Artificial Intelligence and Patent Ownership

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Abstract

Invention by artificial intelligence (AI) is the future of innovation. Unfortunately, as discovered through Freedom of Information Act requests, the U.S. patent regime has yet to determine how it will address patents for inventions created solely by AI (AI patents). This Article fills that void by presenting the first comprehensive analysis on the allocation of patent rights arising from invention by AI. To this end, this Article employs Coase Theorem and its corollaries to determine who should be allowed to secure these patents to maximize economic efficiency. The study concludes that letting firms using AI to create new technologies (as opposed to software companies, programmers, or downstream parties) to obtain the resulting patents is the optimal policy.

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I. Introduction

The inventor's tale is traditionally the story of a lone genius relentlessly toiling in a garage or attic until achieving a groundbreaking innovation.[1] Although research on iterative invention has largely discredited this narrative, it remains a mainstay in the American psyche.[2] But while the public struggles to accept the reality that important discoveries occur via small

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1. *See* Robert L. Park, *Science in the Courts*, 36 NEW ENG. L. REV. 575, 585 (2002) ("We have this myth of the lone genius laboring all by himself in his little workshop in the attic."); Keith Sawyer, *The Collaborative Nature of Innovation*, 30 WASH. U. J.L. & POL'Y 293, 312 (2009) (arguing that collaboration has replaced creativity as the responsibility of "the lone genius, the solitary inventor working long hours to finish ahead of the competition").

2. *See* Mark A. Lemley, *The Myth of the Sole Inventor*, 110 MICH. L. REV. 709, 710–11 (2012) (explaining how the "lone genius inventor" is a myth by illustrating the true factual accounts of Thomas Edison's, Bell's, and the Wright Brothers' inventions); Erin Shinneman, Note, *Owning Global Knowledge: The Rise of Open Innovation and the Future of Patent Law*, 35 BROOK. J. INT'L L. 935, 935 (2010) ("[T]he narrative of the lone inventor has faded over the years as technological advances, especially the internet, have resulted in dramatic changes to the innovative landscape.").

steps,[3] an even greater break from the accepted narrative is forthcoming—invention by non-human parties.[4]

Artificial intelligence (AI) permeates much of modern business[5] and is increasingly a powerful tool of innovation.[6] Inventing computers are routinely used to create new technologies,[7] such as BMW's recent design of self-driving automobiles.[8] Some analysts believe it is only a short time until AI is responsible for the majority of invention.[9] This raises the issue of how the patent system should treat technologies created solely

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3. *See* Sawyer, *supra* note 1, at 313 (explaining how consumers rarely see how "each innovation builds incrementally on a long history of prior innovations").

4. *See* Liana B. Baker, *Tech Moguls Declare Era of Artificial Intelligence,* REUTERS (June 2, 2016, 9:06 PM), https://www.reuters.com/article/us-tech-ai-conference/tech-moguls-declare-era-of-artifical-intelligence-iduskcn0yp035 (last visited Dec. 4, 2018) (discussing Elon Musk's warning that "artificial intelligence and machine learning will create computers so sophisticated and godlike that human will need to implant 'neural laces' in their brains to keep up") (on file with the Washington and Lee Law Review).

5. *See id.* (explaining how artificial intelligence is used in "web search systems, marketing recommendation functions and security and financial trading programs" and predicting it will spread to healthcare, education, and financial services).

6. *See* Rory Cellan-Jones, *Stephen Hawking Warns Artificial Intelligence Could End Mankind,* BBC (Dec. 2, 2014), https://www.bbc.com/news/technology-30290540 (last visited Dec. 4, 2018) (explaining Stephen Hawking's concerns about machine learning advancements that will surpass human intelligence and potentially eliminate the human race) (on file with the Washington and Lee Law Review).

7. *See* Baker, *supra* note 4 (explaining how artificial intelligence technology will allow for the innovation of driverless cars and service robots).

8. *See* Bernard Marr, *How BMW Uses Artificial Intelligence and Big Data to Design and Build Cars of Tomorrow,* FORBES (Aug. 1, 2017, 12:28 AM), https://www.forbes.com/sites/bernardmarr/2017/08/01/how-bmw-uses-artificial-intelligence-and-big-data-to-design-and-build-cars-of-tomorrow/#450c6f2a2b91 (last visited Dec. 4, 2018) (discussing how BMW used artificial intelligence to create self-driving virtual chauffeur software) (on file with the Washington and Lee Law Review).

9. *See* Ryan Abbott, *I Think, Therefore I Invent: Creative Computers and the Future of Patent Law,* 57 B.C. L. REV. 1079, 1080 (2016) ("Soon computers will be routinely inventing, and it may only be a matter of time until computers are responsible for most innovation.").

by computers with insufficient human engagement to recognize a human inventor (AI inventions).[10]

Patents have been granted on technologies designed exclusively by software,[11] but in these situations, AI's part in the innovation was not disclosed to the United States Patent and Trademark Office (the "USPTO" or "Patent Office").[12] These patentees chose not to mention the computer's invention[13] due to uncertainty about the law.[14] The question of whether, and to whom, patents can be granted for AI inventions has yet to be addressed by the legislature or courts,[15] though several countries plan to do so in the near future.[16]

Regarding domestic policy, the USPTO has no internal guidelines on AI inventions.[17] The Author filed a Freedom of Information Act (FOIA) request seeking all promulgations or

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10. *See* Charlotte Walker-Osborn & Christopher Chan, *Artificial Intelligence and the Law*, ITNOW, March 2017, at 36–37 ("[T]he law envisages an individual as the inventor who contributes to conception of an invention and, yet, there is no concept of a computer being able to conceive of a patentable invention.").

11. *See* Abbott, *supra* note 9, at 1084–87 (describing the granted patents of two AI-created computational inventions); *see also* Ben Hattenbach & Joshua Glucoft, *Patents in an Era of Infinite Monkeys and Artificial Intelligence*, 19 STAN. TECH. L. REV. 32, 44 (2015) ("Of a sampling of issued patents that were conceived wholly or in part by computers, none have ever been subject to litigation." (citing U.S. Patent Nos. 4,908,773; 6,847,851; 7,521,463; 7,915,245; 8,053,477; 8,338,464; 8,445,537; 8,450,368; 8,476,273)).

12. *See* Abbott, *supra* note 9, at 1085–88 (explaining two AI-created inventions for which the Patent Office granted patents without knowing about the non-human inventors' role).

13. *See, e.g., id.* at 1088 (providing the example of one patentee whose legal counsel advised him not to disclose AI's involvement and considered him and his team the sole inventors despite the fact that AI created the entire invention).

14. *See* Hattenbach & Glucoft, *supra* note 11, at 44 (stating that courts have not ruled definitively on "whether computer-conceived inventions are patentable" and discussing the lack of litigation on the issue).

15. *See id.* ("The courts do not appear to have explicitly ruled on whether computer-conceived inventions are patentable."); *see also* Abbott, *supra* note 9, at 1099 ("The Patent Act does not directly address the issue of a computer inventor . . . and there appears to be no case law on the issue of whether a computer could be an inventor.").

16. *See* Walker-Osborn & Chan, *supra* note 10, at 36–37.

17. *See* Abbott, *supra* note 9, at 1099 ("The Patent Office has never issued guidance addressing the subject [of computer inventors], and there appears to be no case law on the issue of whether a computer could be an inventor.").

directives "to patent examiners instructing them on how to examine patent applications listing one or more inventor that is not a human (including software, computers, artificial intelligence, etc.)."[18] In response, the USPTO stated that it had no relevant information,[19] indicating a lack of internal direction on the issue.

This Article provides needed guidance on the efficient allocation of patent rights, should the USPTO decide to grant AI patents. The extant literature has, at best, given passing discussion regarding who should be allowed to secure these rights.[20] To address this void in the literature, the Article employs one of the primary tools in law and economics: Coase Theorem.[21] This proposition holds that aggregate wealth is maximized through inter-firm transactions where property entitlements are clearly allocated and transaction costs are zero.[22] The second

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18. Email from Mike Schuster, Assistant Professor, Okla. State Univ., to USPTO FOIA Officer, U.S. Patent and Trademark Office (Feb. 13, 2017, 09:33 AM) (on file with author) (stating the full request). In full, the request asked for "[a]ny internal instructions (formal or informal) or promulgations communicated to patent examiners instructing them on how to examine patent applications listing one or more inventor that is not a human (including software, computers, artificial intelligence, etc.)." *Id.*

19. *See* Letter from Louis J. Boston, Jr., USPTO FOIA Officer, Office of Gen. Law, to Mike Schuster, Assistant Professor, Okla. State Univ. (Mar. 9, 2017) (regarding FOIA Request No. F-17-00124) (on file with the Washington and Lee Law Review).

20. *See, e.g.*, Abbott, *supra* note 9, at 1082 (arguing that computers and nonhuman authors should qualify as legal inventors, but not analyzing efficient allocation).

21. *Infra* Parts III–IV; *see also* James W. Bowers, *The Elementary Economics of Bijuralism: A First Cut*, 52 J. LEGAL EDUC. 68, 68 n.2 (2002) ("The Coase Theorem, the fundamental analytical tool of law and economics, holds that if there were no transaction costs, law would, in economic theory, become irrelevant." (citing R.H. Coase, *The Problem of Social Cost*, 3 J.L. & ECON. 1 (1960))).

22. *See* Jeanne L. Schroeder, *The End of the Market: A Psychoanalysis of Law and Economics*, 112 HARV. L. REV. 483, 527 (1998) ("If one assumes rationality, no transaction costs, and no legal impediments to bargaining, all mis-allocations of resources would be fully cured in the market by bargains." (citing Guido Calabresi, *Transaction Costs, Resource Allocation and Liability Rules—A Comment*, 11 J.L. & ECON. 67, 68 (1968))); *see also* Jeff Sovern, *The Coase Theorem and the Power to Increase Transaction Costs*, 40 McGEORGE L. REV. 935, 935 n.1 (2009) ("[I]n a regime of zero transaction costs, . . . negotiations between the parties would lead to those arrangements being made which would maximize wealth . . . irrespective of the initial assignment of rights." (citing R.H.

assumption does not exist in reality,[23] but a corollary to the Theorem is that minimization of transaction costs can effect a real world situation mimicking the efficient situation predicted by Coase.[24] Based on this corollary, the Article proposes that efficiency is best attained by allocating AI property rights to parties that purchase or license AI software and utilize it for invention (herein called "AI users").[25] These parties hold these patents in highest value, and thus, aggregate welfare is maximized by allocating the rights to them.[26]

The first substantive Part of this study introduces AI and its capacity to engage in invention, with particular emphasis on genetic algorithms—a type of software that mimics biological evolution to reach optimal design parameters.[27] Part II continues by discussing the legal threshold for inventorship and showing why humans operating inventing software are not inventors. This

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Coase, *The Institutional Structure of Production*, 82 AM. ECON. REV. 713, 717 (1992))).

23. *See* Jeremy Kidd, *Kindergarten Coase*, 17 GREEN BAG 2D 141, 145 (2014), http://www.greenbag.org/v17n2/v17n2_articles_kidd.pdf (providing that the Coase Theorem describes a world without transaction costs "where bargaining is perfectly cheap and easy, where there are no physical, technological, emotional, or other obstacles to bargaining"); *see also* Alan Schwartz, *The Default Rule Paradigm and the Limits of Contract Law*, 3 S. CAL. INTERDISC. L.J. 389, 398 (1993) ("Transaction costs obviously exceed zero . . . .").

24. *See* Barak Y. Orbach & Frances R. Sjoberg, *Excessive Speech, Civility Norms, and the Clucking Theorem*, 44 CONN. L. REV. 1, 8 (2011) (applying the Coase Theorem to the adoption of legal rules and concluding that in order to minimize transaction and social costs, states should avoid creating regulations when possible).

25. *Infra* Parts III–IV.

26. *See* Herbert Hovenkamp, *The Coase Theorem and Arthur Cecil Pigou*, 51 ARIZ. L. REV. 633, 638 (2009) ("[I]n cases of high costs of movement, a legislature . . . could assign the initial allocation to the highest value user *so that movement would not have to occur.*" (emphasis added)); *see also* WERNER Z. HIRSCH, LAW AND ECONOMICS: AN INTRODUCTORY ANALYSIS 18 (2d. ed. 1988) ("As transaction costs are reduced, more transactions result and can be carried out with enhanced efficiency; social welfare is thus increased.").

27. *See* Woodrow Barfield, *Intellectual Property Rights in Virtual Environments: Considering the Rights of Owners, Programmers and Virtual Avatars*, 39 AKRON L. REV. 649, 660 (2006) (explaining that generic algorithms are used to create "intelligent acting" avatars in virtual reality and giving the example of search procedures using natural selection principles to solve problems).

Part concludes by discussing the interplay between AI and intellectual property laws and then reviewing the extant literature on how computer creations should be treated under patent law and the related field of copyright.

Part III introduces Coase Theorem and its pioneering determination that, assuming no transaction costs, self-interested parties will reach economic efficiency[28] (i.e., allocative efficiency)[29] through inter-firm trading if property entitlements are clearly allocated[30] and transactions are costless.[31] It is irrelevant to whom the entitlements are initially assigned, as the party who most values the property interest will trade to obtain them.[32] This Article applies Coase's teachings to find that, within the scope of

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28. *See* Bowers, *supra* note 21, at 61 n.2.

29. This Article specifically refers to allocational or Pareto efficiency when referencing "economic efficiency." *See infra* Part III and note 130; *see also* Stephen E. Ellis & Grant M. Hayden, *The Cult of Efficiency in Corporate Law*, 5 VA. L. & BUS. REV. 239, 241 (2010) ("When economists discuss efficiency, they are typically referring to Pareto optimality, also known as Pareto efficiency or allocative efficiency.").

30. *See* Troy A. Rule, *Airspace in an Age of Drones*, 95 B.U. L. REV. 155, 195 (2015) ("The Coase Theorem suggests that laws that clearly assign initial entitlements relating to a resource promote allocative efficiency." (citing R.H. Coase, *The Problem of Social Cost*, 3 J.L. & ECON. 1, 21 (1960))).

31. *See* R.H. Coase, *The Problem of Social Cost*, 3 J.L. & ECON. 1, 15 (1960)("[I]f such market transactions are costless, such a rearrangement of rights will always take place if it would lead to an increase in the value of production."); *see also* HIRSCH, *supra* note 26, at 18 ("As transaction costs are reduced, more transactions result and can be carried out with enhanced efficiency; social welfare is thus increased."); RICHARD A. POSNER, ECONOMIC ANALYSIS OF LAW 10 (8th ed. 2011) (explaining a simplified version of the Coase Theorem as concluding "if transactions are costless, the initial assignment of a property right will not affect the ultimate use of the property"); Oxford Org., Ltd. v. Peterson (*In re* Stotler & Co.), 144 B.R. 385, 393 (N.D. Ill. 1992) (applying Coase Theorem to bankruptcy and advocating for the free flow of information to protect investors); Coltman v. Comm'r, 980 F.2d 1134, 1137 (7th Cir. 1992) (applying Coase Theorem to conclude: "So long as the rule of law is known when parties act, the ultimate economic result is the same no matter which way the law has resolved issue"); Schwartz, *supra* note 23 at 397–98 (stating that Coase Theorem requires several assumptions, namely "(a) the parties whom the allocation affects are informed about relevant economic variables; (b) wealth effects are absent; (c) competitive markets exist; and (d) the cost of making transactions is zero").

32. *See* Stewart J. Schwab, *Collective Bargaining and the Coase Theorem*, 72 CORNELL L. REV. 245, 265 (1987) (explaining that Coase Theorem predicts that regardless of entitlement assignments, parties will negotiate and trade to reach an efficient bargain).

Coase's assumptions, an efficient state of affairs will be reached with regard to AI patent ownership so long as these rights are clearly defined *regardless of the initial assignment of those rights.*[33]

Part IV deviates from the assumption of no transaction costs and identifies real-world policies that effect the economic efficiency predicted by Coase. A primary strategy towards this goal is to assign property entitlements to those who most value the right.[34] In that situation, the inter-firm transactions underlying Coase Theorem become unnecessary because the party who most benefits from the right (and thus, would always trade to obtain it in the absence of transaction costs) has it initially allocated to them.[35] With this in mind, the Part evaluates a host of parties involved in the AI invention timeline (e.g., software companies, programmers, AI users, product engineers, etc.) to determine which one most values AI patents. As determined through the analysis contained herein, AI users (firms that purchase AI software and utilize it for invention) will most value AI patents and, thus, should be entitled to obtain these patents to maximize economic efficiency.[36]

II. Background

For purposes of patent law, an "inventor" is the party "who conceived [an] invention,"[37] and he has the right to obtain a patent on the technology.[38] Simply coming up with an amorphous idea is

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33.   *Infra* Part III.

34.   *See* Daniel B. Kelly, *Toward Economic Analysis of the Uniform Probate Code*, 45 U. MICH. J.L. Reform 855, 865 (2012) ("Because transaction costs may prevent parties from bargaining to achieve the optimal outcome, Coase suggests that courts should attempt to award an entitlement to the party that values it the most." (citing Hovenkamp, *supra* note 26, at 638)).

35.   *See* Hovenkamp, *supra* note 26, at 638 ("[I]n cases of high costs of movement, a legislature . . . could assign the initial allocation to the highest value user *so that movement would not have to occur.*" (emphasis added)).

36.   *Infra* Part IV.

37.   *See* C.R. Bard, Inc. v. M3 Sys., 157 F.3d 1340, 1352 (Fed. Cir. 1998) ("The 'inventor' in patent law, is the person or persons who conceived the patented invention." (citing Collar Co. v. Van Dusen, 90 U.S. 530, 563–64 (1874); Burroughs Wellcome Co. v. Barr Labs., Inc., 40 F.3d 1223, 1227–28 (Fed. Cir. 1994))).

38.   *See* U.S. CONST. art. I, § 8, cl. 8 (declaring that Congress has the power

insufficient;[39] to qualify as an inventor, one must identify the "definite and permanent idea of the invention as it will be used in practice."[40] But what happens where AI independently creates a patentable invention, and humans are merely non-inventing onlookers?[41]

This Article explores the question of who should own patent rights arising from computer invention with insufficient human contribution to warrant identification of a human inventor.[42] The study does not address situations where AI *and* a human are co-inventors, such that the human can obtain a patent under current precedent. With this in mind, the current Part reviews the state of AI technology and applicable law.

A. Artificial Intelligence Technology

"to promote the Progress of Science and useful Arts by securing for limited Times to . . . Inventors the exclusive Right to their . . . Discoveries").

39. *See* Oasis Research, LLC v. Carbonite, Inc., No. 4:10-CV-00435, 2015 WL 123642, at *5 (E.D. Tex. Jan. 8, 2015), *motion to certify appeal denied*, No. 4:10-CV-435, 2015 WL 12829617 (E.D. Tex. June 11, 2015) (explaining the need for a definite idea rather than a mere general one).

40. *Burroughs*, 40 F.3d at 1229 (Fed. Cir. 1994); *see also* Garrett Corp. v. United States, 422 F.2d 874, 881 (Ct. Cl. 1970) ("One who merely suggests an idea of a result to be accomplished, rather than means of accomplishing it, is not a joint inventor." (citing Forgie v. Oil-Well Supply Co., 58 F. 871 (3d Cir. 1893))); Worden v. Fisher, 11 F. 505 (E.D. Mich. 1882))).

41. *See, e.g.*, Dom Galeon & Sarah Marquart, *Expert: When an AI Invents Something, It Should Be Credited as the Inventor*, FUTURISM (Nov. 8, 2016), https://futurism.com/expert-when-an-ai-invents-something-it-should-be-credited-as-the-inventor/ (last visited Dec. 4, 2018) (noting that nonhuman inventors created the Oral-B CrossAction toothbrush, several music compositions, and some food recipes) (on file with the Washing and Lee Law Review).

42. *See generally* Hattenbach & Glucoft, *supra* note 11 (addressing a similar question of who should be credited with patent ownership of computer-generated technologies and how publication of such material might prevent others from obtaining patents on other inventions); *see also* Kalin Hristov, *Artificial Intelligence and the Copyright Dilemma*, 57 IDEA 431, 435 (2017) (discussing "works generated by AI programs with the direct guidance, assistance or input of human beings").

AI encompasses any technology undertaking an activity that, if done by a human, would require intelligence.[43] In the current "Era of Artificial Intelligence,"[44] smart computers are creating original cuisine,[45] designing the next generation of luxury automobiles,[46] tracking hate crimes,[47] and composing music.[48] Of interest to this Article, of course, is the use of AI to invent new things.[49]

There are many manners by which computers autonomously engage in activities that require "intelligence."[50] For example,

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43. *See* DANIEL CREVIER, AI: THE TUMULTUOUS HISTORY OF THE SEARCH FOR ARTIFICIAL INTELLIGENCE 9 (1993); Marvin L. Minsky, *Artificial Intelligence*, SCI. AM., Sept. 1966, at 247.

44. *See* Baker, *supra* note 4 (stating that Tech CEOs dubbed the present as the "Era of Artificial Intelligence").

45. *See* Hattenbach & Glucoft, *supra* note 11, at 34 (providing that IBM's Watson supercomputer created and predicted the appeal of "quadrillions of different ingredient combinations" (citing Leah Hunter, *How Creative Can Computers Be?*, FAST COMPANY (Mar. 14, 2014), http://www.fastcompany.com/302 7293/how-creative-can-computers-be (last visited Dec. 4, 2018) (on file with the Washington and Lee Law Review))).

46. *See* Marr, *supra* note 8 (discussing the use of artificial intelligence to create self-driving virtual chauffeur software).

47. *See* David Z. Morris, *Google's New Site Uses Artificial Intelligence to Track Hate Crimes*, FORTUNE (Aug. 19, 2017), http://fortune.com/2017/08/19/google-propublica-artificial-intelligence-hate-crimes/ (last visited Dec. 4, 2018) (explaining a tool that uses machine learning to understand the intent behind hate crimes documented in news reports) (on file with the Washington and Lee Law Review).

48. *See* Katherine Bourzac, *A Neuromorphic Chip that Makes Music*, IEEE SPECTRUM (May 23, 2017 1:00 PM), http://spectrum.ieee.org/tech-talk/robotics/artificial-intelligence/a-neuromorphic-chip-that-makes-music (last visited Dec. 4, 2018) (explaining a neuromorphic chip that uses brain-inspired circuits to compose melodies) (on file with the Washington and Lee Law Review).

49. *See, e.g.*, RAY KURZWEIL, HOW TO CREATE A MIND: THE SECRET OF HUMAN THOUGHT REVEALED 124 (2012) (discussing attempts to digitally replicate brain functioning of a roundworm and, eventually, of a human); *see also* John Mannes, *Autodesk Generative Design Takes in Constraints and Makes Its Own 3D Models*, TECHCRUNCH.COM (June 26, 2017), https://techcrunch.com/2017/06/26/generative-design/ (last visited Dec. 4, 2018) ("The software takes in engineering constraints and generates a bunch of potential designs that can either be immediately put to use or used as a jumping-off point for new creations.") (on file with the Washington and Lee Law Review).

50. *See, e.g.*, Erica Fraser, *Computers as Inventors: Legal and Policy Implications of Artificial Intelligence on Patent Law*, 13 SCRIPT-ED 305, 315–19 (2016) (explaining how artificial intelligence employs genetic programming,

neural networks are engineered to mimic human brain activity to "learn" relevant information.[51] Fuzzy logic employs decision-making algorithms that—rather than making assessments premised solely on binary answers to relevant questions—base their output on information that may be partially true or vague, as is common in the real world.[52] While each of these may be employed to create new technology,[53] the below gives a more thorough analysis to a single example of inventing software.[54]

Genetic algorithms independently develop new inventions by mimicking biological evolution[55] via "an iterative process of

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artificial neural networks, and robot scientists to invent new technologies).

51. *See* Dana S. Rao, *Neural Networks: Here, There, and Everywhere—An Examination of Available Intellectual Property Protection for Neural Networks in Europe and the United States*, 30 GEO. WASH. J. INT'L L. & ECON. 509, 509 (1997) (explaining how neural networks learn and generalize information to solve problems that exceed the scope of their initial training); *see also* Serge Jorgensen, *Convergence of Forensics, E-Discovery, Security, & Law*, 12 AVE MARIA L. REV. 291, 291 n.3 (2014) (providing that neural networks attempt to imitate the way the brain works by "creating connections between processing elements" (citing *Neural Network*, WEBOPEDIA, https://www.webopedia.com/TERM/N/neural_ network.html (last visited Dec. 4, 2018) (on file with the Washington and Lee Law Review).

52. *See* Joseph S. Bird, *Cognitive Neuroscience as a Model for Neural Software Patent Examination*, 31 AIPLA Q.J. 273, 297 (2003) (explaining that fuzzy logic is "multi-valued logic with intermediate values to be defined between conventional binary evaluations like zero/one or yes/no" and thus can represent ambiguous knowledge); *see also* Bart Kosko & Satoru Isaka, *Fuzzy Logic*, SCI. AM., July 1993, at 76 ("Fuzzy logic manipulates such vague concepts as warm or still dirty and so helps engineers to build air conditioners, washing machines and other devices . . . ." (internal quotations omitted)).

53. *See* Fraser, *supra* note 50, at 315–19 (explaining how artificial intelligence employs genetic programming, artificial neural networks, and robot scientists to invent new technologies, such as NASA's satellite antennas, electronic toothbrushes, and drug-resistant malaria research identification).

54. Unless specifically identified, the use of the terms "artificial intelligence" and "AI" should be understood herein to reference any type thereof.

55. *See* Abbott, *supra* note 9, at 1086 (explaining how genetic programming emulates the "simple processes" of "mutation, sexual recombination, and natural selection" to generate patentable results and achieve machine intelligence); *see also* KURZWEIL, *supra* note 49, at 147 (explaining the use of genetic algorithms to set "God parameters" by coding potential solutions, defining a list of parameters and randomly generating thousands of genetic codes); John R. Koza, *Human-Competitive Results Produced by Genetic Programming*, *in* 11 GENETIC PROGRAMMING AND EVOLVABLE MACHINES 251, 265 (2010) (providing thirty-one instances in which genetic programming produced a human

simulated competition and improvement."[56] This type of AI functions to optimize a set of design parameters, with each parameter being analogized to a single gene within a larger chromosome.[57] The computer initially creates a fixed number of chromosomes with random values for their constituent genes— forming several sets of parameters with random attributes.[58] The resultant chromosomes are run through a cost function[59] to determine the best performing sets of parameters, and poorly performing chromosomes are discarded.[60] The process further

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competitive result that duplicated the functionality of a previously patented invention); John R. Koza et al., *Evolving Inventions*, SCI. AM., Feb. 2003, at 52 (discussing how computer programmers use software versions of evolutionary processes to achieve machine intelligence). Genetic algorithms were initially developed in the mid-1970s by Professor John Holland. *See* Donald T. Hornstein, *Complexity Theory, Adaptation, and Administrative Law*, 54 DUKE L.J. 913, 936–37 (2005) (describing genetic algorithms as a "paradigm for harnessing the power of adaption").

56.   KURZWEIL, *supra* note 49, at 148.

57.   *See* RANDY L. HAUPT & SUE ELLEN HAUPT, PRACTICAL GENETIC ALGORITHMS 19, 30 (2d ed. 2004) (providing and applying background on cellular heredity to cost functions of genetic algorithms); *see also* KURZWEIL, *supra* note 49, at 148 (discussing the process of enabling solutions to emerge by rejecting the iterative cycles with no generation improvements and using the best designs in the last generation).

58.   *See* HAUPT & HAUPT, *supra* note 57, at 36, 52 (explaining how the gene can represent a binary setting or some parameter within an array of potential entries because the genetic algorithm assigns random numbers to a group of chromosomes, or population, which it later converts to floating-point numbers); KURZWEIL, *supra* note 49, at 147 ("First, we determine a way to code possible solutions . . . . [T]hen we define a list of all of the parameters . . . . Then we randomly generate thousands or more genetic codes."). "The population size affects both the ultimate performance and the efficiency of GA's. GA's generally do poorly with very small populations, because the population provides an insufficient sample size for most hyperplanes. A large population is more likely to contain representatives from a large number of [potential solutions]." J.J. Grefenstette, *Optimization of Control Parameters for Genetic Algorithms, in* BILL P. BUCKLES & FREDERICK E. PETRY, GENETIC ALGORITHMS 7 (1992) (internal citation omitted). "On the other hand, a large population requires more evaluations per generation, possibly resulting in an unacceptably slow rate of convergence." *Id.*

59.   *See* Preston C. Green, III et. al., *Race-Conscious Funding Strategies and School Finance Litigation*, 16 B.U. PUB. INT. L.J. 39, 49 (2006) ("Cost function analysis is a statistical method which determines the costs associated with attaining a particular set of outcomes . . . .").

60.   *See* KURZWEIL, *supra* note 49, at 148 (describing how researchers "run

mimics natural selection by allowing the best performing candidates to survive and "mate" (i.e., trading values for some subset of their attributes with another set of parameters to produce "children").[61] This methodology ensures a variety of attribute combinations is tested[62] and is repeated until the entire population (the number of initial chromosomes) has been filled with the remaining parents and their children.[63]

The AI lastly ensures that a large variety of genetic pairings are explored by randomly altering ("mutating") some subset of parameters.[64] Mutation rates are selected to be high enough to ensure some variability, but sufficiently low to guarantee continuation of preferred attributes.[65] The process then begins again with the remaining population of chromosomes subjected to the cost function to determine which sets of parameters perform

each program generated by the parameters and judge it on appropriate criteria (did it complete the task, how long did it take, and so on)"); HAUPT & HAUPT, *supra* note 57, at 36, 54 (explaining that only the strongest chromosomes survive). This determination can be made so the best-performing $X\%$ of the population is retained, chromosomes satisfying some performance threshold are retained, or via some other methodology of retention. *Id.* at 36–38. "Deciding how many chromosomes to keep is somewhat arbitrary. Letting only a few chromosomes survive to the next generation limits the available genes in the offspring. Keeping too many chromosomes allows bad performers chance to contribute their traits to the next generation." *Id.* at 38.

61. *See* RICHARD DAWKINS, THE SELFISH GENE 33 (1976) (explaining how natural selection encourages species to mimic those with more advantageous genetic traits); HAUPT & HAUPT, *supra* note 57, at 38–41, 56 (demonstrating that the selection of chromosomes to be paired together can be done in a variety of manners, including random pairing and weighting the likelihood of procreation based on the level of performance).

62. *See* Grefenstette, *supra* note 58, at 6 (explaining that the "power of GA's derives largely from their ability to exploit efficiently [a] vast amount of accumulating knowledge by means of relatively simple selection mechanisms").

63. *See* KURZWEIL, *supra* note 49, at 148 (explaining that the researchers "cause each of the survivors to multiply themselves until they reach the same number" as the initial population).

64. *See* HAUPT & HAUPT, *supra* note 57, at 43 (describing how mutations occur in the genetic algorithm and the benefits of altering the chromosomes); Grefenstette, *supra* note 58, at 7 ("Mutation is a secondary search operator which increases the variability of the population. After selection, each bit position of each structure in the new population undergoes a random change with the probability equal to the mutation rate M.").

65. *See* Grefenstette, *supra* note 58, at 7 (explaining how mutation levels that are too high or too low negatively affect an experiment).

best.[66] Iterations continue for a specified number of repetitions or until an acceptable level of performance is achieved.[67]

This type of inventing software has proven effective.[68] General Electric utilized genetic algorithms to design jet engines that outperform existing units.[69] Hitachi used the technology to create a quieter bullet train nose case with better aerodynamics.[70] Likewise, genetic algorithms have created novel communications systems, diesel engines, pharmaceuticals, and power plant turbines.[71]

Beyond the above discussion about what AI is, it is notable to define what it is not. Alongside the expanding scope of rights for non-human corporations,[72] some have discussed personhood for AI

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66.   *See* HAUPT & HAUPT, *supra* note 57, at 44 ("After the mutations take place, the costs associated with the offspring and mutated chromosomes are calculated . . . . The process described is iterated.").

67.   *See id.* at 47, 52, 62 (describing the point at which the researcher should stop the genetic algorithm).

68.   *See* Ray Kurzweil, *The Virtual Thomas Edison*, TIME (Dec. 3, 2018), http://content.time.com/time/magazine/article/0,9171,90538-1,00.html (last visited Dec. 4, 2018) ("The results of [using genetic algorithms] can be surprisingly effective, often solving difficult engineering and other design problems.") (on file with the Washington and Lee Law Review).

69.   *See id.* ("General Electric also uses genetic algorithms, in the design of jet engines . . . .").

70.   *See* ROBERT PLOTKIN, THE GENIE IN THE MACHINE: HOW COMPUTER-AUTOMATED INVENTING IS REVOLUTIONIZING LAW AND BUSINESS 60 (2009) (explaining how genetic algorithms optimized the design and performance of the bullet train).

71.   *See* Peter M. Kohlhepp, *When the Invention is an Inventor: Revitalizing Patentable Subject Matter to Exclude Unpredictable Processes*, 93 MINN. L. REV. 779, 786–87 (2008) ("Virginia engineers designed a novel and effective satellite communications antenna." (citing Anne Eisenberg, *When a Gizmo Can Invent a Gizmo*, N.Y. TIMES, Nov. 25, 1999, at G9)); PLOTKIN, *supra* note 70, at 60 (explaining that a genetic algorithm "produced such a significant improvement in the efficiency of the drug discovery process that it has become the most-used software by 1,500 computational chemists at Pfizer" (citing Interview by Robert Plotkin with David Fogel (Sept. 20, 2007))); Liza Vertinsky & Todd M. Rice, *Thinking About Thinking Machines: Implications of Machine Inventors for Patent Law*, 8 B.U. J. SCI. & TECH. L. 574, 581 (2002) (discussing how genetic algorithms increased the efficiency of turbines by five percent).

72.   *See* Ronit Donyets-Kedar, *Challenging Corporate Personhood Theory: Reclaiming the Public*, 11 LAW & ETHICS HUM. RTS. 61, 61–62 (2017) ("Two recent landmark decisions by the American Supreme Court, *Citizens United* and *Hobby Lobby*, have expanded constitutional protections for corporations to include First

in fields such as real property ownership,[73] maritime regulations,[74] and constitutional law.[75] The current discussion assumes that AI is not an entity that will be granted personhood rights under patent law, and it will not be able to own AI patents.[76] Should that happen, the instant question—pertaining to who should own AI patents—becomes moot.

B. The Legal Threshold for Inventorship

This subpart analyzes precedent regarding what constitutes invention for patenting purposes and uses it to show why humans using AI to create new technologies do not satisfy this threshold. A primary requirement for inventorship is "mak[ing] a significant contribution to the invention."[77] To meet this standard, one must bring about a "definite and permanent idea of the invention

Amendment rights and the right to religious liberty."); Anna Gentry, *Corporate Personhood and Nonprofit Director Duty of Obedience: Legal Implications That Necessitate Expanded Standing to Sue*, 23 GEO. MASON L. REV. 165, 186 (2015) ("[B]eginning in the 1960s, corporations saw a massive expansion of legal rights and protections.").

73. *See* David Marc Rothenberg, *Can Siri 10.0 Buy Your Home? The Legal and Policy Based Implications of Artificial Intelligent Robots Owning Real Property*, 11 WASH. J.L. TECH. & ARTS 439, 447 (2016) ("Because of the moral principles tied to real property ownership, this right must be carefully scrutinized before it is extended to autonomous artificial intelligent entities . . . .").

74. *See* Michal Chwedczuk, *Analysis of the Legal Status of Unmanned Commercial Vessels in U.S. Admiralty and Maritime Law*, 47 J. MAR. L. & COM. 123, 164 (2016) (discussing the liability implications of using artificial intelligence on ships).

75. *See* Lawrence B. Solum, *Legal Personhood for Artificial Intelligences*, 70 N.C. L. REV. 1231, 1255 (1992) (addressing the question of whether the Constitution should extend to artificial intelligence).

76. *But see* Fraser, *supra* note 50, at 330 (discussing the possibility of "recognising computers as legal persons" with regard to inventing activity); Jason Tashea, *Estonia Considering New Legal Status for Artificial Intelligence*, ABA (Oct. 20, 2017, 1:10 PM), http://www.abajournal.com/news/article/estonia_considering_new_legal_status_for_ai/?utm_campaign==tech_monthlyabajournal.com/news/article/e (last visited Dec. 4, 2018) ("Estonia is considering a legal status for artificial intelligence beyond property.") (on file with the Washington and Lee Law Review).

77. Netscape Commc'ns Corp. v. ValueClick, Inc., 684 F. Supp. 2d 699, 721 (E.D. Va. 2010), on reconsideration in part, 704 F. Supp. 2d 544 (E.D. Va. 2010) (citing Pannu v. Iolab Corp., 155 F.3d 1344, 1351 (Fed. Cir. 1998)).

[sufficient to allow] a skilled artisan [to] carry out the invention without undue experimentation."[78] This requirement is not satisfied by merely providing information describing the state of the art.[79] On this point, the Federal Circuit's *Nartron Corp. v. Schukra U.S.A., Inc.*[80] is instructive.[81]

Nartron turned on whether Mr. Joseph Benson was an inventor of a massaging car seat.[82] Benson alleged inventorship because he suggested the use of an "extender for a lumbar support adjustor" in the patented invention.[83] No one contested that he recommended use of this element, but neither did anyone dispute that this component was common in prior inventions.[84] The court resolved the issue by recognizing that Benson's suggestion only mimicked the existing state of technology, and thus, showed no ability beyond that of one of ordinary skill in the art.[85] Because simply providing information about the current state of the art is not an invention, Benson was held not to be an inventor.[86]

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78. Burroughs Wellcome Co. v. Barr Labs., Inc., 40 F.3d 1223, 1229–30 (Fed. Cir. 1994). The logic of this holding is exemplified in the Supreme Court's 1847 *Wood v. Underhill*, 46 U.S. 1 (1847), opinion—dealing with patent enablement—which held that where a patent "gives only the names of the substances which are to be mixed together, without stating any relative proportion, undoubtedly it would be the duty of the court to declare the patent to be void." *Id.* at 6.

79. *See* Nartron Corp. v. Schukra U.S.A. Inc., 558 F.3d 1352, 1356 (Fed. Cir. 2009) ("One who simply . . . explains the state of the art without ever having a firm and definite idea of the claimed combination as a whole does not qualify as a joint inventor." (quoting Ethicon Inc. v. U.S. Surgical Corp., 135 F.3d 1456, 1460 (Fed. Cir. 1998))).

80. 558 F.3d 1352 (Fed. Cir. 2009).

81. *See id.* (describing the requirements for inventorship).

82. *See id.* at 1353 (finding that Benson was not an inventor because he "provided only an insignificant contribution to the invention").

83. *Id.* at 1357.

84. *See id.* at 1355 ("[Benson] admits that the idea of an extender for a lumbar support adjustor in an automobile seat was in the prior art.").

85. *See id.* at 1358 ("Benson's contribution of the extender amounted to 'nothing more than explaining to the inventors what the then state of the art was and supplying a product to them for use in their invention.'" (quoting Hess v. Advanced Cardiovascular Sys., Inc., 106 F.3d 976, 981 (Fed. Cir. 1997))).

86. *See id.* (reversing the district court to hold that Benson was not a co-inventor).

In addition, "[o]ne who merely suggests an idea of a result to be accomplished, rather than means of accomplishing it, is not [an] inventor."[87] This rule is embodied by the Eastern District of Texas's *Oasis Research, LLC v. Carbonite, Inc.*,[88] wherein Carbonite argued that Mr. Jack Byrd should have been included as an inventor on a data-handling patent.[89] Carbonite proffered that Byrd "conceived the idea for a remote online backup service" in the early 1990s.[90] Lacking skills needed to create the technology, he passed the project to other employees and had nothing further to do with it.[91] The court reasoned that—due to his failure to participate in the actual creation of the invention beyond identifying a goal—Byrd was not an inventor.[92]

A related line of cases hold that employing another party to invent does not make one an inventor.[93] This proposition, for example, set forth in *TS Holdings, Inc. v. Schwab*[94] from the Eastern District of Michigan is instructive. Therein, Mr. Barry Schwab was hired to create a "video product to be used in automobile marketing."[95] Schwab obtained a patent on the subsequent invention, and his employer later alleged that he

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87. Garrett Corp. v. United States, 422 F.2d 874, 881 (Ct. Cl. 1970). *Garret Corp.* has been cited by the Federal Circuit for this proposition. *See Nartron Corp.*, 558 F.3d at 1359 (adopting the rule stated in *Garrett Corp.*); Eli Lilly & Co. v. Aradigm Corp., 376 F.3d 1352, 1359 (Fed. Cir. 2004) (adopting the rule stated in *Garrett Corp.* as well); *see also* Drone Techs., Inc. v. Parrot S.A., 838 F.3d 1283, 1306 (Fed. Cir. 2016) (applying the *Garrett Corp.* rule); *Netscape Commc'ns Corp.*, 684 F. Supp. 2d at 721 (explaining that the *Garrett Corp.* rule is well-established).

88. No. 4:10-CV-00435, 2015 WL 123642 (E.D. Tex. Jan. 8, 2015).

89. *See id.* at *6 (listing Byrd's contributions to the patents in question).

90. *Id.* at *3.

91. *See id.* at *6–7 (detailing Byrd's role in creating the invention).

92. *See id.* at *7 ("[T]he contributions made by Byrd merely suggest an idea of a result to be accomplished . . . rather than a means of accomplishing it.").

93. *See* Nartron Corp. v. Schukra U.S.A. Inc., 558 F.3d 1352, 1359 (Fed. Cir. 2009) (explaining that an "entrepreneur's request to another to create a product that will fulfill a certain function" does not make the entrepreneur an inventor (quoting Ethicon, Inc. v. U.S. Surgical Corp., 937 F. Supp. 1015, 1035 (D. Conn. 1996))); TS Holdings, Inc. v. Schwab, No. 09-CV-13632, 2011 WL 13205959, at *4 (E.D. Mich. Dec. 16, 2011) (categorizing one who hires another to complete the invention as the owner, not the inventor).

94. No. 09-CV-13632, 2011 WL 13205959 (E.D. Mich. Dec. 16, 2011).

95. *Id.* at *1.

should be included as an inventor.[96] The court disagreed, rebuffing arguments that Schwab's employer was an inventor because he "financed the reduction to practice" and was the initial reason Schwab began work on the invention.[97] Because providing monetary support and instructing others to create new technology are not sufficient to constitute invention, Schwab's employer was not an inventor.[98]

This precedent establishes that a human using inventing AI is not an inventor for purposes of patent law.[99] To initiate AI invention, a person may input seed information,[100] including existing technologies, e.g., for neural networks,[101] or relevant parameters to be optimized, e.g., for genetic algorithms.[102] Such acts merely provide the AI with access to existing knowledge in the field, which *Nartron* held is not invention.[103]

After uploading this information, a human may identify a technology to invent or technological field within which to invent.[104] For instance, one piece of inventing software—the Invention Machine—requires a user to input "specifications for a desired result," which the AI will seek to satisfy.[105] Genetic

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96. *See id.* at *2 ("[The employer] filed suit against Schwab, claiming that he is a co-inventor . . . .").

97. *Id.* at *4 (citing Hybritech Inc. v. Monoclonal Antibodies, Inc., 802 F.2d 1367, 1376 (Fed. Cir. 1986)).

98. *See id.* ("[T]here is no legal basis for [the] assertion that financing such reduction to practice equates to invention itself.").

99. *See* Hattenbach & Glucoft, *supra* note 11, at 46 ("[I]t seems highly unlikely that courts would bestow inventorship status on a computer.").

100. *See* Abbott, *supra* note 9, at 1094 ("Computers require some amount of human input to generate creative output.").

101. *See* Fraser, *supra* note 50, at 317–18 (explaining how Artificial Neural Networks, a form of AI, mimic brain activity to accelerate technological development).

102. *See* HAUPT & HAUPT, *supra* note 57, at 36, 52; *Watson Cooks Up Computational Creativity*, IBM, https://perma.cc/GGV7-NHT4 (last visited Dec. 4, 2018) (listing the parameters that developers placed on a computer program to create recipes) (on file with the Washington and Lee Law Review).

103. *See Nartron Corp.*, 558 F.3d at 1358 (explaining that one who merely describes the state of the art is not an inventor).

104. *See* Abbott, *supra* note 9, at 1094 (describing the role humans play in computer-generated inventions).

105. *Id.* at 1087 (citing Telephone Interview with John Koza, President,

algorithms may also be set to meet a particular set of performance parameters.[106] Inputting these parameters is not invention. As made clear in *Oasis Research*, identification of a goal or technology to be created by others (be it AI or another human) is insufficient to constitute invention.[107]

Lastly, the fact that a human finances, owns, or operates AI is insufficient to qualify that person as an inventor.[108] As made clear in *TS Holdings*, financing or initiating the process of invention (e.g., by setting inventors to task) does not satisfy the standard to be named on a patent.[109] In such situations, a person may be responsible for an invention, but they have not actually invented a new technology.[110] This subpart establishes that humans may not an inventor where AI is involved. The following subpart evaluates how this issue has been addressed in the literature.

C. Literature Review of Artificial Intelligence and Intellectual Property Law

The interplay of intellectual property law and computer creations (both inventions and works of authorship) has been the subject of some scholarship.[111] This subpart reviews the literature

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Genetic Programming Inc. (Jan. 22, 2016)).

106. *See* HAUPT & HAUPT, *supra* note 57, at 47, 52, 62 (discussing how genetic algorithms can be run until a particular goal, set by the user, is satisfied).

107. *See* Oasis Research, LLC v. Carbonite, Inc., No. 4:10-CV-00435, 2015 WL 123642, at *7 (E.D. Tex. Jan. 8, 2015) (declining to extend inventorship to one who "merely suggest[ed] an idea of a result to be accomplished . . . rather than a means of accomplishing it"); *see also* Eli Lilly & Co. v. Aradigm Corp., 376 F.3d 1352, 1359 (Fed. Cir. 2004) ("One who merely suggests an idea of a result to be accomplished, rather than a means of accomplishing it, is not a joint inventor." (quoting Garrett Corp. v. United States, 422 F.2d 874, 881 (Ct. Cl. 1970))).

108. *See* TS Holdings, Inc. v. Schwab, No. 09-CV-13632, 2011 WL 13205959, at *4 (E.D. Mich. Dec. 16, 2011) ("[T]here is no legal basis for [the] assertion that financing such reduction to practice equates to invention itself.").

109. *See id.* (declining to classify someone who hires another to develop the invention as an inventor).

110. *See id.* at *6 ("Ownership of a patent application guaranties neither inventorship nor ownership of subsequent continuations-in-part . . . .").

111. *See generally* Ralph D. Clifford, *Intellectual Property in the Era of the Creative Computer Program: Will the True Creator Please Stand Up?*, 71 TUL. L. REV. 1675 (1997) (arguing that computer generated inventions cannot qualify for

pertaining to whether AI patents can be constitutionally granted, application of patent laws to AI inventions, and copyright's interplay with computer-generated works—a relevant subject because patents and copyrights issue pursuant to a common enumerated power (the Intellectual Property (IP) Clause).[112]

Early legal commentary discussed whether AI patents and copyrights could be issued pursuant to the IP Clause, which allows Congress to grant these rights to "authors and inventors."[113] Clifford argues that copyright and patent statutes both implicitly require that "a *human* must creatively toil to produce the [authorship or invention,]" and this limitation should be read into the IP Clause.[114] In contrast, Miller asserts that there are no caselaw, statutory, or policy limitations inhibiting the extension of authorship (and by implication, inventorship) to computers.[115] On the issue, the Supreme Court stated that—with regard to the IP Clause—terms such as authors and inventors "have not been construed in their narrow literal sense but, rather, with the reach necessary to reflect the broad scope of constitutional principles."[116] This Article proceeds assuming such precedent renders AI patents constitutional.[117]

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copyright protection); Arthur R. Miller, *Copyright Protection for Computer Programs, Databases, and Computer-Generated Works: Is Anything New Since CONTU?*, 106 HARV. L. REV. 977 (1993) (arguing that copyright law would protect computer generated inventions).

112. *See* U.S. CONST. art. I, § 8, cl. 8 (establishing intellectual property rights).

113. *Id.*

114. Clifford, *supra* note 111, at 1701 (emphasis added) (footnote omitted).

115. *See* Miller, *supra* note 111, at 1067 n.445 (arguing that computers could be considered copyright authors).

116. Goldstein v. California, 412 U.S. 546, 561 (1973).

117. The IP Clause has previously been used as a source of legislative authority to grant copyrights to other non-human entities, e.g., corporations. *See* U.S. CONST. art. I, § 8, cl. 8. Since the early 1900s, copyright law has provided that an employer is the author of a "work made for hire." *See* Easter Seal Soc'y for Crippled Children and Adults of La., Inc. v. Playboy Enters., 815 F.2d 323, 325 (5th Cir. 1987) (explaining the progression of the interpretation of the "work for hire" doctrine and providing the current statutory definition under 17 U.S.C. § 1); Catherine L. Fisk, *Authors at Work: The Origins of the Work-for-Hire Doctrine*, 15 YALE J.L. & HUMAN. 1, 5 (2003) ("The creation of the modern [work for hire] doctrine preceded its first appearance in the federal Copyright Act of 1909 . . . . The concept began to appear after 1860, though no case actually applied such a rule until a pair of cases did so in 1899 and 1900."). In these

Initial scholarship likewise addressed AI invention's impact on the scope of patentable subject matter.[118] Plotkin analyzed how the "ubiquity of artificial invention technology" influences the non-obviousness requirement,[119] concluding that AI expands the scope of obvious discoveries and therefore narrows the breadth of patentable inventions.[120] Recognizing the same issue, Ravid and

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instances, a business is deemed the author of works prepared by employees in the scope of their employment. *See* 17 U.S.C. § 201(b) (2012) (providing that the buyer is the author if the work is made for hire); *id.* § 101 (defining "work made for hire"). This interpretation of "author" deviates from the traditional understanding that an author is the party that actually reduces an expression to a tangible form and expands the definition to include non-human parties, e.g., corporations. *See* SAMUEL JOHNSON, A DICTIONARY OF THE ENGLISH LANGUAGE AUT-AWY (10th ed. 1792); WEBSTER'S COLLEGIATE DICTIONARY 72 (3d ed. 1917) (providing a definition of "author" as being an originator—which could potentially include an employer—but also providing another definition stating that an author is the first to write something).

118. *See* PLOTKIN, *supra* note 70, at 111 (exploring the idea of AI inventions and whether AI inventions may be patentable).

119. *Id.; see also* Brenda M. Simon, *The Implications of Technological Advancement for Obviousness*, 19 MICH. TELECOMM. & TECH. L. REV. 331, 333 (2013) ("As access to searchable information and computing capabilities expand, it might appear that very few inventions are nonobvious enough to merit patent protection."); Brenda M. Simon, *Rules, Standards, and the Reality of Obviousness*, 65 CASE W. RES. L. REV. 25, 33 (2014) ("Advances in technology have muddled the definition of the PHOSITA and the scope of the prior art—two central factors in the determination of obviousness.").

120. *See* PLOTKIN, *supra* note 70, at 102 ("Supply every engineer with state-of-the-art artificial invention technology and train them in how to use that technology, and you have effectively boosted the level of ordinary inventive skill in the field . . . ."); *id.* at 112 ("What this means is that the patent examiner will need to ask whether an inventor of ordinary skill, *using artificial invention technology*, would have found the invention at issue obvious."). On the contrary, Plotkin recognized that if patent examiners do not acknowledge that those of ordinary skill in the art utilize invention technologies, inventors can employ these technologies to create vast numbers of patentable inventions that are obvious using advanced technologies but would not have been obvious without the technology (and thus are patentable under the "old standard"). *See id.* at 107 (explaining that if patents inventors do not take into account the effect of publicly available "artificial invention technology" on the inventor of ordinary skill, then there may be a "patent flood" for patents on obvious inventions); *see also* William Samore, *Artificial Intelligence and the Patent System: Can a New Tool Render a Once Patentable Idea Obvious?*, 29 SYRACUSE J. SCI. & TECH. L. 113, 142 (2013) (arguing the widespread use of genetic programming will "change invention and creative thinking" and make previously non-obvious inventions obvious and non-patentable); Saurabh Vishnubhakat, *The Antitrusting of Patentability*, 48 SETON HALL L. REV. 71, 95 (2017) (discussing the identification of what constitutes

Liu argue that—rather than revising the law on obviousness—Congress should avoid the topic and simply not grant AI patents.[121] Hattenbach and Glucoft disagreed, asserting that patents could arise from computer-generated patent claims describing new technologies.[122]

Abbott has likewise addressed the issue of whether AI can be an "inventor" and if its inventions should be patentable.[123] Viewing the issue through the Constitution's mandate that patent law incentivizes inventive activity, Abbott concluded AI patents encourage the creation of inventing machines (and the resultant inventions).[124] Abbott's paper briefly discussed ownership of these patents, finding that a software's owner/licensor should receive any patent rights.[125]

In a directly analogous field, scholars have addressed whether AI creations are copyrightable, and if so, who ought to own the rights.[126] Samuelson concluded that a computer's user should own any copyright arising therefrom, as that party was most responsible for satisfying the requirements for copyright.[127] In contrast, Wu argued that where a work is not attributable to a computer user or software programmer, "the court should assign

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a person having ordinary skill).

121. *See* Shlomit Yanisky Ravid & Xiaoqiong (Jackie) Liu, *When Artificial Intelligence Systems Produce Inventions: The 3A Era and an Alternative Model for Patent Law*, 39 CARDOZO L. REV. 2215, 2215 (2018) (arguing the current patent system is "outdated, inapplicable, and irrelevant with respect to inventions created by AI systems").

122. *See* Hattenbach & Glucoft, *supra* note 11, at 50 (arguing that if a computer-generated claim meets all the requirements for a patentable invention, then those types of inventions should be patentable); *see also Technology*, CLOEM, https://www.cloem.com/flat/technology/ (last visited Dec. 4, 2018) (explaining "Cloem technology combines human [patent] drafting and machine drafting") (on file with the Washington and Lee Law Review).

123. *See* Abbott, *supra* note 9, at 1081 (examining whether a computer can be an inventor and whether "computational inventions" are patentable).

124. *See id.* at 1104 (arguing that making AI patentable will encourage people to invent); Fraser, *supra* note 53, at 325–28 (reaching a similar conclusion).

125. *See id.* at 1082 (explaining that if the "computer's owner, developer, and user are different entities, such parties could negotiate" contract arrangements).

126. *See generally* Pamela Samuelson, *Allocating Ownership Rights in Computer-Generated Works*, 47 U. PITT. L. REV. 1185 (1986).

127. *See id.* at 1203 (using the work for hire doctrine as support for a computer's user to own any copyrightable material arising from that computer).

the copyright to whoever owns the copyright to the computer program."[128] Building from this background, the following Part begins the analysis of how to allocate AI patent rights to best promote efficiency.

III. Coase Theorem

Economic theory mandates that a competitive marketplace should seek economic efficiency—a situation wherein no party can be made better without harming another.[129] This target—known as Pareto or allocative efficiency,[130] but referenced herein simply as "economic efficiency"—is likewise a goal of patent law.[131] The following Part discusses means by which this aim can be achieved when allocating patent rights arising from AI discoveries.[132] The

128. Andrew J. Wu, *From Video Games to Artificial Intelligence: Assigning Copyright Ownership to Works Generated by Increasingly Sophisticated Computer Programs*, 25 AIPLA Q.J. 131, 138 (1997).

129. *See* Sean Leibowitz, Note, *State Insurance Rate Regulation: A Coasian Perspective*, 17 J.L. BUS. & ETHICS 107, 110 (2011) (providing background information on accepted economic theory on economic efficiency); PAUL A. SAMUELSON & WILLIAM D. NORDHAUS, ECONOMICS 148 (18th ed., McGraw-Hill Irwin 2005). A Pareto optimal situation "maximizes the surplus from cooperation." Eric A. Posner, *Economic Analysis of Contract Law After Three Decades: Success or Failure?*, 112 YALE L.J. 829, 833 n.8 (2003); *see* Mark M. Bykowsky & William W. Sharkey, *Using a Market to Obtain the Efficient Allocation of Signal Interference Rights* 13–14 (F.C.C., Working Paper No. 4, 2012), https://docs.fcc.gov/public/attachments/DOC-314439A1.pdf (examining how the pareto optimal situation could be achieved in the auction context); Wis. Elec. Power Co., 56 P.U.R.4th 509, n.40 (F.E.R.C. Sept. 19, 1983) ("Under optimal economic efficiency, goods and services have been allocated in such a way that no individual, for the time being at least, would choose to consume more or less of any good or service. This state of things is also known as allocative efficiency or Pareto optimality . . . .").

130. *See* Willingham v. NovaStar Mortg., Inc., No. 04-CV-2391, 2006 WL 6676801, at *19 (W.D. Tenn. Feb. 7, 2006) (explaining Pareto efficiency "occurs when no individual can be made better off without making another worse off"); Ellis & Hayden, *supra* note 29, at 241 ("When economists discuss efficiency, they are typically referring to *Pareto optimality*, also known as *Pareto efficiency* or *allocative efficiency*.").

131. *See* Robert P. Merges, *Of Property Rules, Coase, and Intellectual Property*, 94 COLUM. L. REV. 2655, 2661 (1994) (indicating that the "goal of intellectual property law is often described in allocational efficiency terms").

132. *Infra* Part III.

inquiry proceeds by treating these patents as a positive externality and subjecting them to analysis under Coase Theorem and the host of assumptions related thereto.[133] The discussion concludes in Part IV by making policy suggestions once these assumptions are relaxed.

Externalities are side effects from one's activities for which the actor does not bear all consequences for or benefits from.[134] Such secondary effects represent a policy problem because they create "a divergence between private marginal cost and social marginal cost,"[135] whereby producers make choices based on individual economic factors without considering societal costs or benefits. Restated, there are many instances where firms will—acting out of perceived self-interest—choose to produce at a non-efficient level.[136] Coase Theorem, however, minimizes this concern.[137] It holds that—where transaction costs are zero and in the presence of perfect information—resources will be distributed efficiently if relevant property entitlements are clearly allocated regardless of the initial allocation.[138]

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133. *Infra* Part III.

134. *See* Wendy E. Wagner, *What's It All About, Cardozo?*, 80 TEX. L. REV. 1577, 1586 (2002) (providing an explanation of externalities in the economics context); Thomas A. Donovan, *Litigation: An Antidote for Democracy*, 54 FED. LAW. 8, 9 (2007) (providing that "externalities can be positive or negative" and are "the impacts that one person's behavior has on others"); Jonathan R. Macey, *Efficient Capital Markets, Corporate Disclosure, and Enron*, 89 CORNELL L. REV. 394, 411–12 (2004) (discussing how externalities are "economic side effects" that come from actions of various parties that affect a third party who is not compensated or charged for the effects of the externality); Stefan J. Padfield, *In Search of a Higher Standard: Rethinking Fiduciary Duties of Directors of Wholly-Owned Subsidiaries*, 10 FORDHAM J. CORP. & FIN. L. 79, 121 n.160 (2004) (providing another definition of externalities).

135. John W. Mill, Note, *Agricultural Chemical Contamination of Groundwater: An Economic Analysis of Alternative Liability Rules*, 1991 U. ILL. L. REV. 1135, 1154 (1991) (citing ROBERT D. COOTER & THOMAS S. ULEN, LAW AND ECONOMICS 45 (1988)).

136. *Id.*

137. *See generally* Coase, *supra* note 31.

138. *See id.* at 15 (explaining, given transaction costs are zero, that the initial determination of property rights does not matter because the party who values the right most will acquire it eventually); HIRSCH, *supra* note 26, at 19 (stating under the Coase Theorem's assumptions, resource allocation will be at the Pareto-optimal level regardless of initial allocation); POSNER, *supra* note 31, at 10 (explaining how the Coase Theorem, including its assumptions, provides that the

It does not matter whether an entitlement is given to a party that is in a strong position to financially exploit that right or not,[139] because interested parties can bargain between themselves, such that whomever most values the entitlement will pay to obtain it.[140] Any extrinsic costs or benefits will, via inter-firm transactions, find their way to the manufacturer, who then bases decisions on the total social benefit and produces products at an efficient level.[141]

A. Application of Coase Theorem

The below example depicts how—in the presence of no transaction costs and perfect information—firms reach an efficient state of affairs if relevant property entitlements are clearly allocated.[142] Farmer grows wheat and makes a $1,500 daily profit from his operation until TrainCo installs a train track running just

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"initial assignment of a property right will not affect the ultimate use of the property"); Rule, *supra* note 30, at 195 (stating the Coase Theorem and applying it to airspace rights in the context of drones); *In re* Stotler & Co., 144 B.R. 385, 393 (N.D. Ill. 1992) ("Coase's theorem about contracting around the law's assignment of risk depends on the free flow of information."); Coltman v. Comm'r, 980 F.2d 1134, 1136–37 (7th Cir. 1992) (stating Coase Theorem illustrates "so long as the rule of law is known when parties act, the ultimate economic result is the same no matter which way the law has resolved the issue"). Coase theorem requires several assumptions, namely "(a) the parties whom the allocation affects are informed about relevant economic variables; (b) wealth effects are absent; (c) competitive markets exist; and (d) the cost of making transactions is zero." Schwartz, *supra* note 31, at 397–98; *see* Enrique Guerra-Pujol & Orlando I. Martínez-García, *Does the Prisoner's Dilemma Refute the Coase Theorem?*, 47 J. MARSHALL L. REV. 1289, 1300 (2014) (outlining the assumptions of the Coase Theorem).

139. *See* Christopher Buccafusco & Christopher Sprigman, *Valuing Intellectual Property: An Experiment*, 96 CORNELL L. REV. 1, 6 (2010) (stating that the law presumes "parties will negotiate to transfer property rights" to those who "might best exploit them").

140. *See* Leibowitz, *supra* note 129, at 111 (explaining the efficient use of resources under the Coase Theorem and its assumptions); Rule, *supra* note 30, at 195 (explaining that per the Coase Theorem, laws clearly allocating "initial entitlements related to a resource promote allocative efficiency" by making it easy for those who most value the resource to bargain over it).

141. *See* Coase, *supra* note 31 (explaining that if transactions are costless, then the initial determination of rights can be changed if the changes "would lead to an increase" in the value of what is produced).

142. *See generally id.*

outside Farmer's land.[143] The trains emit sparks that ignite fires, with each fire causing $200 in damage to the farm per train per day.[144] TrainCo's profits are highest when running seven trains per day, with profits diminishing beyond that point.[145] The gains for each party are shown below on a per daily train basis.[146]

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143. *See* POSNER, *supra* note 31, at 10 (using a similar railroad and farmer example to illustrate Coase's Theorem).

144. *See id.* (providing a similar example to illustrate Coase's Theorem).

145. *Infra* Table 1.

146. *Infra* Table 1.

Table 1—Coase Theorem
Example, TrainCo & Farmer Surplus Schedule

Trains per Day	TrainCo Profit	Farmer Profit	Total Surplus
0	$0	$1500	$1500
1	$225	$1300	$1525
2	$450	$1100	$1550
3	$675	$900	$1575
4	$900	$700	$1600
5	$1075	$500	$1575
6	$1250	$300	$1550
7	$1350	$100	$1450
8	$1300	$0	$1300

From an economic efficiency perspective, the optimal situation is where net surplus (the sum of all profits) is maximized (regardless of what party receives the surplus).[147] A maximized net

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147. *See* ROBERT H. BORK, THE ANTITRUST PARADOX: A POLICY AT WAR WITH ITSELF 90–91, 405 (1978) (explaining that "[c]onsumer welfare" is greatest when resources are efficiently allocated and antitrust law aims to "preserve, improve, and reinforce the powerful economic mechanisms that compel businesses to respond to customers"); HERBERT HOVENKAMP, FEDERAL ANTITRUST POLICY: THE LAW OF COMPETITION AND ITS PRACTICE 61–63 (2d ed. 1999) (explaining Chicago School antitrust policy and stating that economic efficiency "should be the exclusive goal of antitrust laws"); RICHARD A. POSNER, ANTITRUST LAW: AN ECONOMIC PERSPECTIVE 8 (1976) (arguing the economic theory that a monopoly often leads to economic inefficiency "provides the only suitable basis for antitrust policy"); Herbert Hovenkamp, *Chicago and Its Alternatives*, 1986 DUKE L.J. 1014, 1018 (1986) ("The maximization of economic surplus, which is the sum of consumers' surplus and producers' surplus, is conventionally stated as the goal of Chicago School antitrust policy."); Russell S. Jutlah, *Economic Theory and the*

surplus indicates that efficiency has been achieved.[148] Thus, four trains per day (reaching the maximum surplus of $1,600) is optimal.[149] The question thus becomes: how can government incentivize TrainCo to run four trains per day?

In the absence of any regulation or law enforcement, both parties will engage in attempts to change the law via litigation or lobbying to their favor.[150] TrainCo wants a law protecting it from liability for damages to the farm, and Farmer prefers a law holding TrainCo liable. In this situation, the parties will spend some amount $X on lobbying, and total surplus equals the net profits *less* $X. The expenditures on lobbying render it impossible to reach economic efficacy (where total surplus is $1,600).

Coase Theorem predicts that this problem will be solved—and economic efficiency obtained—if relevant property entitlements (e.g., TrainCo's ability to burn farm land liability free or Farmer's ability to sue for damages) are clearly allocated regardless of the allocation.[151] This surprising phenomenon is described below.

Environment, 12 VILL. ENVTL. L.J. 1, 10 (2001) ("[I]t is well settled within welfare economics that a perfect competitive market maximizes social welfare, or achieves a Pareto optimum, through a socially efficient allocation of resources." (citing S.K. NATH, A PERSPECTIVE OF WELFARE ECONOMICS 36 (1973))); *see also* Daniel A. Farber & Brett H. McDonnell, *Why (and How) Fairness Matters at the IP/Antitrust Interface*, 87 MINN. L. REV. 1817, 1818 (2003) (arguing that, beyond maximizing net surplus, "the law should also encourage a fair division of the economic surplus, at least as a secondary goal").

148. *See* Kate Darling, *Contracting About the Future: Copyright and New Media*, 10 NW. J. TECH. & INTELL. PROP. 485, 506 n.161 (2012) (discussing that the pareto-optimal situation occurs when no one actor can be better off without making another worse off); Juan Antonio Gaviria, *An Experiment on the Role of Penalty Clauses and the Level of Legal Remedies for Breach of Contract on the Prevention of the Hold-Up Problem in Colombian Contract Law*, 14 RICH. J. GLOBAL L. & BUS. 1, 4 n.8 (2015) (explaining that "a surplus-maximizing modification is Pareto-efficient"); Maurice E. Stucke, *Morality and Antitrust*, 2006 COLUM. BUS. L. REV. 443, 446 n.4 (2006) (arguing economic efficiency is maximized by both Pareto efficiency and technological efficiency).

149. *Supra* Table 1.

150. *See* Jules L. Coleman, *Markets, Methods, Morals and the Law*, 66 ALA. L. REV. 169, 186 (2014) (providing examples of how to achieve the demanding conditions under which the Coase Theorem functions best).

151. *See* POSNER, *supra* note 31, at 10 (providing an example of how the clear initial allocation of property rights will lead to economic efficiency); *see generally* Coase, *supra* note 31.

If TrainCo is given the right to burn farmland without liability, it will immediately act to maximize profits by running 7 trains a day—giving it a $1,350 profit and Farmer a $100 profit. This knee-jerk business choice maximizes TrainCo's immediate profits, but does not reach economic efficiency (i.e., other courses of action will result in a higher total surplus). Acting in his self-interest, Farmer will propose a trade,[152] whereby TrainCo reduces its trains per day in exchange for a payment of $Y, such that TrainCo's profit plus $Y exceeds its maximum income without trading ($1,350).[153] Behaving to maximize income, TrainCo will accept the proposal.[154]

Likewise, Farmer will engage in a trade whereby his income less a payment of $Y exceeds the $100 he is currently making with seven trains running.[155] Wanting to maximize the total surplus that he may share in, Farmer will propose a trade where TrainCo runs four trains a day and receives a payment of $Y, which will be between $451 and $599—guaranteeing that both parties make more money with four trains running than seven.[156] They are free to negotiate the exact amount of $Y, but regardless of the amount settled out, the parties will reach the efficient outcome of $1,600 total surplus.[157]

Next, assume the same situation, except the government clearly allocates to Farmer the right to recover damages, such that TrainCo makes payments to Farmer to cover any damages sustained. This new information is described below.[158] Note that

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152. This trade could likewise be proposed by TrainCo with the same terms.

153. *See* POSNER, *supra* note 31, at 10 (providing a similar railroad and farmland example of Coase's Theorem).

154. *Id.*

155. *Id.*

156. *Id.* Farmer makes $700 with four trains running and he pays, at most, $599—leaving him with at least $101, which is $1 more than he made with seven trains running. TrainCo makes $900 with four trains running and receives, at minimum, $451—totaling at least $1351, which is $1 more than he made with seven trains running.

157. *Id.*; Farmer will make $700 − $Y. TrainCo will make $900 + $Y. The total surplus is ($700 − $Y) + ($900 + $Y), which equals $1,600 for all values of Y.

158. *Infra* Table 2.

the total surplus does not change; only the allocation of the surplus is different.[159]

Table 2—Coase Theorem
Example, Surplus and Damages Schedule

Trains per Day	TrainCo Profit	TrainCo's Profit Less Damages	Farmer Profit	Farmer's Damages	Total Surplus
0	$0	$0	$1500	$0	$1500
1	$225	$25	$1300	$200	$1525
2	$450	$50	$1100	$400	$1550
3	$675	$75	$900	$600	$1575
4	$900	$100	$700	$800	$1600
5	$1075	$75 .	$500	$1000	$1575
6	$1250	$50	$300	$1200	$1550
7	$1350	-$50	$100	$1400	$1450
8	$1300	-$200	$0	$1500	$1300

In this situation, the parties will again negotiate a settlement whereby four trains run daily. Here, TrainCo will offer some amount between $1 and $99 (plus damages) to Farmer to let it run four trains per day. It will propose to run four trains per day because that produces the greatest surplus that it may share. This offer ensures that Farmer will receive $700 from crops, $800 in damages, and an additional $1–$99, which in total exceeds Farmer's maximum profit absent trading ($1500).[160] Likewise,

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159. *Compare infra* Table 2, *with supra* Table 1.
160. *Supra* Table 2.

TrainCo will enjoy $900 in income less $800 in damages and less between $1 and $99 in payment to Farmer, leaving him with between $1–$99, which is more profit than with zero trains running ($0).[161] Again, inter-firm transactions arrive at an efficient outcome by allowing the parties to trade among themselves to distribute property rights (i.e., the right run or stop trains) to the parties that most value them.[162]

While the above example deals with a negative externality (fires caused by the running of the train), Coase Theorem is likewise applicable to situations involving positive externalities—external benefits created by market activity.[163] Patenting AI technologies is properly treated as such because—depending on how the government allocates the right to obtain a patent—it potentially creates benefits for parties outside the initial sale of software (e.g., software programmers, engineers, product designers, downstream users or owners of the software, etc.).[164] Analyzing these rights as externalities is consistent with prior literature on extrinsic benefits arising from information creation and dissemination.[165]

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161. *Supra* Table 2.

162. *See generally* Coase, *supra* note 31.

163. *See* Christopher J. Coyne & Peter T. Leeson, *Who's to Protect Cyberspace?*, 1 J.L. ECON. & POL'Y 473, 479 (2005) (discussing positive externalities, such as a scientific research breakthrough); Brett M. Frischmann, *Speech, Spillovers, and the First Amendment*, 2008 U. CHI. LEGAL F. 301, 305–06 (2008) (explaining positive externalities as benefits freely realized by someone due to the actions of another).

164. *See* Paul E. McGreal, *On the Cost Disease and Legal Education*, 66 SYRACUSE L. REV. 631, 637 (2016) (discussing positive externalities); Coyne & Leeson, *supra* note 163, at 479 (explaining how goods creating positive externalities are under-supplied in the market because of the free-rider problem of non-rivalrous goods).

165. *See* Julie E. Cohen, *Lochner in Cyberspace: The New Economic Orthodoxy of "Rights Management"*, 97 MICH. L. REV. 462, 546 (1998) (discussing value generated by "transactions in information" and stating that "mass media products" that create positive externalities will be underproduced in an unregulated market); C. Edwin Baker, *Giving the Audience What It Wants*, 58 OHIO ST. L.J. 311, 350–66 (1997) (discussing the positive externalities created by mass media); Daniel J. Gifford, *The Damaging Impact of the* Eastman Kodak *Precedent Upon Product Competition: Antitrust Law in Need of Correction*, 72 WASH. U. L.Q. 1507, 1507 n.1 (1994) (explaining the "diffusion of skills and knowledge" occurs as positive externalities as new products and technology are

In the presence of positive externalities, firms underproduce goods for sale because they base manufacturing decisions only on the value inherent in the good (e.g., the value of the inventing AI), rather than considering the net social value created (e.g., the value of the AI plus the value of the positive externality—the AI patents).[166] This failure to consider the value of positive externalities when deciding output means software companies will cease to manufacture even while the net public value of the good still exceeds production costs.[167] This is not an economically efficient situation, as one party's (the public's) situation could be improved (by being able to buy goods at or below their net utility to the consumer), but the producer will cease production of goods while there are still net marginal gains to be had on additional units.[168]

For example, assume that the public will buy each unit of inventing AI for $50 and that each unit sold will create $10 in social welfare associated with AI patents.[169] Assume that the per unit cost of production for the software company increases with each unit produced, such that the 100th unit produced costs $30.01 to make, the 101st costs $30.02, etc.[170] If a software company is unable to realize the $10 in value associated with the patent (e.g., if the patent rights are assigned to some other party), then it will cease production where costs to manufacture another unit are $50. This is inefficient. Production is ceasing where cost to produce

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developed).

166. *See* Coyne & Leeson, *supra* note 163, at 479 (explaining goods creating positive externalities are typically under supplied in the market).

167. *See* Jeffrey Standen, *The Exclusionary Rule and Damages: An Economic Comparison of Private Remedies for Unconstitutional Police Conduct*, 2000 B.Y.U. L. REV. 1443, 1447–48 (2000) (arguing deterrence of unconstitutional police conduct is a positive externality that is likely to be underproduced if certain conditions are met); Lawrence B. Solum, *Public Legal Reason,* 92 VA. L. REV. 1449, 1457–58 (2006).

168. *See* Coyne & Leeson, *supra* note 163, at 479 (describing that goods that create positive externalities will be under supplied and lead the unregulated market to be inefficient).

169. Assuming consistent consumer demand and patent value is unrealistic but appropriate for this example.

170. Again, this is an unrealistic assumption as production costs usually decrease with quantity produced but the assumption does not harm the example.

($50) is still below the total social welfare produced ($60). The next unit produced (assuming it costs $50.01 to make) would create a social welfare gain of $9.99 (the $50 inherent value of the AI + the $10 value of the patent – the $50.01 cost to produce).

This presents the question of to whom the Patent Office should grant AI patents if it is attempting to maximize net surplus (i.e., social welfare) by allowing software companies to realize the full value of their AI and thus produce at an economically efficient level.[171] Potential receipts of such rights include programmers, software companies, AI users, downstream technical experts, product engineers, etc.? Within the bounds of no transaction costs and perfect information, Coase Theorem renders this question superfluous.[172] It does not matter to whom the patent rights are allocated because the party that most values them will purchase the patent and this value will trickle upstream to the software company.[173]

Returning to our example, assume that the government allocates AI patent rights to any downstream party that identifies a novel invention made by AI—a situation discussed by Abbott.[174] Likewise, assume companies that purchase AI and use it to invent ("AI users") value patent rights at their maximum level ($10), with all other parties holding them in lesser esteem.[175] In this situation, the AI user will pay $50 to the software company to buy the AI.[176] Assuming costless transactions, it will also be willing to pay up to $10 to the downstream party for the patent rights.[177] With perfect information, the downstream party would have previously realized

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171. *See* Gaviria, *supra* note 148, at 4 n.8 (maximizing net surplus is Pareto optimal).

172. *See generally* Coase, *supra* note 31.

173. *Id.*

174. *See* Abbott, *supra* note 9, at 1098 ("For the purposes of this Article, assuming that a computer cannot be an inventor, individuals who subsequently 'discover' computational inventions by mentally recognizing and appreciating their significance would likely qualify as inventors."). Abbott does not recommend this allocation from a policy perspective, but it serves well as an example in this instance.

175. *See* Coase, *supra* note 31 (stating that in the absence of transaction costs the party that most values a property right will bargain to hold that right).

176. *Id.*

177. *Id.*

it will not be able to secure the patent rights unless the software company produces and sells the particular copy of the software used in inventing the new technology.[178] With this in mind, the software company will demand a payment of up to $10 from the downstream party (leaving that party with a small gain) or it will not manufacture that copy of the software (and the downstream party loses out on all income). Through this stream of costless transactions, the full $60 in value ends up with the software company, and it will be incentivized to produce at an efficient level (up to the point where the cost of manufacture is $60).

This example is (admittedly) a bit unrealistic but so are Coase's assumptions of perfect information and costless transactions. It does, however, depict how inter-firm transactions ensure ownership of rights by the party that most values them and ensures the full value of economic activity is secured by a manufacturer. The manufacturer will then produce at an economically efficient level where production cost equals social welfare (net surplus) produced.[179] These conclusions provide insight into Coase's holding, namely that, regardless of the initial allocation of an entitlement, software companies will manufacture inventing AI at an economically efficient level in the presence of zero transaction costs and perfect information.[180] These assumptions do not, of course, hold true in reality.[181] With that in mind, this Article will later attempt to mimic this efficient state of affairs in the presence of transaction costs, as in the real world.[182]

B. Using Coase Theorem to Construct Policy

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178.   *See* Ravid & Liu, *supra* note 121, at 2236 (explaining a patent owner can exclude others who "independently invent" inventions similar to his or her system).

179.   *See* POSNER, *supra* note 31, at 10 (providing an example of how costless transactions will allow a right to be put the most productive use regardless of its initial assignment).

180.   *See* Coase, *supra* note 31, at 8 (arguing the most efficient outcome will occur if the initial determination of rights is clear and transactions are costless).

181.   *See id.* at 15 (acknowledging the assumptions that transactions are costless and perfect information are unrealistic).

182.   *Infra* Part III.B.

Coase recognized his assumptions do not represent the real world and pragmatism must be considered when constructing policy.[183] His theorem thus proves to be a useful tool to begin analysis of entitlement allocation.[184] Transaction costs do exist and must be contemplated when implementing new policy.[185] Legislators should therefore attempt to effectuate a system in reality that most closely mimics an idealized Coasean market[186] to bring about an efficient state of affairs.[187]

Commenters suggest two means by which Coase's insights can be implemented in the real world[188]—both of which are intended to minimize expenditures arising from inter-firm trading.[189] High transaction costs detract from efficient allocation of resources, and in the worst case scenario, completely impede inter-firm trading.[190]

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183. *See* Gareth Porter, *Pollution Standards and Trade: The "Environmental Assimilative Capacity" Argument*, 4 GEO. PUB. POL'Y REV. 49, 63 (1998) (acknowledging that in reality transaction costs do exist).

184. *See* Guido Calabresi & A. Douglas Melamed, *Property Rules, Liability Rules, and Inalienability: One View of the Cathedral*, 85 HARV. L. REV. 1089, 1096 (1972) (stating Coase's Theorem and its assumption of no transaction costs is a good starting point for an entitlement allocation analysis).

185. *See* Porter, *supra* note 183, at 63 (discussing that transaction costs in the real world must be taken into account to provide effective policy).

186. *See* HIRSCH, *supra* note 26, at 20 (explaining if transactions costs are not zero, efficiency is assisted if the property right is initially "assigned to the party who would normally buy it"); Coleman, *supra* note 150, at 186 (explaining how in many situations the costs of determining who "our bargaining partners are can be too high for bargaining to work"); Michael I. Swygert & Katherine Earle Yanes, *A Unified Theory of Justice: The Integration of Fairness into Efficiency*, 73 WASH. L. REV. 249, 288 (1998) (stating users of the Coase Theorem must remember that the "Coasean world" differs from the real world).

187. *See* Calabresi & Melamed, *supra* note 184, at 1096–97 (explaining that when there are transaction costs, society can assist in allocating entitlements to achieve efficiency).

188. *See* Seth D. Harris, *Coase's Paradox and the Inefficiency of Permanent Strike Replacements*, 80 WASH. U. L.Q. 1185, 1193–94 (2002) (stating that when Coase's assumptions are relaxed, legal rules can be used to further economic efficiency by designing them to minimize transactions or legal rules can impose a solution that "approximates the efficient agreement").

189. *See* Kelly, *supra* note 34, at 864 (stating that policymakers can minimize transaction costs "by lowering the costs of borrowing or by allocating entitlements efficiently so that bargaining is unnecessary").

190. *See* Pierre Schlag, *An Appreciative Comment on Coase's* The Problem of Social Cost: *A View from the Left*, 1986 WIS. L. REV. 919, 923 (1986) (explaining how in reality transactions costs could be so high that the allocation of

Specifically, where gains from trade are outweighed by transaction costs, parties have no incentive to bargain,[191] and thus, may fail to reach the efficient allocation of property predicted by Coase. At minimum, transaction costs deduct from economic surplus.[192]

The first manner to approximate a Coasean property allocation is to assign entitlements to the party that most values them.[193] This type of rule mimics Coase Theorem by avoiding transaction costs all together; there is no need to engage in trades to place an entitlement in the hands of a party that maximally values it if that party holds the initial assignment.[194] In the aggregate, this policy will—consistent with Coase Theorem—maximize net surplus and achieve economic efficiency.[195]

Similarly, entitlements can be distributed to minimize transaction costs.[196] In such a situation, efficient allocation (as predicted by Coase) is feasible where the transaction cost remains below the potential gains from trade.[197] As a corollary, it is preferable to minimize the number of parties involved in a transfer because costs increase on a per party basis.[198] Of course, the goal of minimizing transaction costs is furthered by following the first policy recommendation—simply allocating rights to the party that most values them (eliminating the need for any transaction and

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entitlements will not change after the initial allocation).

191. *See* Kelly, *supra* note 34, at 864 (describing how transaction costs can prevent parties from reaching the most efficient outcome for all).

192. *Id.*

193. *See* Hovenkamp, *supra* note 26, at 638 (describing that policymakers could assign the "initial allocation to the highest value user" so trading of the entitlement is not needed).

194. *See* HIRSCH, *supra* note 26, at 20 (stating that when transaction costs are high, efficiency is advanced if the party who would buy the property right is initially assigned that right).

195. *Id.*

196. *See* Kelly, *supra* note 34, at 864 (using legal rules to minimize transaction costs will move the market towards the most efficient point).

197. *See* Harris, *supra* note 188, at 1193–94 (explaining the two ways legal rules can improve economic efficiency).

198. *See* Porter, *supra* note 183, at 63 (acknowledging that relaxing Coase's zero transaction costs assumption makes the bargaining approach impractical for large groups).

associated cost).[199] The following Part looks to how this insight can be implemented into policy.

IV. Coasean Analysis of Patent Ownership

Coasean assignment of property entitlements is a function of the parties' respective valuations of the good, transaction costs, and the number of firms involved in the matter.[200] As discussed above, rights should be allocated to whomever most values them (which minimizes transaction costs).[201] The below presents a multi-step analysis towards efficient allocation of patent rights for AI inventions.[202]

This Part begins by discussing various candidates to whom AI patent rights might be assigned. Benefits arising therefrom are evaluated, and each benefit is analyzed to determine whether— and to what quantum—it accrues to a respective candidate for patent ownership.[203] From this, it is possible to determine which party in the AI invention lifecycle most values the ability to secure AI patents.

Building from this information, the Article concludes by making Coasean policy suggestions pertaining to the assignment of ownership rights for AI patents.[204] The analysis determines that—to maximize social welfare—these rights should be allotted to AI users who utilize the software for invention because they hold these patents in greatest value. This assignment minimizes transaction costs.[205] In turn, such a policy ensures substantial

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199. *See* HIRSCH, *supra* note 26, at 20 (making the argument that efficiency is improved if property rights are initially assigned to the party who would ultimately buy the right).

200. *See* Porter, *supra* note 183, at 62–63 (stating a Coasean analysis is based on willingness to bargain, transaction costs, and becomes impractical as the number of parties increases).

201. *See* Kelly, *supra* note 34, at 864 (stating that if property rights are initially allocated to the party who would eventually buy them then efficiency is improved).

202. *Infra* subparts IV.A–D.

203. *Infra* subparts IV.A–C.

204. *Infra* Part V.

205. *See* Kelly, *supra* note 34, at 865 (explaining how assigning property

internalization of positive externalities and economic efficiency (i.e., maximum social welfare).[206]

A. Types of Patent Value

Patent ownership creates value in a variety of manners.[207] Depending on the situation, these benefits may (or may not) accrue themselves to particular owners.[208] Patents have historically been seen as a manner for a firm to insulate itself from competition and charge supra-competitive prices.[209] While this remains a focus of patent strategy, a variety of additional benefits have presented themselves as the field has matured.[210] These are discussed below.

Owning a patent serves a signaling function in the entrepreneurial financing market.[211] Signals allow a party to incur some cost to convey information about itself to outside firms.[212] Securing a patent transmits a positive message about the state of

rights initially to those who value the right most minimizes transaction costs).

206. *See* Coyne & Leeson, *supra* note 163, at 479 (demonstrating how positive externalities that are not internalized by firms creating them lead to an inefficient market).

207. *See* David H. Hsu & Rosemarie H. Ziedonis, *Resources as Dual Sources of Advantage: Implications for Valuing Entrepreneurial-Firm Patents*, 34 STRATEGIC MGMT. J. 761, 762 (2013) (arguing that patents provide an advantage as a signaling devices and that patents confer an even greater advantage in "strategic factor markets"); Vincent J. Roth, *Will FDA Data Exclusivity Make Biologic Patents Passé?*, 29 SANTA CLARA COMPUTER & HIGH TECH. L.J. 249, 273 (2013) (outlining the various ways patents create value).

208. *See* Hsu & Ziedonis, *supra* note 207, at 766 (arguing the signaling function of patents is "particularly important for new ventures").

209. *See* Andrew Chin, *Teaching Patents as Real Options*, 95 N.C. L. REV. 1433, 1446 (2017) (explaining that a patent owner likely will try to charge high prices during the patent grant period to obtain higher profits).

210. *See* Knut Blind et al., *Motives to Patent: Empirical Evidence from Germany*, 35 RES. POL'Y 655, 655 (2006) (arguing the value of patents has increased over time).

211. *See* Hsu & Ziedonis, *supra* note 207, at 764 (discussing how the "informational imperfections" in entrepreneurial markets make patent signaling effects valuable).

212. *See* Clark D. Asay, *The Informational Value of Patents*, 31 BERKELEY TECH. L.J. 259, 277 (2016) (discussing how a firm's patent can translate into an indication of a firm's positive value in the marketplace).

the firm's research and development,[213] which may lead to successfully obtaining outside investment.[214]

Likewise, patents serve two distinct blocking functions, whereby a patentee limits the scope of a rival's strategic behavior.[215] Offensive blocking occurs when a party secures a patent not with the hopes of utilizing the technology but rather to preclude competitors from implementing the claimed inventions to compete with the patentee's own offerings.[216] Defensive blocking prevents other firms from patenting relevant technologies and then inhibiting a firm's capacity to manufacture goods.[217] In the

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213. *See* Paul J. Heald, *A Transaction Costs Theory of Patent Law*, 66 OHIO ST. L.J. 473, 478 (2005) (discussing that patents can be a signal that a firm has a high research and development capacity (citing Clarisa Long, *Patent Signals*, 69 U. CHI. L. REV. 625, 627–28 (2002))).

214. *See* Dov Solomon & Miriam Bitton, *Intellectual Property Securitization*, 33 CARDOZO ARTS & ENT. L.J. 125, 159 (2015) (arguing that one reason companies obtain patents is to secure outside investment); Stuart J.H. Graham et al., *High Technology Entrepreneurs and the Patent System: Results of the 2008 Berkeley Patent Survey*, 24 BERKELEY TECH. L.J. 1255, 1306 (2009) (discussing how "VC investors rely on patents in their investment decisions"); Kevin G. Rivette, Henry R. Nothhaft & David Kline, *Discovering New Value in Intellectual Property*, 78 HARV. BUS. REV. 54, 60 (2000) (stating that companies can "repackage" their patents to attract new investors); Hsu & Ziedonis, *supra* note 207, at 774

> [W]e find that (1) patents are more influential for founders lacking prior entrepreneurial success in securing initial funds from prominent VCs; (2) patents induce steeper valuation adjustments in earlier rounds of VC financing; and (3) conditioned on an IPO exit, patents play a more influential role in bridging information gaps with public investors when start-ups lack prominent VC investors.

215. *See* Blind et al., *supra* note 210, at 657 (explaining offensive blocking and defensive blocking patents); T. Randolph Beard et al., *Quantifying the Cost of Substandard Patents: Some Preliminary Evidence*, 12 YALE J.L. & TECH. 240, 245 (2010) (arguing a "loose" patent system leads to a misallocation of resources, including more defensive patents and blocking patents); Steven C. Carlson, *Patent Pools and the Antitrust Dilemma*, 16 YALE J. ON REG. 359, 367 (1999) ("Patentees, too, may deliberately acquire blocking positions as a strategic move to frustrate the patenting programs of competitors." (citations omitted)).

216. *See* Blind et al., *supra* note 210, at 657 (providing that offensive blocking patents are patents obtained to prevent other firms in the same or a closely related field from using the technical inventions of the firm holding the patent).

217. *See* Colleen V. Chien, *From Arms Race to Marketplace: The Complex Patent Ecosystem and Its Implications for the Patent System*, 62 HASTINGS L.J. 297, 320–21 (2010) (identifying a defensive strategy of "obtaining a large portfolio of patents . . . to prevent competitors from blocking its new products").

defensive aspect, the patentee is acting only to ensure that it has the right to use strategically relevant technologies.[218]

Patents likewise serve a negotiation-facilitating function—both before and during litigation.[219] Parties commonly facilitate manufacture by cross-licensing relevant portfolios to each other, such that both can operate without the threat of infringement litigation.[220] Absent a patent portfolio to cross-license, a manufacturer may incur licensing fees or risk infringement litigation.[221] Likewise, should a patentee be sued for patent infringement, it has the ability to counter-claim for infringement of its own patents, creating incentives for the plaintiff to settle on reasonable terms or end the suit via cross-license.[222]

Lastly, patents may create an income stream independent of product manufacture.[223] This value is obtained via litigation or licensing efforts,[224] whereby firms sell the right to use the patented

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218. *See id.* at 321 ("In defensive contexts, patents are used to ward off suits, as well as to gain access to technology and to further technological adoption.").

219. *See* Joshua Chao, *Tax Incentives for Innovation in a Modern IP Ecosystem*, 15 VAND. J. ENT. & TECH. L. 753, 761 (2013) (explaining that companies strategically use cross licensing agreements to resolve potential or actual legal disputes).

220. *See id.* at 760–61 (describing the process of cross licensure as an option for companies to prevent litigation in manufacturing situations involving semiconductor production); *see also* Rivette, Nothhaft & Kline, *supra* note 214, at 57 ("[Dell] used its patents as the collateral for a $16 billion cross-licensing deal with IBM that provides it with lower cost components. Dell is freed from having to pay IBM tens of millions of dollars in royalties, which makes Dell more price competitive.").

221. *See* Robert E. Thomas, *Debugging Software Patents: Increasing Innovation and Reducing Uncertainty in the Judicial Reform of Software Patent Law*, 25 SANTA CLARA COMPUTER & HIGH TECH. L.J. 191, 210 (2008) (stating small companies without patents may either negotiate license fees without leverage or risk litigation).

222. *Cf.* Aria Soroudi, Comment, *Defeating Trolls: The Impact of Octane and Highmark on Patent Trolls*, 35 LOY. L.A. ENT. L. REV. 319, 323–24 (2015) (stating that parties cannot counter-claim or use patent agreements against patent trolls—a common settlement method in patent disputes—because patent trolls do not use patented inventions).

223. *See* Rivette, Nothhaft & Kline, *supra* note 214, at 55–56 (explaining how a former Chief Financial Officer at IBM viewed patent licensing royalties as "largely free cash flow" independent of production).

224. *See id.* at 56 (citing both licensing and patent infringement suits as two

invention.[225] This strategy may mimic the business model adopted by patent assertion entities (also known as patent trolls).[226]

B. Patent Valuation as a Function of Market Participation

This subpart describes why, among the above discussed sources of patent value, the majority are maximized if the owner participates in a market relating to the patented technology. It follows that patents are most valuable to market participants, and as presented below, AI users (parties using the software to invent) are most likely to be marketplace participants. Thus, AI users will, in all probability, maximally value the patents arising therefrom. The fact that other parties can lucratively engage in patent monetization (e.g., patent licensing and litigation) does not dissuade this conclusion.

The traditionally recognized benefit of a patent—market exclusivity[227]—is enjoyable only by parties that participate in the relevant market.[228] Elimination of competition is valueless if a patentee does not participate in relevant commerce, and thus, is unable to enjoy benefits such as supracompetitive pricing[229] and advantages in manufacturing efficiency.[230] Market participants

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values of patents).

225. *See id.* at 57 (describing a licensing agreement between Dell and IBM whereby Dell saved money using licensing agreements as a way to avoid paying royalties to IBM to use IBM's patented components).

226. *See* Ted Sichelman, *The Vonage Trilogy: A Case Study in "Patent Bullying"*, 90 NOTRE DAME L. REV. 543, 547–58 (2014) (describing the patent troll goals as earning revenue from patent litigation and licensing).

227. *See* Chin, *supra* note 209, at 1436 (stating that the value the patent derives is from the right to exclude others from otherwise profiting off of the invention).

228. *See* Mark A. Lemley & A. Douglas Melamed, *Missing the Forest for the Trolls*, 113 COLUM. L. REV. 2117, 2128 (2013) (contrasting the non-practicing entity—entity not participating in the market—with the traditional strategies of practicing entities, including the competitive benefits against other market participants).

229. *See* Chin, *supra* note 209, at 1446 (stating that firms may only obtain supracompetitive profits when the patents cover all close substitutes, implying that a company would only be able to reap these supracompetitive profits if they involved themselves in the same marketplace as competitors).

230. *See* Ofer Tur-Sinai, *The Endowment Effect in IP Transactions: The Case*

will thus most value patent ownership with regard to market exclusivity.

The conclusion is consistent for signaling in the venture capital market and using patents for blocking purposes. Parties that are not participating in the market—and have no intent to do so in the future—need not raise capital for endeavors in that field, and positive signals regarding the firm's research are essentially valueless. Similarly, blocking patents—which proscribe competitors' business options—are without worth if a party is not a market participant and has no competitors.[231]

With regard to the use as negotiation tools, patents are (again) most valuable to firms participating in commerce.[232] Companies not in the market cannot face the threat of patent infringement litigation and cannot have their planned business endeavors limited by competitors' patent rights.[233] Absent commercial activity, a company will not engage in infringing activities or plan future market activities.[234] Without these threats, firms have no need to engage in cross-licensing to terminate potential litigation or avoid licensing costs.[235] Accordingly, patents create no value via facilitating negotiations for parties that do not engage in relevant markets.

The final source of patent value—monetization via licensing and litigation[236]—is the sole patent benefit that is not

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Against Debiasing, 18 MICH. TELECOMM. & TECH. L. REV. 117, 135 n.102 (2011) (describing the situation in which a patent owner foregoes licensing technology which increased the patent owner's profitability to gain a "significant competitive advantage").

231. *See* Chien, *supra* note 217, at 320–21 (describing the blocking benefits of patents and how companies go about exploiting these benefits).

232. *See* Chao, *supra* note 219, at 761 (identifying the negotiation benefits of licensing agreements to resolve potential litigation).

233. *See* Soroudi, *supra* note 222, at 323–24 (highlighting the issue of counter-suing non-practicing entities due to their lack of participation in the market through the production of patented inventions).

234. *Cf. id.* (characterizing the issues associated with non-practicing entities not participating in the market through use of patented inventions).

235. *See* Lemley & Melamed, *supra* note 228, at 2129–30 (comparing the non-practicing entity goal of monetizing profit with the practicing entity settlement with cross-licensing with other practicing entities).

236. *See* Brian J. Love & James Yoon, *Predictably Expensive: A Critical Look at Patent Litigation in the Eastern District of Texas*, 20 STAN. TECH. L. REV. 1, 3

disproportionately valuable to market participants.[237] Essentially any patentee can attempt to monetize its patents by selling the rights to practice the technology; the business model only requires patent ownership and startup funds.[238] This type of patent value is thus equivalent for all parties.[239] Of course, market participants may have the technical knowledge necessary for licensing, which creates efficiencies and increases a patent's licensing value for market participants.[240]

In summary, all relevant benefits arising from patent ownership are most valuable when the patentee participates in the relevant marketplace.[241] It is true that any owner can transfer their patent to a market participant,[242] but that is not equivalent to assigning the initial entitlement to the party that most values it. This conclusion is warranted in light of the transaction costs associated with patent assignment (i.e., expenditures associated with selling the patent to a market participant who most values the patent), which decrease the value of the patent.[243]

(2017) (listing the sole purpose of patent troll companies as "monetizing patent rights through litigation").

237.   *See* Lemley & Melamed, *supra* note 228, at 2128–29 (identifying the similarities of non-practicing entities and practicing entities in the way they use patent litigation).

238.   *See* Matthew Fawcett & Jeremiah Chan, *March of the Trolls: Footsteps Getting Louder*, 13 INTELL. PROP. L. BULL. 1, 12 (2008) (listing the only real expense as buying patents and hiring lawyers and consultants on a contingency basis).

239.   *See* Lemley & Melamed, *supra* note 228, at 2131–32 (providing two hypothetical examples of non-practicing entities and practicing entities engaging in licensing and litigation and arriving at the same revenue).

240.   *Cf.* WORLD INTELLECTUAL PROP. ORG., SUCCESSFUL TECHNOLOGY LICENSING 6 (2015), http://www.wipo.int/edocs/pubdocs/en/licensing/903/wipo_pub_903.pdf (arguing that technical knowledge is required to maximize the value on both sides of a licensing negotiation).

241.   *Supra* notes 231–235 and accompanying text.

242.   *See* Lemley & Melamed, *supra* note 228, at 2122 (stating that patents may be bought and sold, and thus the party holding the patent at the time of the action can enforce the patent).

243.   For instance, assume a patent is worth $100 to a market participant, but the right to obtain the patent was assigned to a non-participant. A market participant may pay $100 for the patent, but the non-participant seller will only receive $99 after it pays $1 in transaction costs (e.g., legal fees). Thus, the patent is worth $100 to a market participant, but only $99 to a non-participant.

C. Assignment of Patent Rights

The literature on real world application of Coase Theorem holds that—in order to maximize economic efficiency—property entitlements should be allocated to the party that most values them.[244] As discussed in the above subsection, market participants will maximally value AI patent rights.[245] There is thus only one issue left towards determining what party should be entitled to AI patents to maximize economic efficiency: who in the AI invention timeline has the highest probably of engaging in commerce associated with AI-produced invention? As discussed below, AI users (those using the software to invent) are most likely market participants, and thus, should be entitled to receive AI patents.[246]

There are a host of parties involved in AI innovation that might be considered for patent ownership.[247] The software's lifecycle begins with researchers and programmers (collectively programmers) who design and write the AI package.[248] "Software companies" make and distribute the software available for purchase or license.[249] These firms may employ programmers.[250] The AI is subsequently purchased or licensed by a firm for use in creating AI inventions in a particular field (hereinafter AI users), and the results are analyzed for market relevance and

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244. *See* Kelly, *supra* note 34, at 864 (stating that if property rights are initially allocated to the party who would eventually buy them, efficiency is improved).

245. *Supra* notes 231–235 and accompanying text.

246. *Infra* notes 268–269 and accompanying text.

247. *See* Abbott, *supra* note 9, at 1114 (identifying various potential entities who would have a vested interest in patent ownership); *see also* Samuelson, *supra* note 126, at 1190 (discussing the issue from the copyright perspective).

248. *See* PLOTKIN, *supra* note 70, at 5–6 (explaining the process of programmers creating software).

249. *See* Bronwyn Fryer, *High Tech the Old-Fashioned Way: An Interview with Tom Siebel of Siebel Systems*, HARV. BUS. REV. (March 2001), https://hbr.org/2001/03/tom-siebel-of-siebel-systems-high-tech-the-old-fashioned-way (last visited Dec. 16, 2018) (identifying a standard practice among competitor software companies of engineering and selling software products) (on file with the Washington and Lee Law Review).

250. *See* James Martin & Carma McClure, *Buying Software off the Rack: Packages Can Be the Solution to the Software Shortage*, 61 HARV. BUS. REV. 32, 33 (1983) (discussing the employment of programmers in "software houses").

patentability by technically trained "reviewers."[251] These experts are likely employees of AI users.[252] Any number of additional downstream parties may come into contact with the AI-produced inventions, including product engineers, technical experts, and others exposed to the information.[253] The following analysis of these parties determines that AI users are most likely to participate in the market relevant to their AI inventions, and thus, should be allocated relevant patent rights to maximize social welfare.

Software companies and programmers in the AI innovation realm are unlikely to be engaged in commerce specific to any particular area of invention beyond the creation of AI.[254] For instance, IBM (a software company) and its employees (including programmers) labored to create and distribute one of the better known pieces of AI—called "Watson"[255]—which is used in a variety

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251. *Cf.* Donal O'Connell, *How to Best Run a Patent Review Board*, IPEG (2014), https://www.ipeg.com/how-to-best-run-a-patent-review-board/ (last visited Dec. 4, 2018) (discussing company use of patent review processes to determine patentability of company creations) (on file with the Washington and Lee Law Review).

252. *See id.* (discussing the employment of patent reviewers directly by the companies creating the potentially patentable material).

253. *See supra* note 219 and accompanying text (discussing the usefulness of cross-licensing opportunities for companies focusing in technology production based on the frequency of working with patented material created by other entities).

254. *See* Peter S. Menell, *Envisioning Copyright Law's Digital Future*, 46 N.Y.L. SCH. L. REV. 63, 74 (2002–2003) (discussing the highly specialized nature of programming at software companies).

255. *See* Libby Plummer, *Why Isn't IBM's Watson Supercomputer Making Money?*, WIRED (July 21, 2017), http://www.wired.co.uk/article/ibm-watson-supercomputer-profit (last visited Dec. 4, 2018) (describing IBM's Watson supercomputer) (on file with the Washington and Lee Law Review); *see also* Abbott, *supra* note 9, at 1089 (describing IBM's goals with developing the Watson supercomputer).

of fields including finance,[256] law,[257] and medicine.[258] Despite being utilized in these areas, however, IBM has yet to open a law office or hospital.[259] Software companies and programmers tend to remain within their area of expertise, as opposed to participating in the market for every field in which their AI might be employed.[260]

In contrast, AI users (e.g., product manufacturers) are likely to participate in commerce relevant to the field of their AI innovations. These parties are disproportionately expected to purchase or license inventing software for the specific purpose of gaining a marketplace advantage though innovation.[261] Examples of this phenomenon include General Electric (jet engines)[262] and Hitachi (high-speed trains).[263]

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256. *See* Jen Doll, *'Jeopardy!' Win Behind Him, Watson Seeks Billions on Wall Street*, ATLANTIC (Mar. 6, 2012), https://www.theatlantic.com/business/archive/2012/03/jeopardy-win-behind-him-watson-seeks-billions-wall-street/330903/ (last visited Dec. 4, 2018) (listing finance as an area IBM's Watson is now being used) (on file with the Washington and Lee Law Review).

257. *See* Paul Lippe, *What We Know and Need to Know About Watson, Esq.*, 67 S.C. L. REV. 419, 427 (2016) (stating that IBM has started partnering with companies in numerous fields including law).

258. *See* Zina Moukheiber, *Mayo Clinic Turns to IBM's Watson to Match Cancer Patients with Clinical Trials*, FORBES (Sept. 8, 2014, 8:00 AM), http://www.forbes.com/sites/zinamoukheiber/2014/09/08/mayo-clinic-turns-to-ibms-watson-to-match-cancer-patients-with-clinical-trials/ (last visited Dec. 4, 2018) (explaining how clinicians are using IBM's Watson in the medical field for things such as selecting patients for clinical trials) (on file with the Washington and Lee Law Review).

259. *See generally IBM Services*, IBM, https://www.ibm.com/services?lnk=hpmse_ts&lnk2=learn (last visited Dec. 4, 2018) (listing the services IBM does engage in excluding any reference to law offices or hospitals) (on file with the Washington and Lee Law Review).

260. *See* Menell, *supra* note 254, at 74 (discussing the highly specialized nature of programming).

261. *See* Michael A. Gollin, *Using Intellectual Property to Improve Environmental Protection*, 4 HARV. J.L. & TECH. 193, 197 (1991) ("[A]s with all innovation, an overarching goal is to gain a competitive advantage in the marketplace.").

262. *See* Kurzweil, *supra* note 68, at 114 (discussing the use of genetic algorithms in the design of jet engines).

263. *See* PLOTKIN, *supra* note 70, at 60 (discussing the use of genetic algorithms to evolve the design of Hitachi trains to optimize aerodynamic performance).

There are a variety of individuals employed by software owners, including reviewers who evaluate AI inventions for market value or patentability and engineers who attempt to implement the idea in new inventions.[264] While these downstream parties may have technical expertise germane to the relevant inventions—some commenters even argue these individuals may be "inventors" under current patent law[265]—they are likely to be employed by market participants rather than actually manufacturing or providing products or services.[266] As such, the parties are unlikely to directly participate in relevant commerce.[267]

Premised upon the above, it is most likely that AI users (firms using AI to create inventions for use in commerce) will be market participants. Such parties are expected, as discussed previously in Part IV.B, to most value AI patents. Accordingly—consistent with the idea that entitlements should be allocated to the party that most values them to mimic an idealized Coasean market[268]—AI users should be afforded the opportunity to patent inventions created by AI to achieve economic efficiency.[269]

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264. *See supra* note 251 and accompanying text (discussing company use of patent review processes to determine patentability of company creations).

265. *See* Abbott, *supra* note 9, at 1098 (arguing that the person downstream who receives the computational inventions and recognizes their significance could qualify as the person who discovers the invention).

266. *See supra* notes 254–260 and accompanying text (discussing the tendency of software companies to employ programmers who engage specifically in the specialized market producing software to be used by production and service industries); *see also* Brad Smith, *Intuit's CEO on Building A Design-Driven Company*, HARV. BUS. REV. (Jan. 2015), https://hbr.org/2015/01/intuits-ceo-on-building-a-design-driven-company (last visited Dec. 4, 2018) (discussing Intuit's situation in the market of only working with software and providing a product to be implemented in other business models) (on file with the Washington and Lee Law Review).

267. *See supra* notes 231–235 and accompanying text (demonstrating that the parties not participating in the actual manufacturing process are more likely to not engage directly in the relevant market).

268. *See* Kelly, *supra* note 34, at 864 (stating that if property rights are initially allocated to the party who would eventually buy them, efficiency is improved).

269. It is likewise notable that, beyond merely allocating these patent rights to parties that will most value them, allocating the rights in this manner likewise incentivizes the market participants to engage in further inventive activity. This leads to a relative increase in patentable inventions, and thus, value created via patents.

D. Considerations on Not Allocating Patent Rights to Software Companies

The above analysis establishes that patent rights should be allocated to AI users. Several related points, however, warrant discussion in this final substantive part. Software companies may—in response to the grant of patent rights to AI users—attempt to circumvent this allocation by internalizing the invention process.[270] In such a situation, the software company becomes an AI user and may secure related patents.[271] Such artifice will not, however, work for reasons discussed below.[272]

Further, some commenters disagree with the allocation of patent rights proposed herein, arguing that software companies should be entitled to AI patents (or AI copyrights).[273] Beyond failing to allocate rights to those that most value them, such a policy creates inefficiencies by promoting patent troll activity[274] and creating substantial costs associated with the policing of relevant contracts.[275] These points are discussed in the following subsections.

1. Internalization of Invention by Software Firms

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270. *Infra* notes 286–287 and accompanying text.

271. *Infra* notes 293–294 and accompanying text.

272. *Infra* notes 300–301 and accompanying text.

273. *See, e.g.*, Abbott, *supra* note 9, at 1114–15 ("Ownership rights to computational inventions should vest in a computer's owner because it would be most consistent with the way personal property . . . is treated in the United States and it would most incentivize computational invention."); Wu, *supra* note 128, at 138 ("[W]here neither the programmer nor the user meet the requirements of authorship to a copyrightable work, the court should assign the copyright to whoever owns the copyright to the computer program.").

274. *See* James Bessen & Michael J. Meurer, *The Direct Costs from NPE Disputes*, 99 CORNELL L. REV. 387, 423 (2014) (arguing that assigning patents to non-practicing entities increases litigation and costs for market participants).

275. *See* Michael A. Carrier, *Two Puzzles Resolved: Of the Schumpeter-Arrow Stalemate and Pharmaceutical Innovation Markets*, 93 IOWA L. REV. 393, 406 n.59 (2008) ("Monitoring costs, which include policing costs of enforcing contracts, reduce the value of property rights." (citing John Lunn, *The Roles of Property Rights and Market Power in Appropriating Innovative Output*, 14 J. LEGAL STUD. 423, 425 (1985))).

The proposed allocation of patent rights to AI users raises the issue of how software companies will react. An expected response is to capture the value of these patents by internalizing AI invention, such that software companies undertake the actions of an AI user and become a potential patentee for inventions arising therefrom. Should this artifice succeed, relevant property rights (patents) would not be allocated to market participants and economic efficiency would not be achieved.[276] On this issue, a second work by Coase—*The Nature of the Firm*—describes why such internalization is unlikely.[277]

In his study, Coase addressed the question of "why is not all production organized in a single large firm?"[278] His answer was that economic activities are internalized where transaction costs associated with external contracts exceed the savings created by allowing an external firm to undertake a particular activity.[279] An example is a company considering internalizing an economic activity which it can do it for $50 but which provides it with $60 of value. It will internalize the activity (and secure a $10 gain) unless it can be outsourced to obtain a larger aggregate benefit. With this in mind, even if an outside entity will undertake the same activity for $45, the company will internalize the job if the cost of contracting with the external party is $5.01 or more. Deducting the cost of outsourcing ($45) and transaction costs (at least $5.01) from the activity's value ($60) leaves the firm in a worse position if it outsources (securing at most a $9.99 gain, instead of $10 from doing the act in house). The choice to internalize (or not) is thus a function of the benefit from an activity, costs of outsourcing, and costs of internalizing the act. As shown below, benefits associated with AI invention by software companies are substantially

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276. *See supra* Parts IV.C–D (discussing the economic efficiency of giving patents to market participants).

277. *See* Ronald H. Coase, *The Nature of the Firm*, 4 ECONOMICA 386, 395 (1937) (arguing that firms will externalize when the costs of internalization are greater than the costs of externalization).

278. *Id.* at 394.

279. *See id.* at 395 ("[A] firm will tend to expand until the costs of organizing an extra transaction within the firm become equal to the costs of carrying out the same transaction by means of an exchange on the open market or the costs of organizing in another firm.").

undermined by new information costs and is not expected to be financially viable.

At first blush, it appears that software companies are likely to internalize the AI inventive process. They have the know-how to efficiently operate their software, are aware of the industries interested in AI invention (via past sales), and will enjoy the value of AI patents to which they would be entitled.[280] These considerations favor a determination that software firms will internalize AI invention in a fiscally efficient manner (e.g., such that it costs less to internalize the activity relative to letting others do so).[281] This conclusion, however, ignores substantial information costs associated with producing relevant inventions and associated patents.

To utilize AI to create valuable inventions (which lead to valuable patents), a party must maintain significant organizational knowledge.[282] Firms in any particular field have information relevant to identifying subject areas where invention will prove valuable as that market evolves, as there is no need to invent products with no future market value.[283] An entity must likewise have the technical expertise necessary to identify a valuable invention produced by AI; invention cannot lead to patent value if no one recognizes which inventions are important.[284] Lastly, only a party actively participating in the market can assess its particular inventive needs relative to its private business plans;

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280. *See supra* Part IV.C (discussing the benefits associated with patent ownership by software companies).

281. *See* Coase, *supra* note 277 (hypothesizing that firms will internalize costs until it is less expensive for the firm to externalize the cost or start another firm).

282. *See* Morten T. Hansen et al., *What's Your Strategy for Managing Knowledge?*, 77 HARV. BUS. REV. 106, 106–07 (1999) (discussing how firms maintain organizational knowledge relevant to their field of expertise).

283. *See* Marco Verweij, *Why Is the River Rhine Cleaner Than the Great Lakes (Despite Looser Regulation)?*, 34 L. & SOC'Y REV. 1007, 1048 (2000) ("Firms have detailed knowledge of their cost structure, and they are well positioned to develop new technologies and to find efficient, practical solutions to [their] problems.").

284. *See* Timothy R. Holbrook, *Patents, Presumptions, and Public Notice*, 86 IND. L.J. 779, 781 (2011) (discussing the importance of technical knowledge to patenting activities).

this information is not available to outside firms and thus cannot be broadly used to invent the "right" new technologies.[285]

These considerations leave software companies with an unenviable choice. They can either pay significant sums to hire technical experts and obtain necessary information from firms in the field, or they can produce inventions (and thus patents) of little value due to a want of needed information.[286] In these situations, the cost to internalize invention will either rise significantly or the value from AI patents will fall precipitously, respectively. In neither instance can internalization of AI invention be expected to prove a net benefit, except in rare circumstances.[287] Software companies cannot, therefore, be expected to internalize AI invention on a significant scale.

2. Patent Troll Activity

Beyond the prior discussion of benefits arising from patent ownership, a relevant secondary consideration is the social cost that may arise from AI patents. More specifically, it is prudent to determine how these patents might be monetized and the societal impact arising therefrom. This concern is germane to a primary issue in modern patent scholarship, namely attempts to discourage the patent assertion entity (also referred to as "patent troll") business model.[288] The below discusses how AI patents might

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285. *See* Verweij, *supra* note 283, at 1048 ("Firms have detailed knowledge of their cost structure, and they are well positioned to develop new technologies and to find efficient, practical solutions to [their] problems.").

286. *See id.* (arguing that the benefit of having inventors with specific knowledge of the industry and practice area to develop technology to address the market issues).

287. *See, e.g.*, Aatif Sulleyman, *Google AI Creates Its Own 'Child' AI that's More Advanced than Systems Built by Humans*, INDEPENDENT (Dec. 5 2017, 3:40 PM), http://www.independent.co.uk/life-style/gadgets-and-tech/news/google-child-ai-bot-nasnet-automl-machine-learning-artificial-intelligence-a8093201. html (last visited Dec. 4, 2018) (describing Google's production of an open source neural network software that markedly improved on the other available programs at the time) (on file with the Washington and Lee Law Review).

288. *See* W. Michael Schuster, *Invalidity Assertion Entities and* Inter Partes *Review: Rent Seeking as a Tool to Discourage Patent Trolls*, 51 WAKE FOREST L. REV. 1163, 1164 (2016) (discussing the development of Invalidity Assertion Entities and their use of *Inter Partes* Review to challenge the validity of patents

further troll litigation if these rights were allocated to software companies (in contrast to being allocated to AI users, as proposed herein).

Societal costs associated with patent troll litigation are substantial.[289] Activity of this nature cannot proceed, however, unless trolls are able to purchase patents.[290] That end is furthered where—as discussed below—patentees have no means of financially exploiting a patent except selling it. This would be the situation for many AI patent owners if patent rights were given to parties other than market participants (e.g., software companies).

There are limits on how software companies may monetize a patent. As specialized AI firms, these companies will not generally be engaged in commerce related to the field of the AI's invention.[291]

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and target patent trolls); *see also* David Orozco, *Administrative Patent Levers*, 117 PENN ST. L. REV. 1, 17 (2012) (expressing concerns related to the prevalence of patent trolls and their negative impact on business); Daniel R. Cahoy, 9 N.Y.U. J. LEGIS. & PUB. POL'Y 587, 640 (2006) (describing the current environment with patent trolls as a potential crisis); Gregory Day, *Competition and Piracy*, 32 BERKELEY TECH. L.J. 775, 786 (2017) (describing the economic atmosphere of stiff patent violation penalties which has created the patent troll industry).

289. *See* Bessen & Meurer, *supra* note 274, at 423 (finding that the costs from patent troll lawsuits are "substantial, and . . . correspond to substantial social costs as well"); *see also* Richard Posner, *Patent Trolls*, BECKNER-POSNER BLOG (July 21, 2013, 5:12 PM), http://www.becker-posner-blog.com/2013/07/patent-trollsposner.html (last visited Dec. 4, 2018) ("It is extremely difficult to discern any possible social benefit from trolls, and extremely easy to discern substantial social costs.") (on file with the Washington and Lee Law Review); Maayan Perel, *From Non-Practicing Entities (NPEs) to Non-Practiced Patents (NPPs): A Proposal for A Patent Working Requirement*, 83 U. CIN. L. REV. 747, 749 n.3 (2015) ("[A]nnual wealth lost from [non-practicing entity] lawsuits is around $80 billion for publicly traded U.S. firms and that much of this cost is a social loss not a mere transfer to [non-practicing entities]."); Fabio E. Marino & Teri H.P. Nguyen, *Has Delaware Become the "New" Eastern District of Texas? The Unforeseen Consequences of the AIA*, 30 SANTA CLARA HIGH TECH. L.J. 527, 533 (2014) ("The social benefits [non-practicing entities] may offer, if any, are minimal and outweighed by the private and social costs they impose."). *But see* Lauren Cohen et. al., *"Troll" Check? A Proposal for Administrative Review of Patent Litigation*, 97 B.U. L. REV. 1775, 1807 (2017) (asserting that "the net social costs of [patent assertion entity—patent troll—]activity remain subject to heated debate").

290. *See* Carhart v. Carhart-Halaska Int'l, LLC, 788 F.3d 687, 691 (7th Cir. 2015) ("The commonest example of a law troll is the patent troll, who acquires by purchase or application to the Patent and Trademark Office a patent that he uses not to protect an invention but to obtain a license fee from, or legal judgment against, an alleged infringer.").

291. *See supra* Part IV.C (discussing why specialized firms are less likely to

This constrains their sources of patent value to licensing or sale of the patent,[292] which in turn expands the market for discount patents (and thus, furthers patent troll activity). Such a conclusion is made clear though a discussion of avenues available for software companies to monetize their AI patent holdings.

In some instances, software companies might assign their patent to downstream AI users (e.g., firms licensing the use of the AI), and the patent is off the market.[293] Likewise, software companies may sell licenses to use the patented technology and retain all substantial rights, including the right to sell the patent and sue for infringement.[294] Neither of these situations create immediate worry.

Patent troll concerns arise where a software company (that has been allocated relevant patent rights) issues a terminal number of licenses and is left holding a patent which it has no intention or capacity to exploit in commerce.[295] The economically rational choice at that point is to sell the patent for any non-zero

engage in commerce in the specific market where their technology will be used).

292. *See* Lemley & Melamed, *supra* note 228, at 2129–30 (describing the method employed by non-practicing entities to make a profit compared with the ability of practicing entities to cross-license their work to reduce costs).

293. *See* Michael Seringhaus, *E-Book Transactions: Amazon "Kindles" the Copy Ownership Debate*, 12 YALE J.L. & TECH. 147, 181–82 (2010) (discussing the classification of a downstream licensing agreement of a patented technology as an assignment of patent rights).

294. *See* Alfred E. Mann Found. for Sci. Research v. Cochlear Corp., 604 F.3d 1354, 1359–60 (Fed. Cir. 2010)

> Either the licensor did not transfer "all substantial rights" to the exclusive licensee, in which case the licensor remains the owner of the patent and retains the right to sue for infringement, or the licensor did transfer "all substantial rights" to the exclusive licensee, in which case the licensee becomes the owner of the patent for standing purposes and gains the right to sue on its own.

See also Intellectual Prop. Dev., Inc. v. TCI Cablevision of Cal., Inc., 248 F.3d 1333, 1345 (Fed. Cir. 2001) ("[A] nonexclusive license . . . confers no constitutional standing on the licensee under the Patent Act to bring suit or even to join a suit with the patentee because a nonexclusive (or 'bare') licensee suffers no legal injury from infringement.").

295. *See, e.g.*, Tim Carmody, *When Startups Fail, Investors Recoup by Selling Patents*, WIRED (Aug. 11, 2011, 12:02 PM), https://www.wired.com/2011/08/startups-fail-sell-patents/ (last visited Dec. 4, 2018) (discussing the tendency of companies to sell patents when they can no longer profit by selling licenses) (on file with the Washington and Lee Law Review).

sum.[296] This can positively reflect on the bottom line without inhibiting the rights of past licensees.[297] This act, however, additionally benefits trolls looking to purchase inexpensive patents.[298]

A sale of this nature will occur at a discounted rate because all prior licensing opportunities would rationally have been explored, along with any serious assignment opportunities.[299] This situation plays into a common troll business tactic—purchasing discounted patents for subsequent litigation.[300] Accordingly, assigning AI patent rights to software companies would further the patent troll business model. This creates new societal costs and deviates from the stated goal of economic efficiency (i.e., maximizing societal

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296. *See* Stephen Bainbridge, *Contractarianism in the Business Associations Classroom: Kovacik v. Reed and the Allocation of Capital Losses in Service Partnerships*, 34 GA. L. REV. 631, 661 n.99 (2000) (summarizing the ultimatum game where the entity facing a potential loss should settle for any non-zero offer).

297. *See TCI Cablevision of Cal.*, 248 F.3d at 1337 (determining that though one party granted a nonexclusive license to another party, the previous party maintained the ability to bring a suit).

298. Patent trolls commonly attempt to purchase their patents at discounted rates. *See* Ian Polonsky, *You Can't Go Home Again: The* Righthaven *Cases and Copyright Trolling on the Internet*, 36 COLUM. J.L. & ARTS 71, 72–73 (2012) ("The patent troll model works as follows: the troll seeks out opportunities to buy patents on the cheap, often during bankruptcy auctions or from producers hoping to sell under-utilized patents to fund other research projects."); *see also* David B. Heedy, *Has* Alice *Brought Us to Patent Wonderland?: Can the Supreme Court's New Analysis of Abstract Ideas Affect the Current Problems Associated with Business-Method and Software Patents*, 15 FLA. ST. U. BUS. REV. 57, 62 (2016) (characterizing the patent troll business model as one of buying patents from firms who do not have enough capital to enforce patents themselves); Overstock.com, Inc. v. Furnace Brook, LLC, 420 F. Supp. 2d 1217, 1218 (D. Utah 2005) (patent troll "purchased its patent at a bankruptcy auction in 2003 and, without any apparent attempts to practice it, has since sent infringement letters" to numerous large companies), *aff'd*, 191 Fed. Appx. 959 (Fed. Cir. 2006).

299. *See* Erik Oliver et al., *When Do Operating Companies Sell Their Patents*, IPWATCHDOG (Aug. 16, 2016), https://www.ipwatchdog.com/2016/08/16/operating-companies-sell-their-patents/id=71890/ (last visited Dec. 4, 2018) (performing empirical analyses on the sale prices of patents to non-practicing entities to demonstrate that the likely cause of discounted patent sales is poor company health); *see also supra* notes 295–296 and accompanying text (discussing the economic pressure to sell for any non-zero sum when the company can no longer exploit the patent).

300. *See supra* note 298 and accompanying text (describing the need to purchase patents at discounted rates to fulfil the patent troll model).

surplus).[301] Such an allocation of AI patent rights cannot, therefore, be a preferred policy.

3. Costs Associated with Software Company Patentees

Additional inefficiencies would arise from allocating AI patent rights to software companies. Coase Theorem—and the economically efficient state of affairs that it predicts—relies on the assumption of costless transactions and perfect information.[302] Part III.B described how to mimic costless transactions in reality, but had little need to substantively address the perfect information assumption. Real world deviation from this assumption would create substantial costs (and thus economic inefficiencies) if AI patent rights were allocated to software companies.[303]

For software companies to successfully exploit AI patent rights allocated to them, they must be aware of, and capable of understanding, the means by which their software is being used by downstream AI users. While potentially able to monitor the operation and output of its AI, software companies are not guaranteed a technical understanding of that information. As discussed in the previous subsection, technical knowledge in the field of invention is not commonly held by software companies, and obtaining such expertise would come at the expense of hiring experts.[304]

This want of relevant knowledge would create substantial costs for software companies in two distinct manners. Initially, the firms must maintain sufficient expertise to recognize what output (i.e., inventions) are worth the investment of patenting.[305] It is a

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301. *See supra* note 289 and accompanying text (identifying the social costs of patent trolls).

302. *See* Swygert & Yanes, *supra* note 186, at 270 (identifying the assumptions behind Coase Theorem, including "perfect knowledge" and "zero transaction costs").

303. *See supra* notes 298–301 and accompanying text (discussing the significant social costs and inefficiencies associated with patent troll ownership of patents).

304. *See supra* Part IV.C (discussing why specialized firms are less likely to engage in commerce in the specific market where their technology will be used).

305. *See* Hansen et al., *supra* note 282, at 106–07 (discussing how firms

bad investment to patent all inventions produced by their AI (including bad ones), and it is likewise foolhardy to patent none of the inventions.[306] The potential patentee must be able to distinguish the good from the bad.[307] Software companies may secure technical expertise by making new hires or exchanging patent licenses for relevant knowhow.[308] Regardless of the path chosen, however, the company is incurring additional expenses and deducting from economic efficiency.[309]

A related cost comes from the expense of policing AI users.[310] Were software firms to be allocated the right to AI patents, they would need to be vigilant against attempts by users of their software to illicitly patent technologies in the users' own name. Should an AI user create a particularly valuable invention, there are significant financial incentives to secure a patent with an employee of the firm incorrectly listed as the inventor. Absent recognition of the illicit activity and subsequent legal action, this would cut the software company out of income from the AI patent.

To avoid such losses, significant policing measures would need be taken by the software firm. Initially, it would have to review patent filings by downstream users of its AI and compare them to

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maintain organizational knowledge relevant to their field of expertise).

306.   *See, e.g.,* Stephen Key, *Software Startups: This Is How You Craft a Patent Strategy,*   FORBES   (June   27,   2018,   5:12   PM), https://www.forbes.com/sites/stephenkey/2018/06/27/software-startups-this-is-how-you-craft-a-patent-strategy/#21973d591fee (last visited Dec. 4, 2018) (discussing the general drawbacks of patenting software in certain circumstances and not patenting in others) (on file with the Washington and Lee Law Review).

307.   *See* Verweij, *supra* note 283, at 1048 ("Firms have detailed knowledge of their cost structure, and they are well positioned to develop new technologies and to find efficient, practical solutions to [their] problems." (alteration in original)).

308.   *See supra* notes 231–235 and accompanying text (demonstrating that the parties not participating in the actual manufacturing process are more likely to not engage directly in the relevant market).

309.   *See* discussion *supra* Part IV.B (discussing the tendency for parties participating in the market to value the patents most).

310.   *See* Edward Brunet & David J. Sweeney, *Integrating Antitrust Procedure and Substance After Northwest Wholesale Stationers: Evolving Antitrust Approaches to Pleadings, Burden of Proof, and Boycotts,* 72 VA. L. REV. 1015, 1028 (1986) (discussing the costs of policing contract compliance); *see also* Note, CBS v. ASCAP: *Performing Rights Societies and the Per Se Rule,* 87 YALE L.J. 783, 786 (1978) (describing the enormity of the costs associated with policing the contracts).

the invention output of its software. To effectively do so, the software company must expend resources on technical experts and patent lawyers to determine whether others are illicitly patenting inventions arising from its AI. Beyond the mere cost of such policing, this type of activity is likely to further decrease economic efficiency through legal expenses and soured business relationships should misdeeds be identified. This host of additional costs detract from economic efficiency, and again, disfavors allocation of AI patent rights to software companies.

E. Future Research

This Article presents the first significant analysis of the allocation of patent rights arising from AI invention. There are, not surprisingly, a variety of other issues in this nascent field that warrant future research. This subpart briefly recognizes several of these issues.

A majority of the literature and commentary believes that AI patents will eventually be issued,[311] and indeed, this Article proceeds under that expectation. There are, however, a variety of policy issues underlying this determination that should be fully vetted in the literature. Initially, refusing to issue AI patents creates several incentives that cut against public policy. A primary goal of the patent system is dissemination of technological advances.[312] Refusing to issue AI patents, however, encourages inventing software users to maintain their inventions as a trade secret (if possible) because public disclosure makes the technology available to competitors with no benefit to the inventor beyond a head start in the marketplace.[313] Such a policy likewise incents

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311. *See, e.g.*, Hattenbach & Glucoft, *supra* note 12, at 51 (citing the adherence to the "Constitutional objective of advancing the progress of useful arts" as the reason for future allowance of AI patents); Abbott, *supra* note 9, at 1081–82. (arguing that AI ownership should not be prevented by the history of the "Copyright Office's Human Authorship Requirement"). This belief is not, however, universally held. *See* Ravid & Xiaoqiong, *supra* note 121, at 2222 (arguing for the abolishment of patent protections for AI created inventions).

312. *See* Miller, *supra* note 115, at 1067 (citing the goal of copyright is progress).

313. *See* Symposium, *A Manifesto Concerning the Legal Protection of*

deceit in naming a human as inventor where a technology was actually created by AI. This type of duplicitousness could successfully circumvent a ban on AI patents, as the Patent Office will not investigate or reject applications for failures to correctly name an inventor.[314] Patents issued under such subterfuge are subject to invalidation,[315] but the owner will enjoy the same benefits as a legitimate patentee until their patent is invalidated (if caught).[316]

A contrary policy argument recognizes that AI invention is relatively low in cost, and thus, does not need the incentive of a patent to be undertaken. It could likewise be argued that such low-cost invention and patenting creates social costs in the form of patent thickets.[317] Future research is warranted to address these arguments.

Computer Programs, 94 COLUM. L. REV. 2308, 2409 (1994) (arguing that the market-oriented regimes would reduce wasteful duplications by both ensuring return on investment and removing the need for companies to keep discoveries trade secrets); Luigi Alberto Franzoni & Arun Kumar Kaushik, *The Optimal Scope of Trade Secrets Law*, 45 INT'L REV. L. & ECON. 45, 45 (2016) (asserting that excessive secrecy slows down the dissemination of information in a way that does a disservice to the economy and people).

314.   *See* Aaron X. Fellmeth, *Conception and Misconception in Joint Inventorship*, 2 N.Y.U. J. INTELL. PROP. & ENVTL. L. 73, 117 (2012) ("[T]he PTO virtually never questions the applicant's assertions of inventorship when examining the patent."); *see also* 37 CFR § 1.56 (2018) (providing the patent disclosure requirements); Honeywell Int'l Inc. v. Maltseff, No. C14-0283JLR, 2014 WL 3360334, at *2 (W.D. Wash. July 9, 2014) (finding the claim does not rest solely on invention disclosures); 2018 MANUAL OF PATENT EXAMINING PROCEDURE § 2010 (MB 2018) ("[T]he examiner will not comment upon duty of disclosure issues which are brought to the attention of the Office except to note . . . that such issues are not considered by the examiner during examination of patent applications . . . .").

315.   *See* Kennedy v. Hazelton, 128 U.S. 667, 672 (1888) ("A patent which is not supported by the oath of the inventor, but applied for by one who is not the inventor, is unauthorized by law, and void, and . . . confers no right as against the public.").

316.   *See* Norris Boothe, *Exercising a Duty of Clarity:* Nautilus, Inc. v. Biosig Instruments, Inc., 30 BERKELEY TECH. L.J. 445, 467 (2015) (describing the value of patents that the court has not validated or invalidated); *see also* Susan Navarro Smelcer, Note, *Anticompetitive Use of Administrative Trials in Bargaining over Patent Rights*, 91 N.Y.U. L. REV. 1719, 1733 (2016) (describing the choice of when to go to trial as a value assessment of the patent at that moment).

317.   *See* James Bessen, *A Generation of Software Patents*, 18 B.U. J. SCI. & TECH. L. 241, 248 (2012) (describing a patent thicket as the circumstance where

Moving from patent prosecution and ownership, there are future issues to be addressed with regard to patent infringement by AI. For example, assume AI is developed by Company I, licensed to Company II, and then integrated into a product used by Company III.[318] If the AI independently begins to operate the product in a manner that infringes on existing patents, which party is liable (ignoring contractual issues)? Even if no party was aware of the AI's "decision" to operate the product in an infringing manner, liability will arise because "patent infringement is a strict liability offense."[319] While liability seems appropriate for the product's owner (Company III), there are interesting questions of induced infringement by the others.[320] If it was foreseeable that the AI would begin to behave in an infringing manner, liability might be found.[321] These questions must be vetted in the literature and courts as the field of AI and invention progress.

V. Conclusion

Invention via AI is the future of innovation. Unfortunately, at this time, the United States patent regime has yet to address the issue of how, and whether, it will issue AI patents. This Article attempts to make progress on this issue by presenting the first

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firms acquire a large number of patents and subsequently create a barrier of entry to the market). A patent thicket is "a dense web of overlapping intellectual property rights." Jaffe v. Samsung Elecs. Co., 737 F.3d 14, 19 (4th Cir. 2013) (citation omitted).

318. Adapted from an example in Hogan Lovells, *Artificial Intelligence Drives New Thinking on Patent Rights*, LEXOLOGY (July 15, 2016), https://www.lexology.com/library/detail.aspx?g=cfb71b99-e4ac-4a13-96cf-7c1fd6e98543 (last visited Dec. 4, 2018) (on file with the Washington and Lee Law Review).

319. *In re* Seagate Tech., LLC, 497 F.3d 1360, 1368 (Fed. Cir. 2007), *abrogated on other grounds by* Halo Elecs., Inc. v. Pulse Elecs., Inc., 136 S. Ct. 1923 (2016).

320. *See* Carson Optical Inc. v. eBay Inc., 202 F. Supp. 3d 247, 253 (E.D.N.Y. 2016) (describing the standard for induced infringement); *see also* Lynda J. Oswald, *International Issues in Secondary Liability for Intellectual Property Rights Infringement*, 45 AM. BUS. L.J. 247, 256 (2008) (discussing secondary liability generally).

321. *See* Jacqueline K.S. Lee et al., *Catch Me If You Can: Litigating Artificial Intelligence Patents*, 23 CYBERSPACE LAWYER 1 (Jan./Feb. 2018) (discussing a similar situation from a contributory infringement perspective).

substantial consideration on AI patent allocation and societal efficiency. Such information is of primary importance in the choice of to whom to grant AI patents. With this in mind, the Article concludes that, via a Coasean analysis, the rights to AI patent should be allocated to AI users (i.e., parties using AI to create new technologies) to maximize economic efficiency.