, which alerts users to updates and messages in applications other than the one they're currently using. If a phone user takes the time to deal with the unintended notification, the attentional shift required to do so can delay their work on the original application by up to four times.[102] But even when a phone user tries to ignore notifications, they can still interfere with attention. In one study, merely becoming aware of a notification (by hearing the ding or feeling the vibration of the phone) resulted in lower performance on an attention-based task.[103] Perhaps most surprisingly, performance on demanding attentional tasks seems to be affected by the simple presence of a smartphone, even when no notifications or interruptions occur.[104]

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101. Henry H. Wilmer, Lauren E. Sherman & Jason M. Chien, *Smartphones and Cognition: A Review of Research Exploring the Links Between Mobile Technology Habits and Cognitive Functioning*, FRONTIERS COGNITIVE PSYCH., Apr. 2017, at 1, 1 (reviewing the literature).

102. Luis A. Leiva, Matthias Böhmer, Sven Gehring & Antonio Krüger, *Back to the App: The Costs of Mobile Application Interruptions*, PROC. 14TH INT'L CONF. ON HUM.-COMPUT. INTERACTION WITH MOBILE DEVICES SERV.-MOBILE 291, 291 (2012).

103. Cary Stothart, Ainsley Mitchum & Courtney Yehnert, *The Attentional Cost of Receiving a Cell Phone Notification*, 41 J. EXPERIMENTAL PSYCH.: HUM. PERCEPTION & PERFORMANCE 893, 893 (2015).

104. Bill Thornton, Alyson Faires, Maija Robbins & Eric Rollins, *The Mere Presence of a Cell Phone May Be Distracting: Implications for Attention and Task Performance*, 45 SOC. PSYCH. 479, 479 (2014). When a researcher (seemingly by accident) left either a notebook or a smartphone on subjects' desks, those in the smartphone condition performed significantly worse on the demanding aspects of an attention-based task than those in the notebook condition. *Id.* at 481–84.

Smartphones and similar technological innovations may also have both short- and long-term effects on memory and learning. The basic idea is that as we become accustomed to ready access to information, we may consciously or subconsciously exert less effort in memorizing and learning. Wilmer et al., *supra* note 101, at 9. For example, individuals told that newly-learned trivia facts they were typing into a computer would be stored for later access were not able to recall those facts as well as subjects told that the information would be erased. Betsy Sparrow, Jenny Liu & Daniel M. Wegner, *Google Effects on Memory: Cognitive Consequences of Having Information at Our Fingertips*, 333 SCI. MAG. 776, 776–77 (2011). The

More generally, there is also evidence that smartphone use negatively affects cognitive ability. Studies have shown that academic performance—usually measured by grade point average—is negatively associated with time spent instant

authors referred to this phenomenon as the "Google Effect," and it has also been referred to by subsequent researchers as "digital amnesia." Wilmer et al., *supra* note 101, at 7. The authors hypothesized that the expectation of access interfered with processes that encode the information into long-term memory. *See id.* (discussing the study). They also hypothesized that our cognitive processes might be adapting in long-lasting ways to particular digital innovations. In support of this hypothesis, they found that subjects were able to recall *where* information was stored on a computer (folder names) better than they were able to recall the information itself, suggesting that we have adapted to innovations that make it more important to be able to find—rather than to know—particular pieces of information. Sparrow et al., *supra*, at 777–78. Complementary studies involving the camera and GPS navigational functions of smartphones have also found that when test subjects use these features, they remember less of what they experienced at the time of use. Subjects at an art museum told to take pictures of certain objects and merely to observe others were better able to recall, a day later, those objects they observed without taking a photo. Linda A. Henkel, *Point-and-Shoot Memories: The Influence of Taking Photos on Memory for a Museum Tour*, 25 PSYCH. SCI. 396, 396 (2014). In a separate experiment, the authors found that when subjects were asked to zoom in on a particular aspect of the object when taking a picture, they had better recall of not just the zoomed-in features but the object as a whole, suggesting that it is engagement with an object that facilitates recall, and that, in the general case, digital photography discourages this engagement. And subjects who reached a destination with the aid of voice navigation were worse at developing cognitive maps of the navigated environment than those who reached their destination by first studying a paper map. Gary E. Burnett & Kate Lee, *The Effect of Vehicle Navigation Systems on the Formation of Cognitive Maps*, 40 INT'L J. PSYCH. 27, 27 (2005). There are also a number of infamous instances where individuals "offloaded" the cognitive task of navigation to navigational devices to such an extent that they found themselves in a variety of dangerous and inconvenient situations, including driving into a bay, driving across three countries in the wrong direction, driving up a cliff, driving into a sand pit, and wedging a car into a cherry tree. Lauren Hansen, *8 Drivers Who Blindly Followed Their GPS into Disaster*, WEEK (Jan. 8, 2015), https://theweek.com/articles/464674/8-drivers-who-blindly-followed-gps-into-disaster.

messaging,[105] using social networking sites,[106] and engaging with smartphones[107] and electronic media[108] generally.

Finally, some intriguing work has revealed a potential relationship between smartphone use and the way people seek out rewards. Interactions with media innovations, like the texting and social networking applications found on smartphones, provide emotional gratification.[109] On the neural level, researchers believe that checking one's smartphone releases dopamine in the brain,[110]

105. *See, e.g.*, Laura E. Levine, Bradley M. Waite & Laura L. Bowman, *Electronic Media Use, Reading, and Academic Distractibility in College Youth*, 10 CYBERPSYCHOLOGY & BEHAV. 560, 564–65 (2007) (finding a negative correlation between time spent instant messaging and academic performance); Annie Beth Fox, Jonathan Rosen & Mary Crawford, *Distractions, Distractions: Does Instant Messaging Affect College Students' Performance on a Concurrent Reading Comprehension Task?*, 12 CYBERPSYCHOLOGY & BEHAV. 51, 51 (2009) (same).

106. *See, e.g.*, Paul A. Kirschner & Aryn C. Karpinski, *Facebook® and Academic Performance*, 26 COMPUTS. HUM. BEHAV. 1237, 1237 (2010) (finding a negative correlation between Facebook use and academic performance); Reynol Junco, *Too Much Face and Not Enough Books: The Relationship Between Multiple Indices of Facebook Use and Academic Performance*, 28 COMPUTS. HUM. BEHAV. 187, 187 (2012) (same); Aryn C. Karpinski, Paul A. Kirschner, Ipek Ozer, Jennifer A. Mellott & Pius Ochwo, *An Exploration of Social Networking Site Use, Multitasking, and Academic Performance Among United States and European University Students*, 29 COMPUTS. HUM. BEHAV. 1182, 1182 (2013) (finding a negative correlation between social networking site use and academic performance); Jomon Aliyas Paul, Hope M. Baker & Justin Daniel Cochran, *Effect of Online Social Networking on Student Academic Performance*, 28 COMPUTS. HUM. BEHAV. 2117, 2117 (2012) (same). Interestingly, this last study found that time spent on social networking sites was correlated by the attention spans of the students, supporting the link discussed in section II.C.1 between multitasking behavior and attention span.

107. *See, e.g.*, Louis-Philippe Beland & Richard Murphy, *Ill Communication: Technology, Distraction & Student Performance*, 41 LAB. ECON. 61, 61 (2016) (finding that students performed significantly better on exams after their school banned smartphones); Andrew Lepp, Jacob E. Barkley & Aryn C. Karpinski, *The Relationship Between Cell Phone Use, Academic Performance, Anxiety, and Satisfaction with Life in College Students*, 31 COMPUTS. HUM. BEHAV. 343, 343 (2014) (finding that academic performance was negatively associated with cell phone use).

108. *See, e.g.*, Wade C. Jacobsen & Renata Forste, *The Wired Generation: Academic and Social Outcomes of Electronic Media Use Among University Students*, 14 CYBERPSYCHOLOGY, BEHAV., AND SOC. NETWORKING 275, 275 (2011) (finding a negative relationship between electronic media use and academic performance); Reynol Junco & Sheila R. Cotten, *No A 4 U: The Relationship Between Multitasking and Academic Performance*, 59 COMPUTS. & EDUC. 505, 505 (2012) (finding that using Facebook and texting while completing schoolwork were negatively associated with academic performance).

109. *See, e.g.*, Zheng Wang & John M. Tchernev, *The "Myth" of Media Multitasking: Reciprocal Dynamics of Media Multitasking, Personal Needs, and Gratifications*, 62 J. COMMC'N 493, 493 (2012) (finding that media multitasking provides "emotional gratifications" even when the multitasker is not seeking these rewards and is instead seeking cognitive rewards).

110. *See, e.g.*, Sara O'Donnell & Leonard H. Epstein, *Smartphones Are More Reinforcing than Food for Students*, 90 ADDICTIVE BEHAVS. 124, 132 (2019) (finding that smartphones

a neurotransmitter important for reward processing and positive reinforcement,[111] and also implicated in addictive behaviors.[112] But constant access to the rewards smartphones provide might make users less able to delay gratification and more likely to choose smaller, short-term rewards over larger, longer-term goals.[113] In one experiment, heavy smartphone users were more likely than their peers to accept a small, immediate reward instead of waiting for a larger reward; they also tended to be more impulsive.[114] Like many of the other studies presented here, these results are correlational and so tell us nothing about the direction of causality. It could be the case that impulsive people are more attracted to smartphones and so use them more heavily. But it could also be the case that heavy smartphone use affects the way individuals process

provide more positive reinforcement than food in some cases and hypothesizing the involvement of dopamine systems); Aviv Weinstein & Michel Lejoyeux, *New Developments on the Neurobiological and Pharmaco-Genetic Mechanisms Underlying Internet and Videogame Addiction*, 24 AM. J. ON ADDICTIONS 117, 117 (2015) (finding that video game playing results in dopamine release); Markham Heid, *We Need to Talk About Kids and Smartphones*, TIME (Oct. 10, 2017, 6:00 AM), https://time.com/4974863/kids-smartphones-depression/ ("Research has linked social media and other phone-based activities with an uptick in feel-good neurochemicals like dopamine . . . .").

111. *See, e.g.*, Hsing-Chen Tsai, Feng Zhang, Antoine Adamantidis, Garret D. Stuber, Antonello Bonci, Luis de Lecea & Karl Deisseroth, *Phasic Firing in Dopaminergic Neurons Is Sufficient for Behavioral Conditioning*, 324 SCI. 1080, 1080 (2009) (describing dopamine's role in behavioral reward); Wolfram Schultz, *Getting Formal with Dopamine and Reward*, 36 NEURON 241, 241 (2002) (describing how dopamine neurons in various areas of the brain convey reward information); Bill Davidow, *Exploiting the Neuroscience of Internet Addiction*, ATLANTIC (July 18, 2012), https://www.theatlantic.com/health/archive/2012/07/exploiting-the-neuroscience-of-internet-addiction/259820/ (describing dopamine's role in behavioral reward).

112. *See, e.g.*, Marc A. Shuckit, *Science, Medicine, and the Future: Substance Use Disorders*, 314 BMJ 1605, 1606–07 (1997) (describing dopamine's hypothesized role in drug and alcohol addiction); Nora D. Volkow, Gene-Jack Wang, Joanna S. Fowler, Dardo Tomasi & Frank Telang, *Addiction: Beyond Dopamine Reward Circuitry*, 108 PROC. NAT'L ACAD. SCI. 15037 (2011) (reviewing the scientific literature on dopamine's role in addiction); Davidow, *supra* note 111 (stating—in a somewhat oversimplified manner—that "[t]he release of dopamine forms the basis for nicotine, cocaine, and gambling addictions"); *see also* Diana I. Tamir & Jason P. Mitchell, *Disclosing Information About the Self Is Intrinsically Rewarding*, 109 PROC. NAT'L ACAD. SCI. 8038, 8038 (2012) (finding that disclosing information about oneself on social media is highly correlated with increased activation in known "reward" areas of the brain); Dar Meshi, Carmen Morawetz & Hauke R. Heekeren, *Nucleus Accumbens Response to Gains in Reputation for the Self Relative to Gains for Others Predicts Social Media Use*, 7 FRONTIERS HUM. NEUROSCIENCE 439, 439 (2013) (finding that the response in brain reward areas to a reputation-based reward was higher for subjects who used Facebook more often).

113. Wilmer et al., *supra* note 101, at 10.

114. Henry H. Wilmer & Jason M. Chein, *Mobile Technology Habits: Patterns of Association Among Device Usage, Intertemporal Preference, Impulse Control, and Reward Sensitivity*, 23 PSYCHONOMIC BULL. & REV. 1607, 1607 (2016).

rewards, making it more difficult for them to delay gratification.[115] At least one additional study that measured impulsivity before and after controlled smartphone use supports this latter hypothesis.[116]

These results again suggest that particular innovations may be imposing negative externalities on present and future innovators. The process of innovation requires the exertion of attentional control while completing a creative task,[117] and, relatedly, it may require a degree of impulse control as well.[118] And recent research suggests that cognitive skills like memory are also important for creativity.[119] To the extent innovation requires high levels of creativity, smartphones and other similar innovations may be inadvertently disrupting innovators' potential.

3. Digital Innovations and Information Processing

Certain innovations may also be changing how users process information in ways that relate to their innovative potential. A growing body of research suggests that when individuals take in information digitally rather than via print—an increasingly

115. Wilmer et al., *supra* note 101, at 10.

116. A.A. Hadar, D. Eliraz, A. Lazarovits, U. Alyagon & A. Zangen, *Using Longitudinal Exposure to Causally Link Smartphone Usage to Changes in Behavior, Cognition and Right Prefrontal Neural Activity*, 8 BRAIN STIMULATION 318, 318 (2015) (finding that after 3 months of exposure to smartphones, subjects who had not used a smartphone previously tended to be less likely than prior to the study to delay gratification; subjects who had previously not used a smartphone and continued their non-use through the duration of the study showed no change in their tendency to delay gratification).

117. *See, e.g.*, Zabelina et al., *supra* note 100, at 488 ("Creativity, like many mental behaviors, requires attention.").

118. *See, e.g.*, Fa-Chung Chiu, *The Effects of Exercising Self-Control on Creativity*, 14 THINKING SKILLS & CREATIVITY 20, 20 (2014) ("In summary, the data indicated that exercising self-control could increase creativity . . . ."). *But see* David Schuldberg, *Six Subclinical Spectrum Traits in Normal Creativity*, 13 CREATIVITY RES. J. 5, 12 (2001) (finding that creativity scores were positively associated with measures of impulsivity). It is likely that where creativity is concerned there is an "optimal" amount of impulsivity. While impulsivity could boost creativity by promoting norm- and convention-breaking behaviors, *id.* at 11, some degree of impulse control is likely required to actually put in the work creative achievement requires—"to persist with an idea or behavior that ultimately leads to a new musical composition, or a highly original painting[.]" Zabelina et al., *supra* note 100, at 497.

119. *See, e.g.*, Kevin P. Madore, Donna Rose Addis & Daniel L. Schacter, *Creativity and Memory: Effects of an Episodic-Specificity Induction on Divergent Thinking*, 26 PSYCH. SCI. 1461, 1461 (2015) (finding "evidence that episodic memory [memory of autobiographical events] is involved in divergent creative thinking"); Art Markman, *Creativity Is Memory*, PSYCH. TODAY (Oct. 6, 2015), https://www.psychologytoday.com/us/blog/ulterior-motives/201510/creativity-is-memory (discussing the Madore study and his book SMART THINKING, which argues that "[c]reativity is driven by memory[,]" because "all creative work requires using your existing knowledge to help you to do new things").

common occurrence given innovations like personal computers, tablets, smartphones, e-readers, and the like—their brains handle the information differently. One study by Geoff Kaufman and Mary Flanagan, for example, found that when subjects took in information from a digital platform, they tended to focus on and remember concrete details, but were less likely to engage in abstract thinking and make high-level inferences about the information compared to subjects who took in the same information in hard copy.[120] A review of the relevant literature also found that students had better comprehension of print versus online texts, at least when the texts were more than a page long.[121] And a recent series of studies revealed that although students subjectively preferred digital media and read faster and judged their own comprehension as better using this format, their overall comprehension was better when they engaged with print media.[122] These differences in comprehension were less important when it came to gleaning the main idea from a text, but became more striking when students were asked more specific questions about what they had read.[123]

These results too could be conceptualized in the language of externalities. Innovation is often an incremental process[124]

120. Geoff Kaufman & Mary Flanagan, *High-Low Split: Divergent Cognitive Construal Levels Triggered by Digital and Non-digital Platforms*, PROC. 2016 CHI CONF. ON HUM. FACTORS COMPUT. SYS. 2773, 2773 (2016).

121. Lauren M. Singer & Patricia A. Alexander, *Reading on Paper and Digitally: What the Past Decades of Empirical Research Reveal*, 87 REV. EDUC. RSCH. 1007, 1016 (2017) (discussing the "reported associations between length and medium for texts longer than one page").

122. Lauren M. Singer & Patricia A. Alexander, *Reading Across Mediums: Effects of Reading Digital and Print Texts on Comprehension and Calibration*, 85 J. EXPERIMENTAL EDUC. 155, 166–67 (2017).

123. *Id.* The way users engage with texts might also vary based on the format. A recent study published in *Pediatrics*, for example, found that when parents read to their toddlers on a tablet, parent and child engaged in less of the back-and-forth dialogue necessary for language acquisition than when they read from a print book. Tiffany G. Munzer, Alison L. Miller, Heidi M. Weeks, Niko Kaciroti & Jenny Radesky, *Differences in Parent-Toddler Interactions with Electronic Versus Print Books*, 143 PEDIATRICS 1, 1 (2019); *see also* Perri Klass, *Reading to Your Toddler? Print Books Are Better Than Digital Ones*, N.Y. TIMES (Mar. 25, 2019) (discussing the study). This was true whether or not the digital version of the book included so-called "enhancements"—for example, the option to tap a word and activate narration or sound effects. Munzer, *supra* at 3, 6.

124. *See, e.g.*, Pamela Samuelson, Randall Davis, Mitchell D. Kapor & J.H. Reichman, *A Manifesto Concerning the Legal Protection of Computer Programs*, 94 COLUM. L. REV. 2308, 2330 (1994) ("Innovation in software development is typically incremental."); Clark D. Asay, *Enabling Patentless Innovation*, 74 MD. L. REV. 431, 436 (2015) (describing the "cumulative, incremental nature of open innovation"); Robin A. Moore, *Note: Fair Use and Innovation*

requiring innovators to understand and build on what has come before.[125] The extent to which an innovator will be successful in building on a preexisting idea will depend in part on how well she understands the original idea and in part on her ability to think about the idea in novel and creative ways. If, due to particular technological innovations, the way innovators learn about, process, and think about preexisting ideas changes, this may also change the way in which they go about building on those preexisting ideas. And the change may not be entirely positive. Reduced understanding of and ability to think abstractly about existing ideas may very well result in a lower quality and quantity of sequential innovation. One cognitive scientist, commenting on the results of the Kaufman study, put it this way: when innovators get the bulk of their information from digital platforms, "[t]he opportunity for deeper thinking, for deliberation, or for abstract thinking is much more limited. [Innovators] have to rely more on surface-level information, and that is not a good recipe for creativity or invention."[126]

4. Digital Innovations and Affective Processes

Finally, particular innovations may interfere with emotional processing. As anyone familiar with the process of innovation knows, creativity is not merely a cognitive process. It is also an affective process,[127] requiring emotional involvement and adeptness. If one considers any great work of fiction, for example, one of the things that makes it great is the author's ability to

Policy, 82 N.Y.U. L. REV. 944, 948 (2007) ("In the patent context, incremental innovation occurs frequently . . . .").

125. *See, e.g.*, Christopher Buccafusco, Stefan Bechtold & Christopher Jon Sprigman, *The Nature of Sequential Innovation*, 59 WM. & MARY L. REV. 1, 15 (2017) ("[P}eople do not just 'have' ideas. Ideas develop out of preexisting ideas, and those preexisting ideas . . . shape the choices of later stage innovators.").

126. Saga Briggs, *6 Ways Digital Media Impacts the Brain*, INFORMED (Sept. 12, 2016), https://www.opencolleges.edu.au/informed/features/5-ways-digital-media-impacts-brain/ (quoting Jordan Grafman, chief of cognitive neuroscience at the National Institute of Neurological Disorders and Stroke).

127. *See, e.g.*, Scott Barry Kaufman, *The Emotions That Make Us More Creative*, HARV. BUS. REV. (Aug, 12, 2015) (discussing how cognitive and affective processes work together to motivate creative behaviors); Michael W. Ceci & V. K. Kumar, *A Correlational Study of Creativity, Happiness, Motivation, and Stress from Creative Pursuits*, 17 J. HAPPINESS STUD. 609, 620–21 (finding that subjects with a higher "capacity to feel extreme or intense emotions" scored higher on measures of creativity); Scott Barry Kaufman, *Opening Up Openness to Experience: A Four-Factor Model and Relations to Creative Achievement in the Arts and Sciences*, 47 J. CREATIVE BEHAV. 233, 250 (2013) (finding that "affective engagement" or openness to the full range of human emotions, predicted creative achievement in the arts).

understand and communicate the emotional worlds of her characters.[128] More concretely, empathic accuracy, defined as the ability to accurately estimate the emotions of others, has been empirically linked to objective third-party measures of creative output.[129]

But if empathic accuracy is a skill that contributes to creativity, then creativity may also be threatened by processes that interfere with the acquisition or maintenance of empathic functioning. And it appears that engagement with certain types of innovations—in particular, heavy use of digital media facilitated by innovations like social media applications and the devices that support them—does in fact undermine empathic ability. A 2014 study out of UCLA's psychology department found, for example, that sixth-graders who attended a five-day camp where electronic devices were prohibited were better able to identify emotions in a lab setting than their classmates who went about their normal summer routines, which typically involved an average of four-and-a-half hours of daily screen time.[130] The researchers also found, through pre- and post-testing, that the students who attended camp significantly improved in their ability to identify others' emotions in the five

128. *See, e.g.*, William H. Coles, *Emotional Complexity in Literary Fiction*, STORY IN LITERARY FICTION, https://www.storyinliteraryfiction.com/essays-on-writing/emotional-complexity-in-literary-fiction/ (last visited Mar. 12, 2022) ("Without exception, in good literary fiction, emotional complexity must be earned, it must be credible to the reader, it must be logical for the character's complexities and for the story plot, too, and there must be elements of surprise without being unfaithful to the character's established mores, sensitivities, and beliefs."). This feature is so characteristic of good literary fiction, in fact, that those who regularly read it are better at inferring other people's feelings and are more empathetic, presumably because "the sociocognitive complexity . . . in literary fiction prompts readers to make, adjust, and consider multiple interpretations of characters' mental states." Alison Flood, *Literary Fiction Readers Understand Others' Emotions Better, Study Finds*, THE GUARDIAN (Aug. 23, 2016). In other words, it gives readers practice in familiarizing themselves with others' emotions and mental states, and the actions and behaviors that might arise from them.

129. Glenn Geher, Kian Betancourt & Olivia Jewell, *The Link Between Emotional Intelligence and Creativity*, 37 IMAGINATION, COGNITION, & PERSONALITY 5, 5 (2017); *see also* Glenn Geher, *Creativity Goes with Emotional Intelligence*, PSYCH. TODAY (June 29, 2017), https://www.psychologytoday.com/us/blog/darwins-subterranean-world/201706/creativity-goes-emotional-intelligence (discussing the study).

130. Yalda T. Uhls, Minas Michikyan, Jordan Morris, Debra Garcia, Gary W. Small, Eleni Zgoruoru & Patricia M. Greenfield, *Five Days at Outdoor Education Camp Without Screens Improves Preteen Skills with Nonverbal Emotion Cues*, 39 COMPUTS. HUM. BEHAV. 387, 387 (2014); *see also* Stuart Wolpert, *In Our Digital World, Are Young People Losing the Ability to Read Emotions?*, UCLA NEWSROOM (Aug. 21, 2014), https://newsroom.ucla.edu/releases/in-our-digital-world-are-young-people-losing-the-ability-to-read-emotions (discussing the study's findings).

days they were away from their screens.[131] They hypothesize that real-world social interaction contributes to the development of emotional intelligence, and that "the extensive use of digital media, often text-based and thus inherently lacking nonverbal emotional cues, may thus curtail the face-to-face experiences necessary to master important social skills," even though digital media is often used for social communication.[132]

Because of the link between empathic functioning and creative potential, these results have relevance for innovation externalities. The overuse of certain innovations may inhibit innovators' collective long-term ability to be creative and continue to produce high levels of quality innovation.

5. Conclusions

Pulling together these various strands of the psychology and neuroscience literatures leads to an intriguing hypothesis: certain innovations may be exerting an influence on innovators' brains and the way they think. The resultant negative impact on cognitive

131. Uhls et al., *supra* note 130.

132. *Id.* at 388. A longitudinal study currently in press supports this hypothesis. The study followed 960 Norwegian four-year-olds for four years to examine potential links between screen time and emotional understanding. Vera Skalicka, Beate Wold Hygen, Frode Stenseng, Silja Berg Karstad & Lars Wichstrom, *Screen Time and the Development of Emotion Understanding from Age 4 to Age 8: A Community Study*, 37 BRITISH J. DEV. PSYCH. 427 (2019). The study's authors found that children with more screen time at age four scored lower on measures of emotional understanding at age six. *Id.* They also found that children with a television in their bedroom at age six scored lower on measures of emotional understanding at age eight. *Id.*

Yet it would be premature to conclude that digital media use impairs emotional functioning in all situations. A review of the existing literature suggests that the effects of digital technologies on indicators of affective skill are contextual and depend in part on the way these technologies are used. Adam Waytz & Kurt Gray, *Does Online Technology Make Us More or Less Sociable? A Preliminary Review and Call for Research*, 13 PERSPS. PSYCH. SCI. 473 (2018). The review concluded, for example, that when digital technologies are used to enhance and deepen existing real-world relationships, or when they provide a social outlet for those without access to real-world relationships, their use can have a positive effect on emotional functioning. *Id.* at 480–81. However, consistent with the UCLA and other studies, when digital innovations are used to replace real-world interactions, the impact on emotional functioning is negative. *Id.* Subjects who depend more on their smartphones have lower emotional intelligence, Marta Beranuy, Ursula Oberst, Xavier Carbonell & Ander Chamarro, *Problematic Internet and Mobile Phone Use and Clinical Symptoms in College Students: The Role of Emotional Intelligence*, 25 COMPS. HUM. BEHAV. 1182, 1182 (2009), for example, and surveys have revealed a negative association between internet use and self-reports of empathy. Martin Melchers, Mei Li, Yafei Chen, Wanqi Zhang & Christian Montag, *Low Empathy Is Associated with Problematic Use of the Internet: Empirical Evidence from China and Germany*, 17 ASIAN J. PSYCHIATRY 56, 56 (2015).

tasks associated with and required for creative thinking could potentially lead to long-term, adverse effects on creativity.

There is some additional indirect evidence for this hypothesis. A much-publicized 2011 meta-analysis of decades of creativity measurements by Kyung Hee Kim concluded that creativity scores have been steadily declining since 1990, even while traditional measures of intelligence like IQ and SAT scores have been going up.[133] Kim's striking conclusion is that

> over the last 20 years, children have become less emotionally expressive, less energetic, less talkative and verbally expressive, less humorous, less imaginative, less unconventional, less lively and passionate, less perceptive, less apt to connect seemingly irrelevant things, less synthesizing, and less likely to see things from a different angle.[134]

Kim speculates that some of these effects may be due to the concurrent rise in certain innovations, particularly digital innovations, "some aspects of [which] may hinder the development of a child's creative personality."[135]

If this hypothesis is indeed true, it has implications for innovation externalities.[136] Particular innovations that impact

133. Kyung Hee Kim, *The Creativity Crisis: The Decrease in Creative Thinking Scores on the Torrance Tests of Creative Thinking*, 23 CREATIVITY RES. J. 285, 285, 293 (2011); *see also* Po Bronson & Ashley Merryman, *The Creativity Crisis*, NEWSWEEK (July 10, 2010, 4:00 AM), https://www.newsweek.com/creativity-crisis-74665 (discussing the study).

134. Kim, *supra* note 133, at 292.

135. *Id.* More completely, Kim writes:

> It could be speculated children are learning to interact in more impersonal ways, as they are more dependent on current technologies to communicate, perhaps because these technologies lack person to person, verbal and other interpersonal communicative signals. Technologies can enhance creativity and are useful tools for the creative process; however, some aspects of technologies may hinder the development of a child's creative personality.

136. Innovation is a concept distinct from creativity: while creativity is generally thought of as a characteristic people exhibit to greater or lesser degrees based on their circumstances and individual capacities, innovation is understood as the process by which creative ideas are converted into new products and services in the marketplace. Akbar Fadee & Haitham Obaid Abd Alzahrh, *Explaining the Relationship Between Creativity, Innovation and Entrepreneurship*, INT'L J. ECON., MGMT. & SOC. SCI., Dec. 2014, at 1. Nevertheless, because innovation generally relies on creativity as the raw material for its workings, *see id.* at 3 (referring to the "creative people . . . which are the source of innovation"), most scholars believe (and empirical research supports the idea, Hessamoddin Sarooghi, Dirk Libaers & Andrew Burkemper, *Examining the Relationship Between Creativity and Innovation: A Meta-Analysis of Organizational, Cultural, and Environmental Factors*, 30 J. BUS. VENTURING 714, 714 (2015) (finding in a meta-analysis "a strong positive relationship between creativity and

creativity impose negative externalities on other innovators who use these innovations, leading to their reduced ability to be creative and develop truly innovative advances going forward.

III. IMPLICATIONS

A. Implications for Innovation Subsidies

The conventional wisdom in the innovation literature has been that innovation imposes a positive externality (or spillover) on other innovators, while the negative externalities it imposes—like pollution—are borne by the general population rather than innovators specifically.

This conventional wisdom about innovation's externalities has given rise to a general consensus on the appropriate policy response. According to this consensus, the positive externality on innovators—which may lead to suboptimal levels of innovation because present innovators cannot capture the full value of their innovations[137]—can be addressed through innovation subsidies like grants, tax breaks, and IP, which will help innovators capture the full value of their innovations and thereby encourage them to innovate.[138] The negative externalities, meanwhile, can be addressed through targeting the externality-imposing innovations directly through taxation.[139] Ideally, this policy strategy would play out as follows: technology-neutral innovation subsidies like IP and grants would encourage innovation across the board, while taxation of particular externality-imposing innovations (like polluting innovations) would correct for this particular externality by forcing innovators who innovate in this space to internalize the externalities their activities generate.[140] An important feature of this

innovation")) that innovation generally requires some level of creativity. *See, e.g.*, Fadee & Alzahrh, *supra*; Sarooghi et al., *supra*. Andrew Marshall, an innovation consultant, describes the relationship thusly: "Creativity is the price of admission, but it's innovation that pays the bills." Andrew C. Marshall, *There's a Critical Difference Between Creativity and Innovation*, BUS. INSIDER (Apr. 10, 2013, 3:19 PM), https://www.businessinsider.com/difference-between-creativity-and-innovation-2013-4. Anything that negatively impacts creativity will therefore also negatively impact innovation.

137. Liscow & Karpilow, *supra* note 3, at 390–91. *But see* Frischmann & Lemley, *supra* note 21 (arguing that it is not necessary for innovators to capture the full value of their innovations in order to achieve optimal levels of innovation).

138. Liscow & Karpilow, *supra* note 3, at 390–91.

139. *Id.*

140. *See id.*

strategy is that it treats innovation's positive and negative externalities as separable,[141] in part because they operate in different domains and on distinct categories of third parties. The assumption is that innovation's positive externalities are generated by innovation writ large and therefore can and should be addressed via broad innovation-promoting subsidies. Innovation's negative externalities, meanwhile (according to the conventional wisdom), are confined to particular harms, like pollution, imposed by specific types of innovations; because they do not arise from or directly affect the broader innovation landscape, they can be addressed in a more targeted way.

This assumption of separability is suspect, however.[142] For example, in the context of polluting technologies, Liscow and Karpilow have explained how innovation snowballing means that certain innovations—including polluting innovations—will become exponentially more valuable to develop in a way that targeted taxation of these innovations does not adequately address.[143] More generally, the fact that innovation imposes negative externalities on *innovation and innovators* means that the effects of innovation's positive and negative externalities on innovation—and how policymakers choose to address them—should be considered as a whole.

Specifically, under the conventional wisdom just discussed, policymakers should grant innovation subsidies to innovators to help them internalize the spillovers their activities generate for other innovators, thereby providing them with optimal innovation incentives by allowing them to capture the full value of their innovations. But what is this "full value"? As the thinking goes, it is the value the innovators are able to capture through traditional market-based activities, plus the uncaptured "social value"—or spillovers—the innovation generates, with one beneficiary of these spillovers being other innovators.

What this story misses, however, is that innovators are not only generating positive externalities for other innovators. They are also generating negative externalities for other innovators—by creating path dependencies, contributing to anti-innovation norms, and, in many cases, developing innovations that harm the collective

141. *Id.* at 390.
142. *Id.* at 390–92.
143. *Id.* at 392–93.

potential for creativity. Thus, the full "social value" of their innovations might be significantly less than currently recognized. The more accurate calculation of social value would be the uncaptured spillovers for other innovators minus the un-internalized negative externalities imposed on other innovators.

1. Implications: Level of Subsidy

What does this mean for innovation subsidies? For one thing, it implies that these subsides need not be as robust as the conventional wisdom suggests in order to achieve optimal levels of innovation. This conclusion is consistent with the recommendations of those who have called into question a major assumption underlying the conventional wisdom—that it is necessary for innovators to capture the full value of their innovations in order to incentivize them to innovate. According to Frischmann and Lemley, this assumption is incorrect.[144] Instead, they argue that an expected positive return on investment provides a sufficient incentive to innovate.[145] Even if one does not agree with Frischmann and Lemley, however, and believes that full internalization of externalities is required, once the negative externalities of innovation are recognized and accounted for, the total amount of "value" to be made up via innovation subsidies should be significantly reduced.

2. Implications: Type of Subsidy

Secondly, the current thinking is that strong IP rights are one of the most efficient ways to help innovators internalize the externalities imposed by their innovations.[146] This is because IP operates on a market mechanism that allows the market (which incorporates the preferences of billions of people) to determine the "true" value of the innovation rather than leaving that decision to government officials who have much less information.[147] However, a recognition of innovation's negative externalities calls this thinking into question. These externalities may in fact operate in ways such that market signals do not serve to adequately address them. For example, although certain innovations may impose

144. Frischmann & Lemley, *supra* note 21, at 276.
145. *Id.*
146. *Id.* at 263.
147. Liscow & Karpilow, *supra* note 3, at 428–30.

significant negative innovation externalities by reducing the collective capacity for creative thought, history has demonstrated that the demand for these kinds of innovations—innovations like smartphones and the digital software that runs on them—is high. Market-based mechanisms like IP, therefore, by providing a strong pecuniary incentive to produce these types of innovations may not adequately account for the negative externalities these innovations generate.[148]

One alternative mechanism for granting innovation subsidies is provided in the form of government grants. Grants differ from IP in that they generally take a much more interested role in determining what innovation to promote. While IP relies on private innovators to choose what to work on based on the predicted *ex post* market reward, government grants provide money to innovators *ex ante* to cover the costs of particular innovative projects. The government thus plays a big role in determining up front what innovation will be produced with scarce grant funding.

In the legal innovation scholarship, at least some of the literature comparing grant incentives to other innovation incentives like IP regards the *ex ante* government allocation mechanism of grants as a bug rather than a feature.[149] The problem with this mechanism, according to these scholars, is that the government (which makes the funding decisions) is generally less well informed, and thus less able to predict *a priori* what innovations are desirable,[150] compared to private market actors.[151] Private actors are thus generally in a better position to make decisions about which innovations to pursue.[152]

However, the extent to which one agrees with this critique depends in part on one's definition of "desirable." If it is grounded in market value, then it's likely correct that market actors will have

148. Liscow and Karpilow also describe how because of path dependencies, certain innovations which impose significant negative externalities might nevertheless have high market value. This means that IP will provide a strong incentive to develop these particular innovations, despite the fact that their true social value might be low relative to other innovations. *Id.* at 428–30.

149. W. Nicholson Price II, *Grants*, 34 BERKELEY TECH. L.J. 1, 9–10 (2019).

150. *See, e.g.*, Brett Frischmann, *Innovation and Institutions: Rethinking the Economics of U.S. Science and Technology Policy*, 24 VT. L. REV. 347, 353 (2000) ("[T]he selection process for grants relies on the government's ability to assess the desirability of a project when compared with an array of others . . . .").

151. *See* Price, *supra* note 149, at 9–14 (summarizing the argument).

152. *Id.*

more information on this front than government bureaucrats and will thus be better equipped to make efficient innovation decisions.[153] But if one's definition of desirable takes into account social welfare considerations beyond market value, grants might have an advantage on this front, because they allow for the explicit weighing of these considerations, prompting projects to go forward that might not otherwise come into being because market-based systems like IP do not provide adequate incentives to pursue them. A number of commentators have in fact noted that grants might be useful in spurring socially valuable innovations that may not be adequately incentivized by IP—innovations like advances in healthcare quality[154] or new therapy techniques.[155]

On the flip side, to the extent policymakers use the grant system to explicitly consider questions of social value beyond market value, the result will be a higher allocation of scarce resources to high value projects and a correspondingly lower allocation to projects that implicate social welfare concerns. Granting agencies could thus consider the fact that certain types of innovations pose a high risk of generating negative externalities for creativity and innovation going forward and take this information into account when making allocative decisions.

This analysis does not necessarily suggest that IP should be jettisoned in favor of grants and other, more targeted subsidies like tax breaks. But it does suggest that scholars and policymakers could spend more time (as many are beginning to do) thinking about how to address the negative externalities innovation imposes on other innovators, rather than just assuming that IP and the invisible hand of the market will lead to optimal innovation outcomes. This point is explored in more detail in section B.

153. *See, e.g.*, Peter Lee, *Social Innovation*, 92 WASH. U. L. REV. 1, 52 (2014) ("[G]overnments are notoriously poor at 'picking winners.' Contrary to the distributed information efficiencies of the market, public funding requires a centralized authority to make broad investment decisions with limited information."). *But see* Price, *supra* note 149, at 20–32 (pushing back against this argument and pointing out that the government funding process is in fact quite sophisticated and might be better than most people assume—and not necessarily worse than IP—at selecting desirable projects).

154. Kapczynski & Syed, *supra* note 26, at 1952–53.

155. Lee, *supra* note 153, at 17–19, 47–52.

B. Theoretical Implications

In addition to practical implications for how policymakers think about policy responses to innovation's externalities, the hypothesis presented here—that innovation imposes negative externalities on other innovators—also has implications for how scholars think about promoting innovation. Specifically, it should cause scholars to think more deeply about the types of innovation our policies encourage, rather than assuming that any and all innovation is "good" innovation. Even more fundamentally, it calls into question certain philosophical foundations on which this oft-made assumption—that all innovation is good innovation—rests.

1. What Innovation Should Be Encouraged?

The notion that innovation may impose negative externalities on other innovators, thereby impacting their ability to continue to produce high levels of innovation, ties into a broader literature emphasizing the social (rather than just the market) value of particular innovations. In general, legal and economic innovation scholars tend to assume that almost all innovation is good innovation from a social welfare perspective because it fosters economic growth, which in turn produces wealth and raises the standard of living.[156] As discussed above, this optimistic and laissez-faire approach toward innovation is reflected in one of the primary mechanisms for promoting innovation in the U.S.: IP.[157]

156. *See, e.g.*, Arthur, *supra* note 1, at 10; NELSON, *supra* note 1, at 31 ("Virtually all scholars of productivity growth now agree on the central role of technological advance."); Romer, *supra* note 1, at 63–64.

157. Under the dominant law and economics theory of IP, which motivates many of the doctrines and policies embedded in U.S. patent and copyright regimes, IP—by giving time-limited exclusive rights to the creators of new products and ideas—provides incentives to create things that would otherwise not come into being due to free-rider problems arising from the public goods nature of intellectual products. *See, e.g.*, Dan L. Burk & Mark A. Lemley, *Policy Levers in Patent Law*, 89 VA. L. REV. 1575, 1580 (2003) (discussing the "public goods nature of inventions that are expensive to produce but easy to appropriate"). The theory assumes that any social costs incurred by IP in the form of deadweight losses should be outweighed by the social gains—in the form of "progress" via economic growth and some of the more particular benefits mentioned—the incentivized innovation brings. *See, e.g.*, Robert P. Merges & Richard R. Nelson, *On the Complex Economics of Patent Scope*, 90 COLUM. L. REV. 839, 871-79 (1990). Although patent and copyright regimes have certain prerequisites for acquiring rights—including, in copyright, that a creation have some degree of originality, and in patent, that an invention be new, nonobvious, and useful—in theory, IP rights are available to any creation that meets these requirements. In other words, no government

Pushing back against this narrative, some IP and innovation scholars have argued against the assumption that any innovation that comes into being, simply by virtue of the fact that it was produced, will have a net positive effect on social welfare. For example, Ofer Tur-Sinai has asserted that equating market value with social value, as western IP regimes implicitly do, is an oversimplification that may lead society to incur IP's social costs for innovations that contribute little to—and indeed may detract from—social welfare.[158] Tur-Sinai offers as a prime example "positional goods" meant primarily to signal status. While there might be significant profit to be gained from these goods, in part because people *expect* these goods to boost their well-being, the actual impact on individual well-being, and thus on social welfare more broadly, is likely much lower than the projection on which consumers base their willingness-to-pay.[159] On the flip side, some scholars, including Tur-Sinai, Brett Frischmann, Amy Kapczynski, and Talha Syed have argued that IP, with its focus on market value, provides inadequate incentives to produce high-social-value goods with low market value,[160] like certain drugs that would

entity is deciding *a priori* whether a particular creation will be socially beneficial and therefore deserving of IP rights. The thought, instead, is that the market will sort it out: creations that promise to have high market value will offer a bigger carrot to potential creators, since the reward IP provides comes from being able to charge supercompetitive prices for these goods. Ofer M. Tur-Sinai, *Technological Progress and Well-Being*, 48 LOY. U. CHI. L. J. 145, 155 (2016) ("Roughly speaking, the higher the market demand is likely to be for a future technology, the stronger the incentive the patent system provides to develop it."). Being able to collect supercompetitive prices for a banana slicer or a goldfish walker, *see* Roy, *supra* note 40, for example, may result in little gain, while having that privilege over a blockbuster drug could lead to billions of dollars of profit. *See, e.g.*, Jaime E. Moss, *The Implications of the Supreme Court's Decision Regarding Labeling and Liability of Generic Drugs*, 35 THOMAS JEFFERSON L. REV. 45, 57 (2012) ("Of the $860 billion in sales produced by pharmaceutical industries throughout the world in 2010, $295 billion of the sales were comprised of 133 [patented] blockbuster drugs."). Creators will thus be pushed towards the latter type of invention and away from the former. Tur-Sinai, *supra*, at 149.

158. Tur-Sinai, *supra* note 157, at 149 ("Under [the law and economics] perception of well-being, the concept of technological progress that the state ought to promote is rather simplistic—it includes those future goods that current market participants would value most . . . . [But] there are good reasons to suspect that the patent system provides an overincentive to develop, produce, and disseminate certain innovations with a relatively low social value.").

159. *Id.* at 170–71.

160. BRETT M. FRISCHMANN, INFRASTRUCTURE: THE SOCIAL VALUE OF SHARED RESOURCES 109 (2012) (discussing how IP regimes provide inadequate incentives for "various socially desirable intellectual goods"); Kapczynski & Syed, *supra* note 26, at 1905–06 (discussing IP's "appropriability" problem, wherein IP under-incentivizes creations whose value cannot be fully appropriated by the creator).

benefit primarily poor populations[161] or technological solutions to climate change.[162]

Taking the argument one step further, Estelle Derclaye has proposed that the larger idea of technological "progress" on which the IP system rests is itself flawed,[163] in part because it assumes all such progress will make humanity better off. In Dercalye's view, this assumption is not only unproven, it is very likely simply untrue in many instances.[164] As she points out:

> The simple examples of the two World Wars, pollution, and global warming are enough to prove the point: knowledge, science, and technological progress have both positive and negative consequences. However, people still believe in the idea that progress will generate positive results. The belief that technological progress will, by definition, increase well-being includes the corresponding belief that innovation is good by definition too.[165]

As Declaye acknowledges, she is by no means the first to make this point. The recognition that technological progress is not necessarily synonymous with well-being has its roots in the philosophy literature dating back to the nineteenth century.[166] Yet despite Margaret Chon questioning the concept of "progress" in the IP context in her seminal 1993 article *Postmodern Progress: Reconsidering the Copyright and Patent Power*,[167] the idea has been

161. Amy Kapczynski, *The Cost of Price: Why and How to get Beyond Intellectual Property Internalism*, 59 UCLA L. REV. 970, 996–99 (stating that "the poor . . . are so poor that they make up very little of an expected market for an innovation[,]" and pointing out that in those cases where they make up the entire market for an innovation, the innovation is unlikely to be produced).

162. Ofer Tur-Sinai, *Patents and Climate Change: A Skeptic's View*, 48 ENV'T L. 211, 213 (2018) (arguing that "patents most likely underperform—in various important ways—in fostering environmental innovation and thus cannot be trusted to adequately promote the development of climate change technologies").

163. Derclaye, *supra* note 28, at 498 ("[T]he assumptions on which the idea of progress—and therefore, intellectual property rights—rest are deeply flawed.").

164. *Id.* at 522–23.

165. *Id.* at 522.

166. *Id.* at 524.

167. Margaret Chon, *Postmodern Progress: Reconsidering in the Copyright and Patent Power*, 43 DEPAUL L. REV. 97, 100 (1993) (arguing that the IP system is rooted in a modern view of progress, while a postmodern view (for which she advocates) of progress "rejects the view of 'progress' as a liberating upward trajectory"); *see also* Simone A. Rose, *The Supreme Court and Patents: Moving Toward a Postmodern Vision of "Progress"?*, 23 FORDHAM INTELL. PROP. MEDIA & ENT. L.J. 1197, 1221, 1234–38 (2013) (discussing Chon's article and

slow to make its way into legal and economic treatments of innovation, not to mention the public consciousness.[168] For many innovation scholars and laypeople, all innovation is progress, and progress is inherently "good."

The hypothesis presented here—that certain innovations, or the norms and path dependencies that arise around them, may impose negative externalities by impacting other innovators' collective ability to continue to produce high levels of innovation—relates to this literature in that it offers a specific example of innovation having potential negative welfare effects. But, unlike the classic examples of negative externalities imposed by innovation, like the consequences of weapons technology or polluting technology,[169] the negative externality identified here is unique because it does not rely on a value-based definition of "progress" not commonly accepted by legal and economic innovation scholars. Instead, it strikes at the very heart of what progress means to these scholars—the perpetuation of social-welfare-enhancing economic growth through the positive feedback cycle of innovation begetting innovation. These scholars may have previously been unconcerned with the question of innovation's negative externalities because they reject a broader notion of progress that incorporates values beyond economic growth—in their view, all innovation, to the extent that it promotes economic growth, is good innovation. But the evidence presented here suggests that even under this seemingly all-inclusive definition of good innovation, some innovations, and the infrastructures and processes that give rise to them, may be less than good, in the sense that they inhibit future innovation and therefore stall the positive feedback loop of progress and economic growth embodied in the conventional wisdom. The upshot is that innovation's negative externalities should be a matter of concern for *all* innovation scholars—whether they ascribe to a value-based definition of progress that incorporates multiple ideals, or the more traditional view that progress and economic growth are synonymous.

arguing that the Supreme Court erroneously views the Constitution's mandate that IP promote the progress of science and the useful arts through a modernist lens that emphasizes economic growth rather than a postmodernist lens that considers other values like sustainability and environmental concerns).

168. *See* Declaye, *supra* note 28, at 524–25.

169. *See id.* at 522.

2. Philosophical Conceptions of Innovation

As is evident from the aphorism "innovation begets innovation," the legal and economic innovation literature tends to make certain assumptions about innovation. Specifically, the conventional wisdom depends on a conception of innovation as a passive resource, available for society to use as it sees fit to produce yet further innovation. Under the conventional wisdom, when an innovation is created it begets innovation as people use it to be more productive and do new things they couldn't do before. In other words, innovation begets innovation when people exert their agency on the object of innovation in ways that lead to more innovation.

But this view of innovation as passive tool to be used in the ways that best suit society's thirst for more innovation overlooks an important truth about innovation: it doesn't always work solely in the ways society wants it to. The nature of innovation means that there will often be unintended consequences. Some are quickly and easily discovered. But some might be more subtle and take longer to reveal themselves. In this case, some of these consequences—that is, reduced ability to innovate in the long term—might in fact directly undermine society's goal of promoting innovation.

There is an additional flaw in the conception of innovation as object, available for society to act upon as agent as it sees fit to produce yet further innovation. This flaw lies in the assignment of subject and object status to society and innovation, respectively. In the society-innovation equation, we perhaps rightly think of ourselves as the actors and innovation as the acted-upon. But this is an oversimplification. The truth is that innovation also acts on society in ways we may not fully recognize, changing our behaviors, our preferences, and even our cognitive capacities.

A related point has been made by Dan Burk in the context of artificial intelligence (AI) and algorithms. As algorithms have become more sophisticated, incorporating elements of AI and machine learning, legal scholars have been eager to put them to use to solve a variety of law and policy challenges.[170] Burk points out,

170. *See, e.g.*, Cary Coglianse & David Lehr, *Regulating by Robot: Administrative Decision Making in the Machine-Learning Era*, 105 GEO. L.J. 1147, 1152–55 (2017) (concluding that we should be "reasonably optimistic about machine learning and the instrumental role it can play in making a more promising for administrative government"); Ariel Porat & Lior J.

however, that the idea of deploying algorithms in various legal contexts—to, say, determine default contract terms based on party preferences,[171] or decide what uses of another's copyrighted work are legally permissible[172]—while attractive, overlooks an important reality. According to Burk, the algorithms we use to measure personal preferences and conformance with legal standards will inevitably begin to shape those very preferences and standards.[173] One way in which they might do this is by altering incentives. For example, an algorithm that tries to determine permissible uses of copyrighted videos posted to YouTube by non-owners will inevitably rely on metrics that are somewhat simpler than the complex legal standard of fair use. As people interact with this algorithm, they will come to learn what "passes" as fair use to the algorithm and what does not, and will adjust their behavior according to these algorithmically generated incentives.[174] In turn, this widespread behavioral change will alter peoples' views about what the legal standard is and should be; and, given that the law is a social construct that takes its cues from social norms,[175] it will likely result over time in a modification of the legal standard itself.[176]

The philosophy of innovation literature has also recognized this dilemma. Many scientists and engineers subscribe to the idea that

Strahilevitz, *Personalizing Default Rules and Disclosure with Big Data*, 112 MICH. L. REV. 1417 1440–53 (2014) (arguing that data mining algorithms could be used to help tailor and improve the functioning of the legal system in diverse areas such as contracts, organ donation, medical malpractice, landlord-tenant law, and labor law).

171. *See* Porat & Strahilevitz, *supra* note 170, at 1440–45.

172. Dan Burk, *Algorithmic Fair Use*, 86 CHI. L. REV. 283, 288–94 (2019).

173. *Id.* at 302 (discussing how algorithms, deployed in the legal context, "produce recursive biases that change public practice and so change social meaning").

174. *Id.* at 302–03.

175. *See, e.g.*, John Tehranian, *Infringement Nation: Copyright Reform and the Law/Norm Gap*, 2007 UTAH L. REV. 537, 543 (arguing that copyright law does not function effectively when it diverges significantly from social norms); Gregory Mandel, *The Role of Public Perception in the Rule of Law*, 11 TSINGHUA CHINA L. REV. 1, 3 (2018) ("The rule of law will be hindered when there is a disconnect between the law on the one hand, and the public consensus or understanding on the other hand."); Daron Acemoglu & Matthew O. Jackson, *Social Norms and the Enforcement of Laws* (Stan. L. & Econ. Olin, Working Paper No. 466, 2016) (creating an economic model suggesting "that when laws conflict with prevailing norms . . . most people prefer to break the law.").

176. Burk, *supra* note 172, at 303–05 (describing how such a change actually occurred, in the analog context, via the development and widespread use of simplified guidelines to help stakeholders evaluate fair use of copyrighted educational materials. As people and organizations relied on the guidelines to guide their behavior, they became the de facto "law" by which these groups governed themselves; they even began to be cited in legal briefs and court opinions as evidence that a particular use was fair).

innovation is "value neutral"[177] precisely because, like legal and economic innovation scholars, they view it as an object rather than an agent. If innovation is merely an object to be acted upon, it cannot be normatively "good" or "bad" in and of itself; it acquires normative shading only as human agents use it in good or bad ways.[178]

Many philosophers, however, contest the value-neutrality hypothesis. One philosophical argument against the value neutrality of innovation proceeds along the same lines as Burk's concern with algorithmic solutions to legal problems. According to this argument, innovation can, and often does, change peoples' incentives in ways that lead to changes in behavior, which in turn will affect society in good or bad ways.[179] Innovation cannot, therefore, be normatively neutral because it is responsible for these societal effects.[180] The argument also suggests, contrary to the conception of innovation as static object, that particular innovations "act" on us in some sense, because they lead actors to behave differently than they would have prior to the innovation's inception.

Granted, merely changing an individual's incentives is a relatively weak form of action, and bestowing agent status on innovation for this reason is perhaps an overreaction of sorts. After all, individuals are still acting autonomously according to their individual utility calculations; innovation has merely changed the utility of various options. But there is a stronger philosophical protest to the value-neutrality hypothesis. It posits that innovation is not value neutral because it is itself autonomous. This "technological autonomy" hypothesis was first formulated by French philosopher Jacques Ellul, who argued that "the

177. David R. Morrow, *When Technologies Makes Good People Do Bad Things: Another Argument Against the Value-Neutrality of Technologies*, 20 SCI. ENG'R ETHICS 329, 329–30 (2014).

178. *See id.* at 331 ("[T]he core idea [of the value neutrality of technology] is that the effects of any technology depend on the way technology is used, which is determined by its (potential) users, rather than by the technology itself. Therefore, if a technology has bad effects, it must be because its users have used it in bad ways.").

179. *Id.* at 334–35. Morrow gives as an example a theater-lover who must choose between attending a local community production and traveling for three hours to see a Broadway show. Depending on the person's preferences, she might gain more net utility from seeing the lower quality local production because of the disutility incurred by the long travel time. The advent of an innovation like a high-speed train that greatly reduces travel time, however, might change her utility calculation, leading her to modify her behavior and go see the Broadway play.

180. *Id.* at 333 ("[T]echnologies affect individuals' behavior and, through their behavior, affect society for good or for ill.").

technological system exists beyond the (actual or possible) control of any individual and/or group of people."[181] According to Ellul and political scientist Langdon Winner, who elaborated on Ellul's ideas, the sum of society's modern technology forms a system so complex that it essentially (if not literally) has a mind of its own, following its own rules and directing society along the paths it sets for itself.[182] Under this view, the proposal that innovation is value neutral is incorrect because innovation is itself an agent that has "cease[d] to be primarily a means or a tool and beg[un] to become an end . . . . [F]ollowing a technological logic, increasingly independent of human desires."[183]

The hypothesis presented here—that innovation imposes negative externalities by creating path dependencies, social norms, and even cognitive effects that impact future actions—is consistent with both the mild and strong refutations of the value-neutrality hypothesis, and also strengthens and expands on them. First, consistent with the mild argument against value neutrality, it confirms that particular innovations do in fact change the course of human behavior. But rather than doing so simply by altering the utility of various options, the hypothesis suggests they might also do so by altering *people*—their biology, and, as a consequence, their preferences and capacities. Second, consistent with the strong, technological autonomy refutation of value neutrality, the argument presented here confirms that innovation can indeed be thought of as an agent that acts on humans, largely independent of their desires.[184] But the ways in and extent to which it does so may have surprised even Ellul. Beyond simply moving society as a whole in particular directions via path-dependency and social norms, certain innovations may also act on society by modifying individual capacities to think and act in particular ways.

Brett Frischmann and Evan Selinger have recently explored this topic in detail in their book *Re-Engineering Humanity*. In it, they

181. J. Craig Hanks & Emily Kay Hanks, *From Technological Autonomy to Technological Bluff: Jacques Ellul and Our Technological Condition*, 25 HUM. AFFS. 460, 462 (2015).

182. *See id.* at 464 ("The various large technological systems follow their own rules and, at times, may conflict with one another, but are not truly controlled by the state, rather the state is limited by the content and direction of technological systems and imperatives. For example, once we have dispersed single-family ways of living, distant from commerce, industry, and education, then some forms of transportation become rational and others (subways, for instance) do not.").

183. *Id.* at 464.

184. *See id.* at 464.

argue that many contemporary innovations are changing the very nature of humanity by rendering the individuals who use these innovations more machine-like in their thinking and behavior.[185] Accumulating evidence supports Frishmann and Selinger's thesis: for example, a study from Harvard researchers recently concluded that predictive text systems change the way people write in ways that essentially render their writing more machine-like.[186] The psychology and neuroscience evidence presented here also supports Frishmann and Selinger's conclusions.

As interesting as this theoretical debate is on its own merits, for those more practically minded, it is useful because the framing will inform what policy responses, if any, policymakers believe to be appropriate. As Ellul and Winner have both argued, believing in accordance with the conventional wisdom that innovation is merely a passive tool "misleads people about modern technological systems . . . [and] supports naive and self-serving justification of the present state and future direction of technology."[187] In other words, if we accept, as many innovation scholars from the legal and economic traditions do, that innovation begets innovation in a positive feedback loop, and that most innovation has at least the potential to enhance social welfare, the primary concern will be—as it has been—to ensure that innovation continues to occur at high levels. If, however, scholars recognize that innovation imposes negative externalities that may act on us in ways that may halt or slow down this positive feedback loop, they may be motivated to think more carefully about how to design particular innovation infrastructures and promote and use the innovations that result.

CONCLUSION

Innovation scholars tend to think of innovation as providing positive externalities or spillovers for other innovators, while generating negative externalities not directly related to future innovation. This article argues that in fact, innovation may generate significant negative externalities for other innovators, and describes three mechanisms by which it does so: path

185. BRETT FRISCHMANN & EVAN SELINGER, RE-ENGINEERING HUMANITY 1, 10 (Cambridge University Press 2018).

186. Leah Burrows, *Predictive Text Systems Change What We Write*, HARV. SCH. ENG'G & APPLIED SCIS. (May 11, 2020), https://www.seas.harvard.edu/news/2020/05/predictive-text-systems-change-what-we-write (reporting on the study).

187. Hanks & Hanks, *supra* note 181, at 463.

dependencies, anti-innovation norms, and cognitive effects that reduce creative thinking.

Recognizing these negative externalities not only calls into question the dominant narrative of innovation perpetually giving rise to more innovation in a positive feedback loop; it also has practical implications for the best ways to address innovation's externalities. The view espoused by many is that policy treatment of innovation's positive and negative externalities is separable, with innovation's positive externalities best addressed through innovation subsidies, and its negative externalities best addressed through taxation. But this view fails to account for the fact that innovation's negative externalities also operate on other innovators, and so may not be easily separated from innovation's spillovers. Further, innovation's spillovers for other innovators may not be as expansive as often assumed, precisely because of the countervailing negative externalities innovation imposes on other innovators. For innovation policy, this suggests that innovation subsidies designed to account for innovation's spillovers, like IP, grants, and tax breaks, should also account for innovation's negative externalities, and need not be as robust as the conventional wisdom dictates.

On a higher level, a recognition of innovation's hidden negative externalities, and how they operate, challenges a common philosophical conception of innovation in law and economics circles wherein innovation is viewed as a passive tool to be used at society's convenience to produce yet more socially beneficial innovation. This challenge aligns with a growing movement of innovation scholars concerned with the social welfare effects of particular innovations. More particularly, it suggests that rather than simply assuming all innovation is good from the standpoint of perpetuating the positive feedback cycle of continued innovation and economic growth, scholars would do well to recognize that some innovations, and the institutions and infrastructures that support them, can actually interrupt this cycle. Doing so, and calibrating innovation policy accordingly, should result in a more nuanced, humble, and sustainable approach to innovation.