THE UNITED STATES' CLIMATE PATENTING BEHAVIOR AFTER THE PARIS AGREEMENT WITHDRAWAL ANNOUNCEMENT: AN EMPIRICAL ANALYSIS AND A FAST-TRACK PROPOSAL

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When the United States announced that it would withdraw from the Paris Agreement, some commentators speculated whether this announcement would affect patent applications on climate technologies. This Note studies the effect of that withdrawal on patenting behavior in the U.S. by conducting a difference-in-difference analysis on U.S. patent applications on climate technologies compared to patent applications on climate technologies filed in other countries, patent applications filed on all technologies in the U.S., and patent applications filed on mechanical engineering technologies in the U.S. This Note finds that U.S. patent applications on climate technologies declined relative to these other groups. Yet, this Note does not find that the announced withdrawal from the Paris Agreement caused the decline relative to other countries, nor the decline relative to all technologies in the U.S. It does find that the decline relative to mechanical engineering technologies is statistically significant, which suggests that the announced withdrawal from the Paris agreement caused this decline. Even if the announced withdrawal from the Paris Agreement did not cause these declines, they do have effects on intellectual property protection in climate technologies. Accordingly, this Note proposes a program by the United States Patent and Trademark Office to address these relative declines and provides model rules for this program.

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I. INTRODUCTION

Climate change is here. Carbon and greenhouse gas emissions have already driven up the average temperature of the Earth by 1°C.[1] The situation is dire.[2] The United Nations ("U.N.") projects 200 million climate refugees by 2050. In the midst of this apocalypse, the United States of America ("U.S."), and countries around the globe, promised to restrict emissions to "well below 2°C above pre-industrial levels[,]" under the Paris Agreement in 2016.[3] Even major emitters have ratified the Paris Agreement.[4]

The U.S. reneged on that promise.[5] On June 1, 2017, President Donald Trump announced that the U.S. would cease all participation in the 2016 Paris Agreement on climate change mitigation, leaving by November 5, 2020.[6] States have banded together to comply with the Agreement,[7] but the U.S. is already behaving contrary to it.[8] Though public outcry has focused largely on the environmental and geopolitical effects,[9] this withdrawal may also affect innovation in climate technology.[10] Specifically, if inventors interpret the U.S.' withdrawal as a signal that there is no short-term market for climate technology in the U.S., then those inventors may not deploy or sell their climate-related technologies

1. MYLES ALLEN ET AL., SPECIAL REPORT: GLOBAL WARMING OF 1.5 °C: SUMMARY FOR POLICYMAKERS 4 (2018) ("Human activities are estimated to have caused approximately 1.0°C of global warming above pre-industrial levels, with a likely range of 0.8°C to 1.2°C. Global warming is likely to reach 1.5°C between 2030 and 2052 if it continues to increase at the current rate.").

2. *See generally* DAVID WALLACE-WELLS, THE UNINHABITABLE EARTH: LIFE AFTER WARMING (2019). For example, the summer of 2018 brought a global heat wave, with temperatures hitting 108°F in Los Angeles, 122°F in Pakistan, and 124°F in Algeria. *Id.* at 79. The tropics are already too hot to efficiently grow grain; the world's natural wheat belt is moving pole-ward by 160 miles per decade. *Id.* at 50. The Sahara desert has expanded by 10%. *Id.* at 52. The amount of ocean water with no oxygen at all has quadrupled globally, into more than four hundred "dead zones"; these zones now total the size of all of Europe. *Id.* at 97.

3. Paris Agreement to the United Nations Framework Convention on Climate Change, art. 2, *agreement adopted* Dec. 12, 2015, 16 T.I.A.S. No. 16-1104, 55 I.L.M. 4. [hereinafter Paris Agreement].

4. Erwin Jackson, *Enough with the Fairy Tales About the Paris Agreement. It's Time for Facts*, GUARDIAN (Aug. 15, 2018, 12:12 AM), https://www.theguardian.com/commentisfree/2018/aug/15/enough-with-the-fairy-tales-about-the-paris-agreement-its-time-for-facts [https://perma.cc/N4F3-6J76].

5. *Paris Climate Deal: Trump Pulls US Out of 2015 Accord*, BBC (June 1, 2017), https://www.bbc.com/news/world-us-canada-40127326 [https://perma.cc/Z657-XJ3C].

6. *Id.*; Keith Johnson, *Is the United States Really Leaving the Paris Climate Agreement?*, FOREIGN POL'Y (Nov. 5, 2019, 2:19 PM), https://foreignpolicy.com/2019/11/05/paris-climate-agreement-united-states-withdraw/ [https://perma.cc/5ZFA-PSF6].

7. Press Release, Office of Governor Inslee, New York Governor Cuomo, and California Governor Brown Announce Formation of United States Climate Alliance (June 1, 2017), https://www.governor.wa.gov/news-media/inslee-new-york-governor-cuomo-and-california-governor-brown-announce-formation-united [https://perma.cc/M8C9-T82X] [hereinafter New York Governor Cuomo, and California Governor Brown Announce Formation of United States Climate Alliance].

8. *USA*, CLIMATE ACTION TRACKER, https://climateactiontracker.org/countries/usa/ [https://perma.cc/95P4-XNFR] (last updated July 30, 2020).

9. *Paris Climate Deal: Trump Pulls US Out of 2015 Accord*, *supra* note 5.

10. *See Green Tech IP After Withdrawal from the Paris Climate Agreement*, BRINKS GILSON & LIONE: ALERT (Aug. 14, 2017), https://www.brinksgilson.com/green-tech-ip-after-withdrawal-from-the-paris-climate-agreement [https://perma.cc/G9L7-GERY].

within the U.S.[11] This refusal may negatively affect commercialization of climate technology within the U.S., but may positively expand the public domain for climate technology in the U.S., granting innovators access to unprotected inventions for research and development.[12]

This Note finds little evidence that after the U.S. announced its impending withdrawal from the Paris Agreement ("Paris Withdrawal"), that announcement *caused* annual U.S. climate patent applications to decline relative to climate patents filed in all other countries. U.S. climate patent applications declined relative to climate patent applications in China, Japan, the European Patent Office ("EPO"), and the World Intellectual Property Organization ("WIPO"), but this relative decline was not statistically significant.[13] That is to say, while there is a relative decline between U.S. climate patent applications and those of China, Japan, the EPO, and WIPO, it is not likely that the Paris Withdrawal solely caused this relative decline; statistically, there is a possibility that this relative decline would have occurred without the Paris Withdrawal.[14] Even if the Paris Withdrawal was not the sole cause of this relative decline, though, it may bear partial responsibility, because this relative decline is not fully explained by the U.S.' documented relative decline in *all* patent applications,[15] nor by a global reversion to the mean in climate patent applications after a peak in 2012.[16] This relative decline may negatively affect commercialization while also expanding the public domain, as noted above.

Part II provides a background that surveys the implementation of the Paris Agreement, global and comparative progress on meeting the Paris Agreement goals, the Paris Withdrawal announcement, and the patent system's relevancy to climate change innovation. Part III illustrates the theoretical consequences of inventors refusing to file climate patent applications in the U.S., shows why the consequences may be negative or positive, and then empirically evaluates the effect of the Paris Withdrawal announcement on patent application filings. Part IV recommends opening a new U.S. Green Patent Fast-Track Program to increase both commercialization and the size of the public domain, and provides a model statement and rules for that program.

II. BACKGROUND

This Part surveys the implementation of the Paris Agreement, the Paris Agreement's and other efforts' emphasis on innovation, the reliance of innovation on private markets, the patent system, and the U.S.' withdrawal from the

11. *Id.*

12. *See* discussion *infra* Section III.A.

13. *See infra* Overview of Experimental Results.

14. *See* CONSTANTIN COLONESCU, PRINCIPLES OF ECONOMETRICS WITH R 99–120 (2016).

15. *See* WORLD INTELL. PROP. ORG., WORLD INTELLIGENCE PROPERTY INDICATORS 7 (2019).

16. Miguel Cárdenas Rodríguez, Ivan Haščič & Nick Johnstone, *Global Patent Applications for Climate Change Mitigation Technologies—A Key Measure of Innovation—Are Trending Down*, INT'L ENERGY AGENCY (July 11, 2019), https://www.iea.org/commentaries/global-patent-applications-for-climate-change-mitigation-technologies-a-key-measure-of-innovation-are-trending-down [https://perma.cc/DYC4-Z3R5].

Paris Agreement. Then, Part III will draw upon this material to explain why inventors may choose to not pursue climate patents in the U.S.

A. The Paris Agreement

Given the already dramatic effects of climate change, most countries came together to restrict emissions to mitigate the effects of climate change, starting with the Kyoto Protocol in 2005[17] and culminating with the Paris Agreement in 2016.[18] A total of 179 countries, including all major emitters, have ratified the Paris Agreement.[19] The Paris Agreement aims to hold "the increase in the global average temperature to well below 2°C above pre-industrial levels[,]" preferring to "limit the temperature increase to 1.5°C above pre-industrial levels[.]"[20]

The Paris Agreement and entities involved in climate mitigation heavily rely on technology development to address climate change effects.[21] For example, the Intergovernmental Panel on Climate Change ("IPCC") devotes a whole chapter of its Sixth Assessment Report to innovation.[22] The Paris Agreement declares "the importance of fully realizing technology development and transfer in order to improve resilience to climate change and to reduce greenhouse gas emissions."[23] It further declares that "[a]ccelerating, encouraging, and enabling innovation is critical for an effective, long-term global response to climate change."[24] To do so, the Paris Agreement relies on the existing infrastructure of the Technology Mechanism: the combination of a Technology Executive Committee and a Climate Technology Centre and Network tasked with developing and implementing policy for climate technology development and transfer.[25]

17. *See* Kyoto Protocol to the United Nations Framework Convention on Climate Change, *adopted* Dec. 11, 1997, 2303 U.N.T.S. 162.

18. *See* Paris Agreement, *supra* note 3.

19. *See* Jackson, *supra* note 4.

20. *See* Paris Agreement, *supra* note 3, 16 T.I.A.S. at 3 ("[I]ncluding its objective, [the Paris Agreement] aims to strengthen the global response to the threat of climate change, in the context of sustainable development and efforts to eradicate poverty, including by: (a) Holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change . . . .").

21. *See infra* notes 22–25 and accompanying text.

22. IPCC, CHAPTER OUTLINE OF THE WORKING GROUP III CONTRIBUTION TO THE IPCC SIXTH ASSESSMENT REPORT (AR6) 8 (2017) [hereinafter IPCC SIXTH ASSESSMENT REPORT], https://www.ipcc.ch/site/assets/uploads/2018/03/AR6_WGIII_outlines_P46.pdf [https://perma.cc/KQF2-7BM6].

23. *See* Paris Agreement, *supra* note 3, 16 T.I.A.S. at 14 ("Parties share a long-term vision on the importance of fully realizing technology development and transfer in order to improve resilience to climate change and to reduce greenhouse gas emissions.").

24. *See id.* at 15 ("Accelerating, encouraging and enabling innovation is critical for an effective, long-term global response to climate change and promoting economic growth and sustainable development.").

25. *Id.* at 14 ("The Technology Mechanism established under the Convention shall serve this Agreement."); *id.* ("A technology framework is hereby established to provide overarching guidance to the work of the Technology Mechanism in promoting and facilitating . . . technology development and transfer in order to support the implementation of this Agreement . . . ."); *see Technology Mechanism*, TT: CLEAR, https://unfccc.int/ttclear/support/technology-mechanism.html (last visited Nov. 27, 2020) [https://perma.cc/5AYT-47G4]; *see also* Matthew Rimmer, *Beyond the Paris Agreement: Intellectual Property, Innovation Policy, and Climate Justice*, 8 MDPI: L., 1, 1 (2019).

Within the U.S., the federal government—to the limited extent that it is concerned about climate change—has preferred innovation rhetoric to regulations.[26] The Trump Administration has not demonstrated concern about climate change.[27] In the legislature, Republican members of Congress, who traditionally ignored or dismissed climate risk, now acknowledge its risk.[28] But most of these congressmen are averse to taxes or restrictions, and instead choose to focus on funding and innovation methods.[29] As Senator Barasso (R-Wyo.) argues, the French government suspended a fuel tax increase after protests, voters in Washington State rejected an emissions tax, voters in Colorado rejected a drill restriction, and voters in Arizona rejected a mandate to make Arizona's utilities dependent on renewable energy by 2030 no matter the cost.[30] Democratic politicians' solutions tend towards regulation, but these regulations have been implemented on a state-by-state basis, and are only recently coming into effect.[31]

In turn, the Paris Agreement and those same entities also rely on private market effects to develop technology.[32] The Paris Agreement itself aims to promote non-market approaches to sustainable development and technology *transfer*, but does not offer non-market approaches for technology *development*.[33] The preceding agreement by the United Nations Framework Convention on Climate

26. *See infra* note 27.

27. *Regulatory Rollback Tracker*, HARV. L. SCH. ENV'T & ENERGY L. PROGRAM, https://eelp.law.harvard.edu/regulatory-rollback-tracker/ (last visited Nov. 27, 2020) [https://perma.cc/Y2KZ-N3Y2];*Climate Deregulation Tracker*, SABIN CTR. FOR CLIMATE CHANGE L., COLUM. L. SCH., https://climate.law.columbia.edu/climate-deregulation-tracker (last visited Nov. 27, 2020) [https://perma.cc/MC6K-MWNS]; *see also* Nadja Popovich, Livia Albeck-Ripka, & Kendra Pierre-Louis, *The Trump Administration Is Reversing 100 Environmental Rules. Here's the Full List*, N.Y. TIMES (July 15, 2020), https://www.nytimes.com/interactive/2020/climate/trump-environment-rollbacks.html [https://perma.cc/35CH-AXYU] (counting sixty-eight completed rollbacks of environmental rules, and thirty-two rollbacks in progress); Coral Davenport, *Federal Agencies Told to Halt External Communications*, N.Y. TIMES (Jan. 25, 2017), https://www.nytimes.com/2017/01/25/us/politics/some-agencies-told-to-halt-communications-as-trump-administration-moves-in.html [https://perma.cc/9KSF-ZMUL].

28. Lisa Friedman, *In a Switch, Some Republicans Start Citing Climate Change as Driving Their Policies*, N.Y. TIMES (Apr. 30, 2019), https://www.nytimes.com/2019/04/30/climate/republicans-climate-change-policies.html [https://perma.cc/8GJT-GVPB].

29. *Id.*; John Barasso, *Cut Carbon Through Innovation, Not Regulation*, N.Y. TIMES (Dec. 18, 2018), https://www.nytimes.com/2018/12/18/opinion/climate-carbon-tax-innovation.html [https://perma.cc/R56G-B7ZM].

30. Barasso, *supra* note 29. *But see* Tracey Tully, *With 130-Mile Coast, New Jersey Marks a First in Climate Change Fight*, N.Y. TIMES (Jan. 27, 2020), https://www.nytimes.com/2020/01/27/nyregion/climate-change-nj-environmental-rules.html? [https://perma.cc/U3RX-K7M2] (discussing a widening effort by states to use regulations to address worsening climate conditions).

31. ENVTL. ANALYSIS & COMM. GROUP, BLOUSTEIN SCH. OF PLAN. & PUB. POL'Y & THE RUTGERS CLIMATE INST., AN OVERVIEW OF STATE COASTAL ZONE MANAGEMENT POLICIES DESIGNED TO PROMOTE COASTAL RESILIENCE 23–80 (2019), https://climatechange.rutgers.edu/images/Coastal_Resilience_3-19-19.pdf [https://perma.cc/US2U-6PK8] (surveying the individual states that have integrated science-informed sea-level rise values into land use policy, as compared to states that have not integrated science-informed sea-level rise values into land use policy); Tully, *supra* note 30.

32. Paris Agreement, *supra* note 3, 16 T.I.A.S. at 7–8, 14.

33. *See* Paris Agreement, *supra* note 3, 16 T.I.A.S. at 14 ("Parties share a long-term vision on the importance of fully realizing technology development and transfer in order to improve resilience to climate change and to reduce greenhouse gas emissions.").

Change contemplated using private funding of technology development and creating intellectual property rights to develop new technologies.[34]

B. Climate Change Mitigation Technologies

Many industries, not just those in renewable energy production, have the potential to innovate for climate change mitigation. For example, a U.S. study identified hundreds of technologies in various categories such as transportation, energy supply, carbon capture-storage, greenhouse gas mitigation, and monitoring capabilities.[35] To capture the various technologies that may affect climate change, worldwide patent offices that follow the Cooperative Patent Classification ("CPC") system group multiple technologies under the Y02 label for climate change technologies.[36] Notably, the subclasses underneath Y02 covers technologies related to adaptation, buildings, carbon capture and storage, information and communication, energy generation, production and process of goods, transportation, and wastewater treatment or waste management.[37] Countries emphasize different technical areas.[38] In determining whether a patent application was related to climate change or not, this Note draws exclusively from the set of patent applications underneath the "Y02" label.[39]

C. Global and Comparative Progress on Paris Agreement Goals

Despite the Paris Agreement's lofty rhetoric,[40] very few countries are on track to meet the announced goal of limiting heating to 1.5° or 2°C.[41] A fossil-fuel-free world most likely will not materialize in our lifetimes.[42] The International Energy Agency does not predict world oil demand or production will peak before 2040, due to the needs of transportation technology, heating, and other

34. Joshua D. Sarnoff, *The Patent System and Climate Change*, 16 VA. J.L. & TECH. 301, 303, 311 (2011).

35. Thomas L. Brewer, *Technology Transfers and Climate Change: International Flows, Barriers, and Frameworks*, 2008/2009 BROOKINGS TRADE F. 93, 94–97; Sarnoff, *supra* note 34, at 306, 311.

36. *See, e.g.*, *Y02W, Cooperative Patent Classification*, U.S. PATENT & TRADEMARK OFF. (Aug. 2020), https://www.cooperativepatentclassification.org/cpc/scheme/Y/scheme-Y02W.pdf [https://perma.cc/2JEF-9VGX] (labeling Y02 as Technologies or Applications for Mitigation or Adaptation Against Climate Change).

37. *CPC Section Y*, U.S. PATENT & TRADEMARK OFF.: CLASSIFICATION RESOURCES, https://www.uspto.gov/web/patents/classification/cpc/html/cpc-Y.html (last visited Nov. 27, 2020) [https://perma.cc/C44U-U6X4] (listing the Y02 classifications and their subclasses in various technological fields).

38. Larry Cady, *The Global Patent Landscape for Climate Change Related Patents*, IFI CLAIMS PATENT SERVICES: BLOG (Oct. 7, 2019, 12:01 PM), https://www.ificlaims.com/news/view/blog-posts/the-global-patent.htm [https://perma.cc/TZ8A-ZSXR].

39. *See* discussion *infra* Section III.C.

40. *See* Paris Agreement, *supra* note 3, 16 T.I.A.S. at 1 ("Recognizing the need for an effective and progressive response to the urgent threat of climate change on the basis of the best available scientific knowledge.").

41. *See infra* text accompanying notes 54–64.

42. Leslie Norton, *A World Without Fossil Fuels Is Approaching. But You Might Not Live Long Enough to See It*, BARRON'S (Sept. 20, 2019, 6:16 PM), https://www.barrons.com/articles/a-world-without-fossil-fuels-is-approaching-but-you-may-not-live-long-enough-to-see-it-51569017801 [https://perma.cc/GG4J-9PS8]. The COVID-19 pandemic sparked country-wide shutdowns which sharply reduced travel and emissions, but as countries and states reopened, emissions have also risen. Brad Plumer & Nadja Popovich, *Emissions Are Surging Back as Countries and States Reopen*, N.Y. TIMES (June 17, 2020), https://www.nytimes.com/interactive/2020/06/17/climate/virus-emissions-reopening.html [https://perma.cc/ULY7-YJM2].

costs.[43] To be sure, countries have enacted progressive climate laws and policies across the globe.[44] Yet, no major polluter is on track to meet its obligations, as shown below by the Climate Action Tracker.[45]

The Climate Action Tracker is an independent scientific analysis that tracks government climate action and measures it against the Paris Agreement goals.[46] It measures all of the large emitters and a representative sample of smaller emitters to cover 80% of global emissions.[47] Specifically, the Climate Action Tracker assesses and rates each country's Nationally Determined Contribution ("NDC") to the global response to climate change, pledges and long-term targets, and current policies against that country's estimated contributions to greenhouse gas emissions.[48] A rating of "1.5°C Paris Agreement Compatible" indicates that the government's efforts are in line with the 1.5°C Paris Agreement limit.[49] A rating of "2°C Compatible" is consistent with the 2009 Copenhagen 2°C goal, but not fully consistent with the most stringent Paris Agreement goal.[50] A rating of "Insufficient" is within the Paris-determined "fair share range" but is not consistent with holding warming below 2°C. "If all government NDCs were in this range, then warming would reach over 2°C and up to 3°C."[51] A rating of "Highly Insufficient" is outside the fair share range and inconsistent with either Paris Agreement goal. "If all government NDCs were in this range, warming would reach between 3°C and 4°C."[52] A rating of "Critically Insufficient" indicates that "[i]f all government NDCs were in this range, warming would exceed 4°C."[53]

Most of the major polluters are not on track to meet their obligations. The Climate Action Tracker ranks the EU as "Insufficient" and China as "Highly Insufficient."[54] India, however, is "2°C Compatible," and is thus on track to stay

43. *See* INT'L ENERGY AGENCY, WORLD ENERGY OUTLOOK 2018: REDUCING EMISSIONS FROM OIL AND GAS OPERATIONS (2018), https://www.iea.org/reports/world-energy-outlook-2018/oil-and-gas-innovation#abstract [https://perma.cc/CZM2-LCSV].

44. *See generally* IPCC SIXTH ASSESSMENT REPORT, *supra* note 22.

45. *See Countries*, CLIMATE ACTION TRACKER, https://climateactiontracker.org/countries/ [https://perma.cc/7S5C-9VKC] (last updated July 2020) (showing that most countries in the developed world are Insufficient or less).

46. *About*, CLIMATE ACTION TRACKER, https://climateactiontracker.org/about/ (last visited Nov. 27, 2020) [https://perma.cc/2HAF-65XC] ("The Climate Action Tracker is an independent scientific analysis that tracks government climate action and measures it against the globally agreed Paris Agreement aim of 'holding warming well below 2°C, and pursuing efforts to limit warming to 1.5°C.'").

47. *Id.* ("CAT covers all the biggest emitters and a representative sample of smaller emitters covering about 80% of global emissions and approximately 70% of global population.").

48. *Id.* ("The Climate Action Tracker assesses the total global effort of NDCs, pledges and current policies on . . . .").

49. *Rating System*, CLIMATE ACTION TRACKER, https://climateactiontracker.org/countries/rating-system/ (last visited Nov. 27, 2020) [https://perma.cc/PAA9-UF9W].

50. *Id.*

51. *Id.*

52. *Id.*

53. *Id.*

54. *See Countries*, *supra* note 45.

within the 2°C limit but not the 1.5° limit.[55] Predictably, the Climate Action Tracker ranked the U.S. as "Critically Insufficient."[56]

More specifically, the EU is reducing emissions, though not at a rate sufficient to meet the goals of the Paris Agreement.[57] China's fossil fuel consumption rose in 2018, and to comply with the Agreement, the country must overhaul its recalcitrant power sector to triple its share of non-fossil fuels.[58] It has, however, opened *new* fossil fuel plants.[59] India presents more hope in achieving its targets with currently implemented policies.[60] If it abandons new coal-fired power plants, India could reach the more stringent 1.5°C goals.[61] The U.S. is doing particularly poorly, having weakened the Clean Power Plan, proposed freezing vehicle efficiency standards after 2020, ignored regulations to limit HFC emissions, and allowed methane leaks from oil and gas production in 2018 by reducing the amount of methane required to be captured at drilling locations and relaxing measures on well completions and leak detection.[62] If the U.S. follows its current path, it will *increase* the average temperature by 3–4°C.[63] Not to mention, the U.S. already announced a withdrawal from the Paris Climate Agreement.[64]

D. Leaving the Paris Climate Agreement

The U.S. federal government is visibly ignoring the Paris Agreement targets.[65] On June 1, 2017, President Donald Trump announced that the U.S. would cease all participation in the 2015 Paris Agreement, leaving by November 5, 2020.[66] This step was no surprise as Trump made the promise to withdraw during his presidential campaign.[67] On November 4, 2019, the U.S. filed the official paperwork, pushing up the date to November 4, 2020.[68]

55. *India*, CLIMATE ACTION TRACKER, https://climateactiontracker.org/countries/india/ [https://perma.cc/Q9Q9-LZJ2] (last updated Dec. 2, 2019).

56. *See Countries*, *supra* note 45.

57. *EU*, CLIMATE ACTION TRACKER, https://climateactiontracker.org/countries/eu/ [https://perma.cc/LKX8-AHEL] (last updated Dec. 2, 2019).

58. Marlowe Hood, *Can China Keep Its Climate Promises?*, PHYSORG (Mar. 26, 2019), https://phys.org/news/2019-03-china-climate.html [https://perma.cc/4ZBK-YAAK].

59. *China*, CLIMATE ACTION TRACKER, https://climateactiontracker.org/countries/china/ [https://perma.cc/25M9-Y26N] (last updated Dec. 2, 2019).

60. *See India*, *supra* note 55.

61. *Id.*

62. *See USA*, *supra* note 8. *But see* Timothy Gardner, *Federal Judge Blocks Trump Administration's Easing of Rule on Methane Emissions*, REUTERS: ENV'T (July 16, 2020, 8:31 AM), https://www.reuters.com/article/us-usa-methane-judge/federal-judge-blocks-trump-administrations-easing-of-rule-on-methane-emissions-idUSKCN24H1YG [https://perma.cc/824U-7UE6] (noting that the Northern District of California blocked the easing of this rule).

63. *USA, supra* note 8.

64. *Paris Climate Deal: Trump Pulls US Out of 2015 Accord*, *supra* note 5.

65. *See id.*

66. *Id.*

67. *Id.* ("Mr[.] Trump said during last year's presidential election campaign that he would take the step to help his country's oil and coal industries.").

68. Secretary Pompeo (@SecPompeo), TWITTER (Nov. 4, 2019, 2:41 PM), https://twitter.com/SecPompeo/status/1191455541052289024?ref_src=twsrc%5Etfw [https://perma.cc/5ZAW-V735] ("Today we begin the formal process of withdrawing from the Paris Agreement.").

States, however, have banded together to comply with the Paris Agreement.[69] They formed the United States Climate Alliance the same day the U.S. announced its withdrawal.[70] Other states entered the Regional Greenhouse Gas Initiative, a nine-state carbon trading network.[71] Other states have incrementally implemented carbon prices to comply with the Paris Agreement.[72] And, on April 13, 2020, Virginia passed the Virginia Clean Economy Act into law, embarking on a clean-energy transition, aiming for 100% renewable energy by 2050.[73] Even specific cities have banded together in this manner, such as under the Climate Mayors initiative.[74]

It is debatable whether this state-level action signals that the U.S. is open to climate-change technology.[75] A report by Fulfilling America's Pledge argues that "real economy actors," such as states, cities, and businesses are already leading the U.S. towards a low-carbon future.[76] At the time of the report, "[c]urrent federal and real economy commitments, combined with market forces, [would] drive U.S. emissions to 17 percent below 2005 levels by 2025, roughly two-thirds of the way to the original U.S. target."[77] These real economic actors are assumed to represent over half of the U.S. population and economy and over 35% of greenhouse gas emissions.[78] And the decentralized, bottom-up climate action that they have engaged in has already delivered results—in 2017, U.S. energy-related carbon dioxide fell to its lowest level in twenty-five years.[79] Similarly, a report by the Center for International Environmental Law identified that the oil,

69. New York Governor Cuomo, and California Governor Brown Announce Formation of United States Climate Alliance, *supra* note 7.

70. *Id.*

71. David Roberts, *Virginia Becomes the First State in the South to Target 100% Clean Power*, VOX (Apr. 13, 2020, 2:56 PM), https://www.vox.com/energy-and-environment/2020/3/12/21172836/virginia-renewable-energy-100-percent-clean [https://perma.cc/3M9L-JJL3].

72. *Carbon Pricing in Action*, CARBON PRICING LEADERSHIP COAL., https://www.carbonpricingleadership.org/who/ (last visited Nov. 27, 2020) [https://perma.cc/XEW9-L53T] (listing New Jersey, Virginia, Oregon, and New Mexico as examples of states implementing carbon pricing initiatives).

73. Roberts, *supra* note 71.

74. *See generally* BLOOMBERG PHILANTHROPIES, FULFILLING AMERICA'S PLEDGE: HOW STATES, CITIES, AND BUSINESSES ARE LEADING THE UNITED STATES TO A LOW-CARBON FUTURE (2018) [hereinafter BLOOMBERG PHILANTHROPIES REPORT].

75. *See* Johnson, *supra* note 6 ("But without harmony between cities, states, and the federal government, those piecemeal efforts will be less effective at stimulating large-scale investment in clean energy and nationwide retirement of dirty fuels, making it that much harder—and take that much longer—to make the kind of deep emissions cuts the U.N. now says are necessary to avoid the worst harms of climate change."); *see also* Paul Hockenos, *The Public Can Solve Climate Change If We Let It*, FOREIGN POL'Y (July 28, 2019, 3:21 AM), https://foreignpolicy.com/2019/07/28/the-public-can-solve-climate-change-if-we-let-it/ [https://perma.cc/R99V-TU8Z].

76. BLOOMBERG PHILANTHROPIES REPORT, *supra* note 74, at 9 ("Implementing the vision of the Paris Agreement calls for broad, rapid, and significant engagement across all parts of society in order to reap the benefits of a low-carbon, climate-resilient future fueled by clean jobs and economic growth. In the United States, cities, states, and businesses, and other real economy actors have embraced this future . . . .").

77. *Id.*

78. *Id*. at 14.

79. *Id.* at 17.

gas, and plastic industries are naturally declining and rely on government bailouts to stave off inevitable collapse.[80]

Even so, the U.S. as a whole is already behaving contrary to the Paris Agreement.[81] It is rolling back the Clean Power Plan,[82] loosening the cost-benefit analyses under the Clean Air Act,[83] refusing to enforce its environmental regulations,[84] and cutting Obama-era fuel emissions standards.[85] Furthermore, the U.S. has become the world's largest producer of crude oil and natural gas and has also increased natural gas exports by 53% in 2018.[86] Even as both the clean energy industry and the oil and gas industry suffer deep losses from the COVID-19 pandemic and resultant financial crisis, the U.S. government has funneled a large range of stimulus funds and relief from pollution regulations to the oil and gas industry,[87] while denying the clean energy industry any relief.[88]

Despite the states' enumerated actions towards combating climate change, the Climate Action Tracker is pessimistic about the U.S.' commitments.[89] While state action and commitments, if fully implemented, could bring emissions in line with the Paris Agreement commitment, the Paris Agreement commitment itself would be rated Insufficient by the Climate Action Tracker.[90] Overall, the U.S. is sending mixed signals, at best, about its climate market—and any positive signal was likely impaired by the U.S.' announced withdrawal from the Paris Agreement.

80. STEVEN FEIT & CARROLL MUFFETT, CTR. FOR INT'L ENV'T L., PANDEMIC CRISIS, SYSTEMIC DECLINE: WHY EXPLOITING THE COVID-19 CRISIS WILL NOT SAVE THE OIL, GAS, AND PLASTIC INDUSTRIES 1 (2020), https://www.ciel.org/wp-content/uploads/2020/04/Pandemic-Crisis-Systemic-Decline-April-2020.pdf [https://perma.cc/WHB4-42Z2].

81. *See USA*, *supra* note 8.

82. *See* Eric Lipton, *As Trump Dismantles Clean Air Rules, An Industry Lawyer Delivers for Ex-Clients*, N.Y. TIMES (Aug. 19, 2018), https://www.nytimes.com/2018/08/19/us/politics/epa-coal-emissions-standards-william-wehrum.html [https://perma.cc/UUR7-76VA] (illustrating how the EPA is rolling back the Clean Power Plan).

83. Popovich et al., *supra* note 42.

84. *Regulatory Rollback Tracker*, *supra* note 27; *Climate Deregulation Tracker*, *supra* note 27; *see also* Stephen Lee, *'Secret Science' Rule Could Limit EPA Virus Efforts, Carper Says*, BLOOMBERG L. (Mar. 25, 2020, 3:27 PM), https://news.bloomberglaw.com/environment-and-energy/secret-science-rule-could-limit-epa-virus-efforts-carper-says [https://perma.cc/LS4Z-DNXN].

85. The Safer Affordable Fuel-Efficient (SAFE) Vehicles Final Rule for Model Years 2021-2026 Passenger Cars and Light Trucks, 85 Fed. Reg. 24,174 (Apr. 30, 2020) (to be codified at 40 C.F.R. pt. 86, 600).

86. *USA*, *supra* note 8 ("[The United States] is also the world's largest producer of natural gas, and increased LNG exports by 53% in 2018.").

87. David Roberts, *Coronavirus Stimulus Money Will Be Wasted on Fossil Fuels*, VOX (June 29, 2020, 3:29 PM), https://www.vox.com/2020/4/20/21224659/coronavirus-stimulus-money-oil-prices-fossil-fuels-bailout [https://perma.cc/9FXP-TGHN].

88. David Roberts, *As Trump and McConnell Mock Clean Energy, The Industry Could Soon Lose A Half-Million Jobs*, VOX (Apr. 16, 2020, 9:00 AM), https://www.vox.com/energy-and-environment/2020/4/16/21220312/coronavirus-stimulus-renewable-energy-democrats [https://perma.cc/JG8T-UC9T].

89. *USA*, *supra* note 8 ("To meet its NDC target, the United States would have had to implement the Obama Administration's Climate Action Plan, or equivalent measures. Current US policies are only projected to reduce emissions to 11–13% below 2005 levels (excl. LULUCF) by 2025.").

90. *Id.* ("The US is within striking distance of the upper end of its 2020 target, with emissions projections for 2020 just 2–3% higher than the target.").

E. Effect of Withdrawal

The announced withdrawal from the Paris Agreement has posed visible environmental and geopolitical effects.[91] It may also have exacerbated market and innovation effects.[92]

1. Environmental and Geopolitical Effects

Public outcry has focused largely on environmental and geopolitical effects.[93] Most obviously, one of the world's leading polluters signaling an intent to break the rules, and continue to lean further into fossil emissions, does not bode well for the goal of reducing greenhouse gas emissions.[94] Indeed, after the U.S. announced its withdrawal, the predicted increase in global temperature by 2100, initially estimated at 3.3°C, elevated to 3.6°C.[95] On a geopolitical scale, this move damages the U.S.' reputational standing.[96] Its allies and competitors are proceeding ahead without the U.S.' influence.[97]

Furthermore, the Paris Climate Agreement itself may not survive the next decade.[98] As Professor Sachs notes, the Paris Climate Agreement may face either a "breakdown scenario" as countries ignore the voluntary pledges, or a "breakup scenario," as countries follow the U.S.' example.[99] Conceivably, the U.S. might rejoin the Paris Agreement should a Democrat be elected President on November 4, 2020.[100] Yet the U.S. will have demonstrated that it puts its domestic politics over an international climate agreement. This could encourage other countries to similarly place their domestic politics over a climate change agreement.

The environmental and geopolitical consequences are already severe for the global community, but there may be market and innovation consequences as

91. *See infra* Section III.E.1.

92. *See infra* Section III.E.2.

93. *See, e.g.*, *Paris Climate Deal: Trump Pulls US Out of 2015 Accord*, *supra* note 5.

94. *See* Secretary Pompeo, *supra* note 68 ("Today we begin the formal process of withdrawing from the Paris Agreement.").

95. *USA*, *supra* note 8 ("[G]iven the Trump Administration's decision to withdraw from the Paris Agreement, which nullifies the target, we rate the US 'Critically Insufficient.'").

96. Matt McGrath, *Five Effects of US Pullout from Paris Climate Deal*, BBC NEWS: SCI. & ENV'T (June 1, 2017), https://www.bbc.com/news/science-environment-40120770 [https://perma.cc/E2JA-NQE9] ("There's also a question of moral leadership, which the US will be giving up, which may have consequences for other diplomatic efforts."); *see also* Paul Adams, *Is Trump Abandoning US Global Leadership?*, BBC NEWS: US & CAN. (June 1, 2017), https://www.bbc.com/news/world-us-canada-40127896 [https://perma.cc/X377-EGZA] (showing that Germany and the European Union are moving without United States support, and that China is attempting to step into the leadership vacuum).

97. *See* Adams, *supra* note 96. ("But there are signs that [President Trump's] muscular approach, while popular among supporters at home, has already caused a shift in the tectonic plates of the global world order.").

98. *See generally* Noah M. Sachs, *The Paris Agreement in the 2020s: Breakdown or Breakup?*, 46 ECOLOGY L.Q. 865, 899–900, 909 (2019).

99. *Id.* at 869.

100. David Roberts, *Joe Biden Has a Chance to Make History on Climate Change*, VOX (July 14, 2020, 2:28 PM), https://www.vox.com/2020/5/28/21265416/joe-biden-climate-change-democrats-young-voters [https://perma.cc/X97R-EV76]; Umair Irfan, *A Guide to How 2020 Democrats Plan to Fight Climate Change*, VOX (Dec. 19, 2019 1:59 PM), https://www.vox.com/2019/9/10/20851109/2020-democrats-climate-change-plan-president [https://perma.cc/CSV9-HFNH].

well. Some have worried that innovation and patent application filings in the U.S. would decline after the withdrawal announcement.[101] Given the Paris Agreement's and preceding agreements' reliance on innovation and markets, as outlined above in Section II.A, a decline in innovation could be harsh.

2. Market and Innovation Effects

Anecdotal evidence shows mixed support regarding the U.S.' market for U.S. climate technology.[102] Large companies are performing well in the climate technology market.[103] The American companies most reliant on embracing green technology are outperforming every broad measure of the stock market, having delivered a greater return last year than all but two of the world's ninety-four leading equity indexes.[104] Yet, start-ups implementing climate technology have had trouble attracting funds from groups such as the Silicon Valley venture capital community.[105] Total funding for clean-tech start-ups fell during most of the past decade.[106] In 2018, clean-tech start-ups received $6.6 billion—15% of what software start-ups received.[107] Many venture capital funds invested in solar and other renewable energy ten to fifteen years ago and lost money.[108] Venture capitalists' previous models of investment depended on government subsidies to make the businesses work, but these subsidies were fickle and dependent on the political climate.[109]

Even if the inventors earn a patent on their technology, private investors still face real financial risks in investing in climate technology. In particular, climate technology may be difficult to deploy quickly.[110] For example, much of the research efforts in the 1990s and 2000s into wind and solar power bore fruit only

101. *See, e.g.*, *Green Tech IP After Withdrawal from the Paris Climate Agreement*, *supra* note 10.

102. *See infra* text accompanying notes 103–09.

103. *See* Matthew A. Winkler, *Investors Are Learning That Clean Tech Pays*, BLOOMBERG: OP. (Jan. 13, 2020, 5:00 AM), https://www.bloomberg.com/amp/opinion/articles/2020-01-13/tech-companies-fighting-climate-change-outperform-stock-market [https://perma.cc/QS9T-2B2M].

104. *Id.*

105. *With All of Silicon Valley's Startup Money, Where's the Investment in Climate Tech?*, MARKETPLACE TECH (Sept. 17, 2019), https://www.marketplace.org/shows/marketplace-tech/with-all-of-silicon-valleys-startup-money-wheres-the-investment-in-climate-tech/ [https://perma.cc/XQ25-UR7K].

106. Nathaniel Popper, *Start-Ups Hoping to Fight Climate Change Struggle as Other Tech Firms Cash In*, N.Y. TIMES: BUS. (May 7, 2019), https://www.nytimes.com/2019/05/07/business/carbon-removal-technology-start-ups.html [https://perma.cc/PZ7Z-LYVA] ("Total funding for clean-tech start-ups fell during most of the past decade . . . .").

107. *Id.* ("In 2018, $6.6 billion was invested in clean tech, about 15 percent of what went to software start-ups.").

108. *With All of Silicon Valley's Startup Money, Where's the Investment in Climate Tech?*, *supra* note 105 ("A lot of [venture capital funds] invested heavily in solar and other renewable energy 10 or 15 years ago, and lost a lot of money when many of those companies went under.").

109. *Id.* ("I think a lot of the old models, unfortunately, assumed or depended on government subsidies to make the businesses work, and given how fickle those are with political climates, there was a lot of heartache when those things went away . . . .").

110. Alex Rau, Rob Toker & Joanne Howard, *Can Technology Really Save Us from Climate Change?*, HARV. BUS. REV.: INTELL. PROP., Jan.–Feb. 2010, at 21, 21 ("Even if energy innovations have a lot of potential, they might not be deployable until it's too late.").

in the 2010s.[111] Other clean technologies have taken nineteen to thirty years to achieve wide use.[112] Some sectors of climate technology deployment tend to skyrocket only a few years after a steep increase in patenting.[113] Given that climate patent applications have declined globally after 2012, scholars have raised concerns about technology development and deployment in future years.[114]

Even if the climate technology is quickly deployable, it faces barriers in the marketplace: potential clients take on high risks when they rely on emerging technology, and take on high costs when switching over existing equipment to more "green" technology.[115] Carbon capture and sequestration serve as an example; no one has found an easy way to turn captured carbon dioxide into a profitable business yet.[116] These risks are most likely why private investors such as Daniel Oros and Klaus Lackner believe that the climate technology industry will not take off without supportive government policy, such as a carbon tax or other subsidies.[117]

Even research universities with large budgets and technology transfer offices face these barriers.[118] These offices are charged with commercializing faculty's inventions, by securing patents, negotiating license agreements, and funding start-ups.[119] Even after obtaining a patent, however, these offices regularly navigate further barriers to commercialization, including financial risk, lack of investors, lack of industry partners, ineffective commercialization infrastructure, and unsupportive university and federal policies.[120]

The federal government does not appear committed to supporting climate change technology. Currently, federal financial support for renewable energy,

111. *See* Cárdenas Rodríguez et al., *supra* note 16.

112. Rau et al., *supra* note 110, at 21. ("In the past, they have taken 19 to 30 years to achieve wide use, say researchers at the UK think tank Chatham House and the patent-search firm CambridgeIP.").

113. *Id.* at 22 ("In certain sectors, at least, deployment tends to skyrocket a few years after a steep increase in patenting.").

114. Cárdenas Rodríguez et al., *supra* note 16.

115. Rau et al., *supra* note 110, at 21 ("Entrepreneurs scrounge for capital, investors struggle to manage the risks of emerging technologies, patents get bought and sold but not necessarily used, and incumbent energy giants hesitate to give up their existing equipment.").

116. Popper, *supra* note 106 (detailing the lack of financial support for carbon-capture technologies).

117. *Id.* (explaining how Oros did not see a way for the industry to take off without government policy encouraging it, and how Lackner said that the government would need to create a carbon tax or other subsidies as incentives for new businesses).

118. *See infra* text accompanying 119–20.

119. Nathan L. Vanderford & Elizabeth Marcinkowski, *A Case Study of the Impediments to the Commercialization of Research at the University of Kentucky*, F1000RESEARCH (Sept. 11, 2015), https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4566417/ [https://perma.cc/L9F6-3NXX] ("The University of Kentucky commercializes its research through the Intellectual Property Development and Technology Transfer Office, a unit of the Office of the Vice President for Research.").

120. *Id.* ("Previous studies at academic institutions have documented challenges to the commercialization process that include . . . risk aversion; constraints on faculty time; lack of financial support; policy/regulation barriers; infrastructure insufficiencies; lack of a common understanding of the value of research commercialization; lack of entrepreneurial thinking among faculty; and lack of interaction and collaboration between universities and industry.").

while still in the billions, is decreasing.[121] Federal subsidies for renewable energy—including biofuels for transportation use and renewable generation of electricity—dropped to $6.7 billion in fiscal year ("FY") 2016, a 56% decline from FY 2013.[122]

Conversely, in 2019, the U.S. directly subsidized fossil fuel research to the tune of $20 billion a year.[123] The Environmental and Energy Study Institute provides a list of currently extant fossil fuel subsidies.[124] In 2019, Congress appropriated $740 million for Fossil Energy Research and Development with continued emphasis on coal-power.[125] It is unclear whether the federal government's financial favor towards fossil fuels has by itself increased greenhouse gas emissions,[126] but this financial emphasis on fossil fuels does show less innovative support for renewable energy. As discussed below, an inventor may see barriers to commercializing climate technology in the U.S., which may dissuade that inventor from seeking patent protection in the U.S.[127]

F. The U.S. Patent System and Abroad

This Section provides background on domestic and international patent law to clarify the methodology of the upcoming experiments and to provide background on key terms and concerns.

1. Justifications for Patent Law

The U.S. patent system was built to promote innovation.[128] It is largely focused on utilitarian grounds—to promote the progress of science.[129] The dominant narrative of the patent system is that it provides an incentive to invent; an inventor is likely to put the work into completing an invention and selling it only

121. Steve Hanson & Fred Mayes, *Renewable Energy Subsidies Have Declined as Tax Credits, Other Policies Diminish*, U.S. ENERGY INFO. ADMIN.: TODAY IN ENERGY (Apr. 26, 2018), https://www.eia.gov/todayinenergy/detail.php?id=35952 [https://perma.cc/8H27-XYDR].

122. *Id.*

123. Clayton Coleman & Emma Dietz, *Fact Sheet: Fossil Fuel Subsidies: A Closer Look at Tax Breaks and Societal Costs*, ENV'T. & ENERGY STUDY INST. (July 29, 2019), https://www.eesi.org/papers/view/fact-sheet-fossil-fuel-subsidies-a-closer-look-at-tax-breaks-and-societal-costs [https://perma.cc/84SS-XFZZ] ("Conservative estimates put U.S. direct subsidies to the fossil fuel industry at roughly $20 billion per year; with 20 percent currently allocated to coal and 80 percent to natural gas and crude oil.").

124. *See generally id.*

125. *Id.*

126. Jessica Jewell et al., *Limited Emission Reductions from Fuel Subsidy Removal Except in Energy-Exporting Regions*, 554 NATURE 229, 229 (2018) ("Here we show that removing fossil fuel subsidies would have an unexpectedly small impact on global energy demand and carbon dioxide emissions . . . .").

127. *See infra* Section III.A.1.

128. *See infra* notes 129–30.

129. U.S. CONST. art. I, § 8, cl. 8 ("To promote the Progress of Science and useful Arts, by securing for limited Times to Authors and Inventors the exclusive Right to their respective Writings and Discoveries.").

if he or she can recoup the opportunity cost of the work involved.[130] The patent system has other theoretical benefits.[131]

The empirical case for the patent system itself, however, is unsound. Fritz Machlup famously argued to the Senate Judiciary in 1958 that "[i]f we did not have a patent system, it would be irresponsible . . . to recommend instituting one. But since we have had a patent system for a long time, it would be irresponsible . . . to recommend abolishing it."[132] Whether a patent helps bring new inventions to public markets is also a matter of debate. At least in some industries, patents appear to be a necessary, but not sufficient, condition to commercialize inventions.[133] And in other industries, the disclosure and filing costs of the patent application may drive inventors towards trade secrecy.[134]

2. Anatomy of the Patent System

In the patent prosecution system, when an inventor applies for a patent, the inventor is seeking exclusive rights to prevent others from practicing the invention.[135] These exclusive rights are detailed in patent claims that particularly point out and distinctly claim the subject matter that the inventor regards as the invention.[136] A claim may be either a dependent or independent claim. A claim is a dependent claim if it incorporates by reference all the limitations of another claim to which it refers.[137] A claim is independent if it does not refer to any other claim.[138]

130. *See, e.g.*, Dan L. Burk & Mark A. Lemley, *Policy Levers in Patent Law*, 89 VA. L. REV. 1575, 1580, 1584 (2003).

131. *See, e.g.*, Edmund W. Kitch, *The Nature and Function of the Patent System*, 20 J.L. & ECON. 265, 276 (1977) (arguing that patents efficiently coordinate research by multiple parties by walling off different inventive prospects from each other to avoid duplicate research into the same prospects); *see generally* Paul J. Heald, *A Transaction Costs Theory of Patent Law*, 66 OHIO ST. L.J. 473 (2005) (arguing that patents reduce transaction costs in licensing by clarifying the scope of invention protected.); Clarissa Long, *Patent Signals*, 69 U. CHI. L. REV. 625 (2002) (arguing that patents signal an inventor's or a firm's proclivity to invent).

132. S. REP. NO. 85–15, at 80 (1958).

133. *See* Elizabeth Webster & Paul H. Jensen, *Do Patents Matter for Commercialization?*, 54 J.L. & ECON. 431, 432 (2011); Ted Sichelman, *Commercializing Patents*, 62 STAN. L. REV. 341, 362–63 (2010); Cárdenas Rodríguez et al., *supra* note 16.

134. Scholars have shown that inventors and firms have historically turned to trade secrecy as an alternative to patenting when these costs grew too high. *See, e.g.*, Petra Moser, *How Do Patent Laws Influence Innovation? Evidence from Nineteenth-Century World's Fairs*, 95 AM. ECON. REV. 1214, 1214 (2005).

135. 35 U.S.C. § 271(a) ("[W]hoever without authority makes, uses, offers to sell, or sells any patented invention, within the United States or imports into the United States any patented invention during the term of the patent therefor, infringes the patent.").

136. 35 U.S.C. § 112(b) ("The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the inventor or a joint inventor regards as the invention.").

137. § 112(c) ("A claim may be written in independent or, if the nature of the case admits, in dependent or multiple dependent form."); *id.* § 112(d) ("A claim in dependent form shall be construed to incorporate by reference all the limitations of the claim to which it refers.").

138. § 112(d).

After the inventor applies for the patent, a patent examiner will determine whether the inventor's claims cover only inventions that are patent-eligible subject matter,[139] novel to a single prior disclosure,[140] or non-obvious to multiple prior disclosures.[141] The examiner and the inventor will negotiate over the scope of the claims in a series of Office Actions and Office Action Responses.[142] If the examiner allows the patent claims, then the inventor will, after paying a fee, gain the right to exclude others from making, using, selling, or importing the invention, as set out within the claims, within the U.S.[143]

In addition, patent applications are intended to share the new invention in enough detail for others to learn it—to advance the progress of science.[144] To accomplish this, the inventor must disclose the invention so that a person of ordinary skill in the art could practice the invention without undue experimentation, and disclose a best method of practicing it.[145] The inventor does not need to disclose a working product.[146] In the U.S., these patent applications are typically published eighteen months after their earliest filing date.[147]

As discussed below in Section III.D.3, the inventor can, and often does, file multiple patent applications on a single invention.[148] The inventor may file a provisional patent application, which is not examined nor published but maintains the filing date of that application for any future application filed within a year.[149] The inventor can then file a patent application claiming the filing date of that provisional patent application.[150] Next, the inventor may file continuation applications that claim the provisional application filing date in response to examiner rejections.[151] This Note focuses on the application date and the priority date because they both have relevance in the decision to file a patent application or to continue seeking a patent application in the U.S.[152]

139. 35 U.S.C. §§ 102–103.

140. 35 U.S.C. § 102.

141. 35 U.S.C. § 103.

142. 37 C.F.R. § 1.104(a)–(c) (2020).

143. 35 U.S.C. § 271(c) ("[W]hoever without authority makes, uses, offers to sell, or sells any patented invention, within the United States or imports into the United States any patented invention during the term of the patent therefor, infringes the patent.").

144. U.S. CONST. art. I, § 8, cl. 8 ("To promote the Progress of Science and useful Arts, by securing for limited Times to Authors and Inventors the exclusive Right to their respective Writings and Discoveries.").

145. 35 U.S.C. § 112(a) ("The specification . . . shall set forth the best mode contemplated by the inventor . . . of carrying out the invention.").

146. *Id.*

147. 35 U.S.C. § 122(b)(1)(A) ("Subject to paragraph (2), each application for a patent shall be published . . . promptly after the expiration of a period of 18 months from the earliest filing date for which a benefit is sought under this title.").

148. *See* discussion *infra* Section III.D.3.

149. 35 U.S.C. §111(b)(4); 35 U.S.C. § 119(e)(1) ("An application for patent filed under . . . section 111(b) . . . shall have the same effect . . . as though filed on the date of the provisional application filed under section 111(b), if the application for patent filed under section 111(a) or section 363 is filed not later than 12 months after the date on which the provisional application was filed and if it contains or is amended to contain a specific reference to the provisional application.").

150. § 111(b)(4).

151. 35 U.S.C. § 120.

152. *See* discussion *infra* Section III.D.3.

Internationally, countries who are members of the World Trade Organization ("WTO") must provide minimum standards of patent protection under the Agreement on Trade-Related Aspects of Intellectual Property Rights ("TRIPS Agreement"), including trade in counterfeit goods.[153] Article 27 of the TRIPS Agreement sets these minimum standards to *generally* track the U.S. patent system.[154] In addition, Article 4 of the TRIPS Agreement sets the most-favored-nation principle—that any advantage, favor, privilege, or immunity granted by a member of the WTO to the nationals of any other country shall be accorded immediately and unconditionally to the nationals of all other members.[155]

3. Fast-Track Programs

The U.S. and other countries have created "fast-track" programs to shorten the time between filing a patent application, examining it, and gaining an issued patent with its exclusionary rights.[156] Current acceleration schemes by the U.S. Patent and Trademark Office ("USPTO") include Track One Prioritized Examination ("Track One"),[157] Accelerated Examination,[158] and Patent Prosecution Highway ("PPH").[159] Track One prioritizes original utility or plant applications if the applicant pays a $4,000 fee and limits the patent application to thirty total claims.[160] Accelerated Examination advances an application out-of-turn if the applicant files a petition, pays a fee, conducts a prior art search, and limits the application to twenty total claims.[161] Under PPH, participating patent offices have agreed that when an applicant receives a final ruling from a first patent office that at least one claim is allowed, the applicant may request a fast-track examination of a corresponding claim(s) in a corresponding patent application pending in a second patent office.[162] In 2012, the U.S.' fast-track program reduced the time between application and granting a patent from 2.8 years to 1.6 years.[163]

153. Agreement on Trade-Related Aspects of Intellectual Property Rights, art. 27, Apr. 15, 1994, Marrakesh Agreement Establishing the World Trade Organization, Annex 1C, 1869 U.N.T.S. 299, 33 I.L.M. 1197 (1994) [hereinafter TRIPS Agreement].

154. *Id.*

155. *Id.* art. 4.

156. *See infra* notes 157–59.

157. *USPTO's Prioritized Patent Examination Program*, U.S. PAT. & TRADEMARK OFF., https://www.uspto.gov/patent/initiatives/usptos-prioritized-patent-examination-program (last visited Nov. 27, 2020) [https://perma.cc/6L4D-VGLD].

158. *Accelerated Examination*, U.S. PAT. & TRADEMARK OFF., https://www.uspto.gov/patent/initiatives/accelerated-examination (last visited Nov. 27, 2020) [https://perma.cc/2ZSX-MN77].

159. *Patent Prosecution Highway (PPH)–Fast Track Examination of Applications*, U.S. PAT. & TRADEMARK OFF., https://www.uspto.gov/patents-getting-started/international-protection/patent-prosecution-highway-pph-fast-track (last visited Nov. 27, 2020) [https://perma.cc/52SQ-VLMS].

160. *USPTO's Prioritized Patent Examination Program*, *supra* note 157.

161. *Guidelines for Applicants Under the Accelerated Examination Procedure*, U.S. PAT. & TRADEMARK OFF., https://www.uspto.gov/sites/default/files/documents/ae_guidelines_20160816.pdf (last visited Nov. 27, 2020) [https://perma.cc/V75Q-7RCB].

162. *Patent Prosecution Highway (PPH) –Fast Track Examination of Applications*, *supra* note 159.

163. ANTOINE DECHEZLEPRÊTRE, FAST-TRACKING GREEN PATENT APPLICATIONS: AN EMPIRICAL ANALYSIS 11 (2013).

Antonin Dechezleprêtre notes several theoretical advantages to a reduced examination process that grants issued patents at a faster rate.[164] This process allows patent applicants to start licensing their technologies sooner, thereby reducing the time to reach the market.[165] Possessing a granted patent may also help start-up companies to raise private capital.[166] Furthermore, Dechezleprêtre finds that in the period of his study, fast-tracked patent applications expanded the public domain by being cited in the patent examination process more often.[167] He does note, however, that these programs were only used for a small fraction of patent applications.[168]

4. Trends in Patent Law

Countries have modified their patent systems to accommodate the demand for green technology—mostly by providing fast-track programs targeted towards green technology.[169] The USPTO launched a Green Technology Pilot Program in November 2009, requiring an additional statement as to why the invention covers a "green technology."[170] This program closed in 2012 after receiving its 3,500th application.[171] But, as shown above in Section III.F.3, the USPTO now offers accelerated examinations across technology classes.[172] Other countries have similar programs.[173] For example, China's State Intellectual Property Office launched a fast-track program targeted at specific green technologies in August 2012.[174] Japan did so in November 2009.[175]

These programs, however, vary in what process restrictions inventors are subject to and what kinds of inventions are suitable.[176] For example, USPTO's existing accelerated examination program requires a petition, a costly pre-examination search report—where the applicant, not the examiner, researches prior art—and an examination support document.[177] In contrast, the Israeli fast-track initiative is limited to inventions within specified green classifications, and the burden to prove that an invention is within the specified green classification falls on the inventor.[178] Eric Lane argues that these variations make it costly and time-

164. *Id.* at 1.
165. *Id.*
166. *Id.*
167. *Id.* at viii.
168. *Id.* at vii.
169. *Id.* at 1.
170. *Id.* at 3–4.
171. *Id.* at 4.
172. *Id.*; *see also* discussion *supra* Section III.F.3.
173. DECHEZLEPRÊTRE, *supra* note 163, at 4.
174. *Id.*
175. *Id.* at 3.
176. Eric L. Lane, *Building the Global Green Patent Highway: A Proposal for International Harmonization of Green Technology Fast Track Programs*, 27 BERKELEY TECH. L.J. 1120, 1123 (2012).
177. *Id.* at 1159.
178. *Id.* at 1144.

consuming for applicants to take advantage of the green patent fast-track programs in multiple jurisdictions.[179] Globally, as of 2013, there was a low usage rate for these programs.[180] Even with these programs, climate patents globally have declined since 2012.[181]

U.S. patent applications per year have also declined from 2016, relative to other countries.[182] According to WIPO's annual IP report, the annual rate of U.S. patent applications declined from 2017–2018 by 1.6%, while China's annual patent applications increased by 11.6%.[183] Most of this decline likely stems from § 101 controversy, as explained below.[184]

35 U.S.C. § 101 requires that an invention be a machine, composition of matter, article of manufacture, or process to be patentable subject matter.[185] The common law, however, has extended § 101 rejections past the statute, reading in "judicially recognized exceptions" of not being "directed to a law of nature," a "natural phenomenon," or an "abstract idea."[186] Computer applications have been rejected as abstract under § 101.[187] Medical diagnostics applications have been rejected as directed towards a law of nature.[188] These court-made rules put "U.S. law in conflict with most of the rest of the world on the eligibility of computer-related inventions and software."[189] The suspicion and consensus are that this uncertainty has driven down the value of patent applications in these technological classes.[190] But, as Professor Chien shows, the effect of § 101 jurisprudence so far has not yet touched categories of patent applications other than business methods and medical diagnostics.[191]

III. ANALYSIS

This Part first sets forth why a relative decline in Y02 Climate patent applications in the U.S. compared to other countries matters. It then discusses the experimental set-up and the results. This Note finds that there is a relative decline between the U.S. Y02 climate patents and Y02 climate patents filed elsewhere,

179. *Id.* at 1123.

180. *See* DECHEZLEPRÊTRE, *supra* note 163, at 6.

181. Cárdenas Rodríguez et al., *supra* note 16.

182. WORLD INTELL. PROP. ORG., *supra* note 15, at 5.

183. *Id.* It is unclear whether WIPO measured the annual rates of *patent families* per country in a similar manner, though.

184. It is beyond the scope of this Note to lay out the full § 101 debate.

185. 35 U.S.C. § 101.

186. RANDALL R. RADER & BENJAMIN J. CHRISTOFF, PATENT LAW IN A NUTSHELL 64 (3d ed. 2018).

187. Alice Corp. Pty. Ltd. v. CLS Bank Int'l, 573 U.S. 208, 224–26 (2014).

188. Mayo Collaborative Servs. v. Prometheus Lab'ys, Inc., 566 U.S. 66, 76 (2012).

189. RADER & CHRISTOFF, *supra* note 186, at 67.

190. *See* WORLD INTELL. PROP. ORG., *supra* note 15, at 5.

191. *See* Colleen V. Chien & Jiun Ying Wu, *Decoding Patentable Subject Matter*, 2018 PATENTLY-O PAT. L.J. 10, 11, 15 (2018); James Cosgrove, *The Most Likely Art Units for Alice Rejections*, IPWATCHDOG (Dec. 14, 2015), https://www.ipwatchdog.com/2015/12/14/the-most-likely-art-units-for-alice-rejections/id=63829/ [https://perma.cc/ZMH6-F5JQ]. *But see* Am. Axle & Mfg., Inc. v. Neapco Holding LLC, 989 F.3d 1355, 1357–58, 1368 (Fed. Cir. 2019) (rejecting a claim on a method of manufacturing a physical object under § 101.).

even within the error range.[192] This relative decline is not statistically significant under traditional thresholds;[193] there is some probability that it is a false positive—to show up even without withdrawal from the Paris Agreement.[194] This difference, however, is not wholly explained by the overall U.S. patent decline and the overall non § 101 patent decline.[195]

A. Justifications

A relative decline in patent applications in the U.S. compared to other countries has various effects. First, it may cause a potential decline in commercialized climate products.[196] Second, it may signal inventors' disinterest in selling climate technology in the U.S.[197] Third, the relative decline would expand the climate technology public domain.[198]

1. Decline in Inventor-Commercialized Climate Products

One such effect of the decline in patent applications is a reduction in future climate change products. In some industries, patents are necessary, but not sufficient, for commercialization.[199] In particular, *not* having a patent decreases the probability of commercialization.[200] For instance, some scholars have found that being refused a patent reduced the probability of attempting commercialization by about 13%.[201]

Conversely, having a patent does not by itself guarantee commercialization.[202] Patent law only requires the *conception* of an invention, not a working product, to grant exclusivity.[203] As noted above, a patent disclosure needs only to contain a sufficient written description to enable a person of ordinary skill in the art to build the invention without undue experimentation.[204] It does not need a working product.[205] But as Professor Sichelman notes, the prototype or written

192. *See infra* Overview of Experimental Results.
193. *See infra* Overview of Experimental Results.
194. *See infra* Overview of Experimental Results.
195. *See infra* Section III.E.
196. *See infra* Section III.A.1.
197. *See infra* Section III.A.2.
198. *See infra* Section III.A.3.
199. Webster & Jensen, *supra* note 133, at 433; Sichelman, *supra* note 133, at 362; Cárdenas Rodríguez et al., *supra* note 16.
200. Webster & Jensen, *supra* note 133, at 433.
201. *Id.*
202. Sichelman, *supra* note 133, at 362.
203. MANUAL OF PAT. EXAMINING PROC. § 2138.04 (2020) [hereinafter MPEP] ("[T]he inventor must form a definite and permanent idea of the complete and operable invention to establish conception." (emphasis omitted)); Sichelman, *supra* note 133, at 349–50.
204. *See* 35 U.S.C. § 112(a); MPEP, *supra* note 203, § 2138.04; *see also* Sichelman, *supra* note 133, at 359–60.
205. *See* Sichelman, *supra* note 133, at 359.

description is not usually the most commercially viable embodiment—the commercializer often undertakes further scientific testing, market testing, market research, and marketing to determine how to commercialize the invention.[206]

This work between filing the patent application and putting the useful product on the market takes time.[207] Scholars have identified a long lag in practice between innovation and cost reductions in commercial products.[208] As previously discussed, much of the research efforts in the 1990s and 2000s into wind and solar power only yielded results in the 2010s.[209] Other clean technologies have taken nineteen to thirty years to achieve wide use.[210] Cárdenas Rodríguez et al. thus note that the evidence of declining climate patents after 2012 raises concerns about developments and cost-savings in future years.[211] Similarly, in certain sectors of climate technology, "deployment tends to skyrocket a few years after a steep increase in patenting."[212]

Further, in practice, technology transfer offices and companies mentioned above also navigate barriers to commercialization even after receiving a patent: financial risk, lack of investors, lack of industry partners, ineffective commercialization infrastructure, and unsupportive university and federal policies.[213] As noted in Section II.E.2, climate change startups face a lack of private investors. Silicon Valley venture capitalists, for example, are one group that refuses to invest in climate-change startups.[214] These investors and startups face financial risk and unsupportive federal policies, such as a regular repeal of environmental regulations, high but decreasing climate tech funding, and increasing fossil fuel technologies, as well as the Paris Withdrawal.[215]

Notably, large companies working on climate technologies that are not as reliant on external investors have performed well financially.[216] Moreover, inventors do not necessarily need to commercialize their inventions. Patents, even if not commercialized by the inventor, may be licensed out to large companies to commercialize in return for a royalty payment.[217] Arguably, these patents could avoid some of the barriers to commercialization listed above.[218] But by 2010, only 5% of issued patents were licensed for a royalty, proving many patented inventions face these barriers to commercialization.[219]

206. *Id.* at 360.
207. *See infra* text accompanying notes 208–13.
208. Cárdenas Rodríguez et al., *supra* note 16.
209. *Id.*
210. Rau et al., *supra* note 110, at 21.
211. Cárdenas Rodríguez et al., *supra* note 16.
212. Rau et al., *supra* note 110, at 22.
213. Vanderford & Marcinkowski, *supra* note 119.
214. *See* discussion *supra* Section II.E.2.
215. *See* discussion *supra* Section II.E.2.
216. Winkler, *supra* note 103; *see also* discussion *supra* Section II.E.2.
217. *E.g.*, Cynthia Dahl, *Intellectual Property: Commercializing in a University Setting*, ACAD. ENTREPRENEURSHIP FOR MED. AND HEALTH SCIENTISTS 3 (2019) (describing academic entrepreneur strategies for commercialization).
218. *See supra* text accompanying note 215.
219. Sichelman, *supra* note 133, at 363.

Overall, as mentioned earlier, a decline in patent applications may augur a decline in commercialized goods because patent applications may be necessary for commercialization. Additionally, a relative decline in U.S. climate patent applications compared to other countries now may augur a decline in future climate technology commercial products in the U.S. compared to other countries. This decline in commercialized goods in the U.S. may be aggravated by the barriers identified earlier. This decline may also particularly affect academic and start-up work. It may be mitigated, however, by another effect of this relative decline—the expansion of the public domain.

2. A Signal that Inventors Do Not View the U.S. as a Strong Market for Climate Technology Compared to Other Countries

An inventor faces several costs in pursuing a patent application. For instance, mandatory fees paid to the patent office can range between $5,000 to over $16,000.[220] The investor must also publicly disclose the invention with enough detail so that competitive inventors skilled in the art could practice it without undue experimentation.[221] This allows competitive inventors to copy an inventor's product if the invention does not ultimately earn a patent, and allows competitive inventors to "design-around" an inventor's disclosure to create a competitive product that was not disclosed or protected by the patent.[222] Reasonably, this inventor would only want to pursue patent protection if the inventor believes that the commercial profits from the patent's exclusionary rights would outweigh the patent application filing fees and the costs of disclosure.[223]

As noted in Part II, inventors have many reasons to believe the U.S. is not a profitable place to sell or manufacture climate change technologies.[224] Climate change technologies, particularly renewable energy, require high capital investment and long deployment time to adequately commercialize, and the inventor or funder bears the risk of that investment not working out.[225] There also are reasons private investors such as venture capitalists are "shy about climate tech."[226]

Additionally, the inventor may not be able to rely on climate change technology subsidies from the government in the future. First, compared to other countries, the U.S. is particularly reneging on its greenhouse gas mitigation obligations.[227] The Trump Administration has rolled back over fifty environmental

220. Gene Quinn, *The Cost of Obtaining a Patent in the US*, IPWATCHDOG (Apr. 4, 2015), https://www.ipwatchdog.com/2015/04/04/the-cost-of-obtaining-a-patent-in-the-us/id=56485 [https://perma.cc/6CQ6-ZYTH].

221. 35 U.S.C. § 112(a); MPEP, *supra* note 203, § 2138.04.

222. *See* Brian Moran & Benjamin Jensen, *Designing Around a Patent as an Alternative to a License*, IPWATCHDOG (July 30, 2019), https://www.ipwatchdog.com/2019/07/30/designing-around-patent-alternative-license/id=111683/ [https://perma.cc/3RVU-BUMP].

223. As noted earlier, inventors and firms have historically turned to trade secrecy as an alternative to patenting when the costs of disclosure grew too high. *See, e.g.,* Moser, *supra* note 134, at 1222.

224. *See* discussion *supra* Sections II.C–D.

225. Rau et al., *supra* note 110, at 22–23; Popper, *supra* note 106.

226. *With All of Silicon Valley's Startup Money, Where's the Investment in Climate Tech?*, *supra* note 105.

227. *USA*, *supra* note 8.

regulations[228] and has increased fossil fuel subsidies,[229] to the point that the Climate Action Tracker rates the U.S.' progress on the Paris Agreement goals as "Critically Insufficient."[230] Even though Senator Barasso (R-Wyoming) argues that innovation has proceeded apace, current state-wide plans to mitigate climate change have not relied on U.S. innovation, but rather on regulatory action.[231] Furthermore, the U.S. is withdrawing from the Paris Agreement.[232]

Inventors also know that most other countries are doing more than the U.S. to combat climate change.[233] On a broad level, the Climate Action Tracker has rated only the U.S. as "Critically Insufficient;" every other country is "Insufficient" or better.[234] Other countries' behaviors could thus signal a relative openness to climate change technology.[235] An inventor could look abroad to China or the European Union, for instance, to see plenty of government funding available for the climate change innovation. China has a carbon market and a "Clean Development Mechanism."[236] The European Union has an Innovation Fund.[237] India, too, has a plethora of climate programs.[238] Of course, the outlook is not entirely sunny—Japan, for instance, has doubled down on fossil fuel consumption.[239]

True, an inventor may seek a patent application in the U.S., anticipating that conditions in the future would make commercialization more feasible.[240] For example, the U.S. may elect a President promising to enact ambitious climate policies.[241] But that inventor would know that should the inventor gain a patent too early, the invention would be disclosed to competitors before the market was profitable, and would still be paying issuance and maintenance costs before and until said President is elected.[242]

228. *Regulatory Rollback Tracker*, *supra* note 27; *Climate Deregulation Tracker*, *supra* note 27.

229. Hanson & Mayes, *supra* note 121; Coleman & Dietz, *supra* note 123.

230. *Countries*, *supra* note 45.

231. Barasso, *supra* note 29. *But see* Tully, *supra* note 30.

232. Press Release, White House, President Trump Announces U.S. Withdrawal from the Paris Climate Accord (June 1, 2017), https://www.whitehouse.gov/articles/president-trump-announces-u-s-withdrawal-paris-climate-accord/ [https://perma.cc/HA8U-768Q].

233. *See supra* Section II.C.

234. *See supra* Section II.C.

235. *See supra* Section II.C.

236. *The China Clean Development Mechanism Fund (CCDMF)*, UNITED NATIONS CLIMATE CHANGE, https://unfccc.int/climate-action/momentum-for-change/financing-for-climate-friendly/china-clean-development-mechanism-fund (last visited Nov. 27, 2020) [https://perma.cc/N9GW-KMMP]; *Why China is at the Center of our Climate Strategy*, ENV'T DEF. FUND, https://www.edf.org/climate/why-china-center-our-climate-strategy (last visited Nov. 27, 2020) [https://perma.cc/RHM3-87N2].

237. *Innovation Fund*, EUR. COMM'N, https://ec.europa.eu/clima/policies/innovation-fund_en (last visited Nov. 27, 2020) [https://perma.cc/9R5E-W5SV).

238. *India*, CLIMATE INV. FUNDS, https://www.climateinvestmentfunds.org/country/india (last visited Nov. 27, 2020) [https://perma.cc/L8NM-8T4C].

239. Dennis Normile, *Bucking Global Trends, Japan Again Embraces Coal Power*, SCI. (May 2, 2018, 5:00 PM), https://www.sciencemag.org/news/2018/05/bucking-global-trends-japan-again-embraces-coal-power [https://perma.cc/PVL4-RF9V].

240. *See* Roberts, *supra* note 100; Irfan, *supra* note 100.

241. *See* Roberts, *supra* note 100; Irfan, *supra* note 100.

242. *See* 35 U.S.C. § 41(b)(1).

3. Expansion of the Climate Technology Public Domain

A relative decline in patenting would expand the public domain. The public domain is the "realm embracing property rights that belong to the community at large, *are unprotected by copyright or patent, and are subject to appropriation by anyone*[.]"[243] Here, an inventor expands the public domain in the U.S. if the inventor develops a climate product, patents it in a foreign country, and/or sells the product in a foreign country.[244] These actions disclose the invention to the world and give up the inventor's exclusionary rights, which allows anybody to practice that invention in the U.S.[245]

Patent law itself shapes this result. If the inventor/applicant ("Applicant") sells or offers to sell the invention in a foreign country, then the Applicant's entitlement to a patent is limited.[246] Without a patent, the inventor cannot prevent others from making, using, selling, advertising, or importing the invention in the U.S.[247] Commercializing the invention in a foreign country may bar a U.S. patent in myriad ways.

First, an inventor will be barred from a U.S. patent application if the inventor puts the invention "on sale" in a different country more than a year before filing the U.S. patent application. An inventor is not entitled to the patent under 35 U.S.C. § 102(a) if the "claimed invention was patented, described in a printed publication, or in public use, on sale, or otherwise available to the public before the effective filing date of the claimed invention."[248] An invention is on sale when (1) the product is "the subject of a commercial offer for sale," and (2) if the invention is "ready for patenting" by either "proof of reduction to practice before the [effective filing date]" or proof of constructive reduction to practice, such as preparing "drawings or other descriptions of the invention that were sufficiently specific to enable a person skilled in the art to practice the invention."[249] There is no limit on whether the sale is foreign or in the U.S.[250]

243. *Public Domain*, MERRIAM-WEBSTER (2019) (emphasis added).

244. *See infra* note 245.

245. *See infra* text accompanying notes 209–23; *see also* JAMES G. CONLEY, PETER M. BICAN & NEIL WILKOF, WORLD INTELL. PROP. ORG., STUDY ON PATENTS AND THE PUBLIC DOMAIN (II) 19 (2013), https://www.researchgate.net/publication/331248107_Study_on_Patents_and_the_Public_Domain_II [https://perma.cc/DU2W-2LP7] ("For example, the invention for which a patent is applied, published and ultimately granted in only one country, is effectively contributed to the public domain in all other sovereign states.").

246. 35 U.S.C. § 102(a)(1).

247. 35 U.S.C. § 271.

248. 35 U.S.C. § 102(a)(1).

249. Pfaff v. Wells Elecs., Inc., 525 U.S. 55, 67–68 (1998).

250. *Id.* at 57 n.1 (citing 35 U.S.C. § 102 (2018)). Notably, the modern § 102 language changed under the America Invents Act, but the change did not affect whether foreign or domestic commercializing constituted an on-sale bar. *Compare* 35 U.S.C. § 102(a)(1) (2006) ("[T]he invention was patented or described in a printed publication in this or a foreign country or in public use or on sale *in this country*, more than one year prior to the date of the application for patent in the United States." (emphasis added)), *with* 35 U.S.C. § 102(a)(1) (2015) ("[T]he claimed invention was patented, described in a printed publication, or in public use, on sale, or otherwise available to the public before the effective filing date of the claimed invention. . . ."); *see also* Helsinn Healthcare S.A. v. Teva Pharms. USA, Inc., 139 S. Ct. 628, 631–32 (2019) (explaining that "[t]he AIA precludes a person from obtaining a patent on an invention that was 'on sale' before the effective filing date" and that "[t]he patent statute in effect before the passage of the AIA included a similar proscription, known as the 'on-sale bar'").

The bar is effective only more than a year after putting the invention "on sale." 35 U.S.C. § 102(b)(1)(A) provides a one-year grace period to the "on-sale bar"—the Applicant could still file for a U.S. Patent Application if the Applicant put the invention "on sale" less than a year before the filing date.[251] Here, for example, if the Applicant sells a fully developed and new method of carbon sequestration to Microsoft in Great Britain on January 1, 2015, the Applicant is not entitled to a U.S. patent on that method if the application was filed after December 31, 2015.[252] That invention was the subject of a commercial offer for sale, and Applicant had reduced the invention to practice before selling it.[253]

Second, the inventor will be barred from a U.S. patent application if the inventor files a foreign patent application on the same subject matter more than a year before filing the patent application in the U.S.[254] Prior patent applications are "prior art" that can defeat patentability under 35 U.S.C. § 102.[255] If the prior patent application is the inventor's own, then the 102(b) grace period applies, giving the inventor just under a year to act without losing the ability to file a patent application in the U.S.[256] The inventor could also file a foreign application on January 1, 2014, and then file a U.S. patent application on December 31, 2014, and still have that U.S. patent application be treated as if it was filed on January 1, 2014.[257] Under 35 U.S.C. § 119, a U.S. patent application may claim the filing date of a prior foreign application on that same subject matter and by that same inventor, if the U.S. patent application was filed within twelve months from the earliest date of the prior foreign application's filing date.[258]

In conclusion, an Applicant who sells or files a patent application for the invention in a foreign country will lose out on patent rights in the U.S. if the Applicant waits more than a year before filing.[259] In this scenario, the Applicant no longer has the right to exclude others from practicing the invention.[260] So anybody can use that invention and the information disclosed in the foreign application for free, without fear of being sued for infringement.[261]

Expansion of the public domain comes with some benefits, such as advancing scientific knowledge and increasing access to commercial products. Such expansion is deemed a public benefit because it "[stimulates] ideas and the eventual

251. 35 U.S.C. § 102(b)(1)(A) (2018).

252. *See id.*

253. In practice, Applicant here would be well advised to file a provisional application under § 119 before offering for sale, perhaps on December 31, 2014. If Applicant then claims priority to that provisional application under § 119 (b), any application filed within a year of that provisional and containing the same disclosure as that provisional application would earn that December 31, 2014 filing date.

254. *See infra* text accompanying notes 255–59.

255. 35 U.S.C. § 102(a)(1).

256. § 102(b)(1)(A).

257. 35 U.S.C. § 119(a).

258. *Id.*

259. § 102(a)(1).

260. *Id.*

261. 35 U.S.C. § 271. There are other ways to disclose to the public domain that do not involve foreign commercialization or foreign disclosure. *See, e.g.*, CONLEY ET AL., *supra* note 245, at 19 (noting that patent abandonment, patent publication, and a refusal to enforce a patent, may all expand the public domain).

development of further significant advances in the art[.]"[262] The benefit is only realized, however, if inventors in the U.S. use that public domain information in the course of their own innovation.[263] This requires that U.S. inventors read foreign patents, or that U.S. inventors have access to foreign technology for study.[264] There is extensive discussion about whether inventors read patents or patent applications; the consensus appears to be "no."[265] If inventors do not read patent applications or foreign patents, then that written disclosure would not stimulate ideas and the development of further significant advances in the art.[266] Conversely, if inventors *do* read foreign patent applications and foreign patents, then that written disclosure could stimulate further ideas and achieve the benefits listed above.[267] Alternatively, inventors could access foreign technology and study it. Legally accessing this foreign technology, however, may cost money.[268] Naturally, large companies with greater budgets are more likely to benefit from this avenue than smaller companies.

Expansion of the public domain is also a public benefit because it allows parties in the U.S. to import unpatented climate technology products and increase access to that technology.[269] These importers could use the climate technology themselves, with some reductions in emissions.[270] These importers could also sell the climate technology at a lower cost because they do not need to recoup the opportunity cost of inventing that technology.[271] Selling at a lower cost would increase access to these technologies by consumers, which may itself reduce emissions.

Overall, a relative decline would have mixed effects on the commercialization of inventions and the expansion of the public domain. It is unclear whether these effects are markedly positive or negative with respect to the status quo, but

262. Kewanee Oil Co. v. Bicron Corp., 416 U.S. 470, 481 (1974).

263. *See, e.g.*, Lisa Larrimore Ouellette, *Do Patents Disclose Useful Information?*, 25 HARV. J.L. & TECH. 545, 560–61 n.89 (describing the defense of disclosure theory by calling for invigorated disclosure); Note, The Disclosure Function of the Patent System (Or Lack Thereof), 118 HARV. L. REV. 2007, 2009 (2005) (noting that the patent system does not achieve this disclosure goal).

264. Mark Lemley, *Ignoring Patents*, 2008 MICH. ST. L. REV. 19, 21 (2008) ("[B]oth researchers and companies in component industries simply ignore patents.").

265. *See id.*; *see also* Ouellette, *supra* note 263, at 560–61 n.89.

266. *Cf.* Lemley, *supra* note 264, at 19; Ouellette, *supra* note 263, 560–61 n.89.

267. *Cf.* Lemley, *supra* note 264, at 19.

268. *E.g.*, *How Much Does a Solar Panel Installation Cost?*, ENERGYSAGE, https://news.energysage.com/how-much-does-the-average-solar-panel-installation-cost-in-the-u-s/ [https://perma.cc/4WFJ-KMLD] (last updated July 15, 2020).

269. *See, e.g.*, 35 U.S.C. § 271; Anne C. Mulkern, *Researcher: Ban Patents on Geoengineering Technology*, SCI. AM. (Apr. 18, 2012), https://www.scientificamerican.com/article/researcher-ban-patents-on-geoengineering-technology/ [https://perma.cc/P2ZL-VPZ6] (relaying an argument by Physicist David Keith that geoengineering technologies for climate change mitigation should remain unpatented and in the public domain); Martin Khor, *Climate Change, Technology and Intellectual Property Rights: Context and Recent Negotiations*, 45 S. CTR. 3 (2012) ("[G]overnments and international organisations should promote the formulation of policies and programmes for the effective transfer of environmentally sound technologies that are publicly owned or in the public domain.").

270. *See* 35 U.S.C. § 271. Without a patent, the inventor could not exclude someone else from using this invention.

271. *See, e.g.*, CONLEY ET AL., *supra* note 245, at 29–30; *see also supra* Section II.F.1.

it is reasonable to expect that these effects will occur. Thus, this Note asks: "Has the U.S.' announced withdrawal from the Paris Climate Agreement reduced the number of climate-change technology patent applications filed within the U.S. relative to other countries?"

B. Hypothesis

This Note hypothesizes that the withdrawal and anti-climate behavior highlighted in Section II.D. reduces the U.S. market for green technology.[272] Accordingly, inventors would not pursue patent protection in the U.S. for green technology. In operationalized language, the annual rate of U.S. green technology patents would decline more than it would have had the U.S. not withdrawn from the Paris Agreement.

C. Data Collection

This Note analyzes patent data between 2010 and 2017, supplied by PatentLens ("Lens").[273] Lens provides bibliographical information on published patent applications in various Patent Offices around the globe. The Lens data provides certain fields: Inventor, Jurisdiction, Applicant, Application Date, Publication Date, Granting Date, Publication Year, CPC code, and IPC code.[274] The data came from U.S. patent applications, Chinese patent applications, Japanese patent applications, the European Patent Office's patent applications, and the WIPO's patent applications.[275] This Note specifically focuses on the patents under the technology classes previously highlighted in Section II.B.[276] These are all patent applications with a CPC of "Y02."[277] These applications were later broken into sub-classes: Y02A, Y02B, etc. Each sub-class covers a variety of climate technology.[278]

D. Experimental Design

To claim that the Paris Withdrawal (or an attendant climate policy change by the U.S.) negatively affected U.S. patent applications on climate technology, this Note must show two facts. First, this Note must show that the Paris Withdrawal affected U.S. patent applications compared to other countries' patent applications. If there is no difference between countries who stayed in the Paris Agreement and countries who left the Paris Agreement, leaving the Paris Agreement did not affect U.S. patent applications. Second, this Note must show that U.S. patent applications on climate technology declined compared to U.S. patent

272. *See supra* Sections II.D–E.

273. *New Patent Search*, LENS.ORG, https://www.lens.org/lens/new-search?type=PATENT (last visited Nov. 27, 2020) [https://perma.cc/EZ42-3BUU].

274. *Id.*

275. *Id.*

276. *See supra* Section II.B.

277. *See supra* Section II.B.

278. *See supra* Section II.B.

applications on other technologies. If there is no difference between patent applications on climate technologies and patent applications on other technologies, then U.S. climate policy did not specifically affect patent applications on climate technologies.

To statistically tease-out the relationship between the Paris Withdrawal and U.S. patenting rates, this Note takes advantage of the fact that the U.S. is the only country to announce a withdrawal.[279] But simply observing the change in annual patent applications filed before the withdrawal and after the withdrawal would be problematic. Application rates are certain to change over time for reasons unrelated to the Paris Agreement.[280] Therefore, instead of hypothesizing that U.S. patent application rates will decline on an absolute scale, this Note hypothesizes that U.S. patent application rates will be *lower than they otherwise would be* without announcing the Paris Withdrawal.

This Note uses a "difference-in-difference" estimation approach commonly used in policy evaluation studies.[281] A difference-in-difference approach compares a treatment group, which is subject to some policy intervention, and a control group across a period of time, separately tracking the two group's changes over that time period and then calculating the difference of the two changes.[282] The difference between those two changes describes the effect of the policy intervention.

For example, imagine a treatment group starts at a value of ten in Year 1 and then declines to a value of five in Year 2. The treatment group declined by five units from Year 1 to Year 2, but that value by itself does not show whether the treatment itself caused the five-unit decline, or whether other factors contributed to it. Now, imagine a similarly situated control group starts at a value of seven in Year 1 and then a value of six in Year 2. This control group has declined by one from Year 1 to Year 2. This control group did not receive the treatment of the treatment group, so intuitively the control group's decline was caused by *every other factor that it had in common with the treatment group*. Because the control group declined by one unit without treatment, we can surmise that the treatment group declined by one unit without treatment. Thus, the treatment group's total decline over five units, minus the control group's total decline over one unit, results in a difference-in-difference of four units, where the treatment likely caused a decline for four units. This difference-in-difference is also referred to as a "difference-in-difference estimator" ("DID estimator").

This approach accounts for covariates because a decline after 2018 for U.S. patents may be explained by some combination of a "Paris Withdrawal Effect," global reversion to the mean, retirement of the Green Patent Pilot Program, § 101

279. *USA*, *supra* note 8.

280. There is likely random variation in patent application filings per year. In addition, different countries may change their patent laws to make their markets more or less hospitable to inventors. For example, see *supra* Section II.F.4 for a brief discussion on the § 101 controversy.

281. *See, e.g.*, Anders Fredriksson & Gustavo Magalhães de Oliveira, *Impact Evaluation Using Difference-in-Differences*, 54(4) RAUSP MGMT J. 519–20 (2019).

282. *See* COLONESCU, *supra* note 14, at 111–12.

patent-eligibility controversy, or other unidentified factors.[283] By comparing the decline of U.S. patents with other countries' rates, a difference-in-difference estimation may take into account the effects that influence U.S. and foreign markets, allowing us to identify the difference that is solely caused by U.S. behavior—perhaps one due to U.S. climate policy.

Finally, difference-in-difference experiments must satisfy a parallel trend assumption. Ideally, the two measured trends between the treatment group and the control group are parallel, because this indicates that the treatment is the only difference between the treatment group and the control group.[284] The trends should not have been subject to this differential treatment before the time period.[285] In this real-world setting, no trends were exactly parallel even in the tested experiments.

1. Treatment Groups and Control Groups

This Note defined different treatment groups and control groups to conduct the difference-in-difference experiments. All groups were selected from the years 2010 to 2017. This Note limits data to 2017 or before, because as discussed in Section III.C.5, the publication lag encoded in various statutes makes data from 2018 and 2019 inaccurate reflections of patent applications filed.[286]

The treatment group was the set of climate patents filed in the U.S. This Note compares this treatment group to several control groups, which arguably did not receive the treatment effect from the U.S.' withdrawal, and so theoretically should not be subject to a decline or a lessened incentive to file a patent application.[287] First, this Note compares the annual rate of climate patent applications in the U.S. to the annual rate of climate patent applications filed in a selection of other countries.

Second, this Note compares the annual rate of climate patent applications filed in the U.S. to the annual rate of *all* patent applications filed in the U.S. This control group is to account for trends that would affect all U.S. patent applications equally. This group, however, includes patent applications in technological fields that are likely subject to the § 101 patent-eligible subject matter controversy discussed previously.[288]

Third, this Note compares the annual rate of climate patent applications filed in the U.S. to the annual rate of mechanical engineering patent applications filed in the U.S. This control group of U.S. mechanical engineering patent applications is meant to be more similarly situated to climate patent applications, because it excludes patent applications in technological spaces that are subject to § 101 patent-eligible subject matter controversy.[289] This Note assumes that both

283. *See supra* Parts I–II.
284. *See* COLONESCU, *supra* note 14, at 111–13.
285. *Id.* at 111.
286. *See infra* Section III.D.4.
287. *See infra* Section III.E.3.
288. *See infra* Sections III.A.3, III.C.1, III.F.
289. *See* Chien & Wu, *supra* note 191, at 11–13.

groups of patent applications will not face a subject matter eligibility problem, and thus, there would be no external trend that affects this control differently than the climate trends. As noted in Section II.B., climate patents here are defined as any patent application with a Y02 classification.[290] Mechanical engineering patents are defined as any patent application with an F% CPC.

2. Treatment Dummy Variable

Next, this Note identifies a treatment and then creates a dummy variable to reflect that treatment. In most cases, the Treatment Variable will be the so-called "Paris Withdrawal Effect." For tests where both groups are drawn from climate patent applications, the "Paris Withdrawal Effect" is one for the U.S. and zero for other jurisdictions. For tests where both groups are drawn from U.S. patent applications, the Paris Withdrawal Effect is one for climate patents (those under the Y02 subheading) and zero for all other patent applications.

The Treatment Time is another dummy variable that reflects when the treatment was applied. For the years before the withdrawal announcement, the Treatment Time will be zero, and for years during and after the withdrawal announcement, the Treatment Time will be one. But there are multiple dates that could serve as the withdrawal announcement. President Trump made it clear during his campaign that the U.S. would leave the Paris Agreement, so arguably the Paris Withdrawal Effect kicks in upon his election.[291] In June 2017, President Trump formally announced that the U.S. would soon begin the withdrawal process.[292] His administration officially filed the paperwork in November 2019.[293] This Note uses the date of the formal announcement because it was the earliest unambiguous signal of the U.S.' planned withdrawal.[294] Thus, applications in the year 2016 and before are considered pre-treatment, and applications in 2017 and beyond are considered post-treatment.

This Note also distinguishes between "Priority Year" and "Application Year." The Priority Year is the year of the patent application's earliest effective filing date—when the information disclosed in the patent application was first filed in a previous application by that inventor.[295] The Application Year is the year in which a particular application is filed with a particular patent application. As discussed in Section II.F., this Note compares by Priority Year, which is a better time to measure the inventor's decision to pursue patent protection on new

290. *See supra* Section II.B. This experiment also isolated these climate patents by specific CPC subgroups that cover different technologies, and then conducted these country comparisons for each group. The results are included in the Fig. 1 table, but because they deal with small sample sizes, they are likely error-prone and vulnerable to outliers. Of the categories in the chart, only Y02B patents that deal with buildings and Y02D patents that deal with information and communication technologies show a decline at either end of the error range. Neither of these satisfy the parallel trends assumption enough to support an inference.

291. *See supra* Section II.D.

292. *See supra* Section II.D.

293. *See supra* Section II.D.

294. *See supra* Section II.D.

295. *See* 35 U.S.C § 119.

technology because any further applications claiming that priority date cannot introduce new information to disclose and claim.

3. Accounting for Patent Families

This Note cannot assume that each application corresponds to a separate invention or product because the patent prosecution process features multiple applications for the same technical content. As noted in Section II.F, multiple applications, filed months or even a year apart, can claim the filing date of the earliest application in that chain.[296]

For example, say an inventor files a patent application in the U.S. in 2013. After two years, the inventor has received a Final Rejection from the Patent Office. That inventor could then file a continuation of that same patent application; the continuation would be assigned a different filing date, an identical priority date, and a different number, even though the technical content sought to be protected is the same.[297] Similarly, an inventor could be prosecuting a patent application when the Patent Office decides that the application has enough diverse subject matter to require some of the claims be spun off into a divisional application.[298] The inventor would file a divisional application, which would have its own filing date, identical priority date to the original patent application, and number, even though it was borne of the same technical content sought to be protected.[299] Therefore, when examining application filing dates as a measure for the initial desire to file a patent application, a patent's application date may not reflect that desire because it may just be filed as a strategic matter. Every application year would include multiple applications that reflect strategic patent prosecution decisions, rather than the initial decision to pursue a patent application. The count of applications per year would be greater than the count of decisions to patent within that year.

Similarly, when examining priority dates as a measure for the initial desire to file a patent application, counting all the patent applications per priority year would not wholly capture the decisions to pursue patent protection. The goal of claiming a priority date is to retroactively date all applications to that priority date and avoid more recent prior art.[300] Furthermore, most countries also have a rule against "new matter"—a patent application claiming priority to an earlier application loses that priority for specific claims if the matter claimed in that claim is not disclosed in the earlier application.[301] So, further patent applications would claim that priority date, which retroactively inflates the patent application count for each priority year.

296. *See supra* Section II.F.2.

297. *See supra* Section II.F.2.

298. *See supra* Section II.F.2.

299. *See supra* Section II.F.2.

300. *Patent Families*, EUR. PAT. OFF., https://www.epo.org/searching-for-patents/helpful-resources/first-time-here/patent-families.html (last visited Nov. 27, 2020) [https://perma.cc/4YZR-DJN7].

301. MPEP, *supra* note 203, § 2163.06.

To address this issue, WIPO externally classifies patent applications sharing a priority date as being in a specific "patent family."[302] In the Lens data, this Note used the "one doc per family" option to select only one document per family.[303] In the PATSTAT data, this Note created a subset table that was one doc per family by building one table with one DOCDB.[304] So each application counted in this application reflected the earliest year filed—the earliest priority year. This prevents the experiment from capturing artifacts of the patent prosecution process instead of the initial decision to patent an application.

4. Accounting for Publication Lag

This Note also deals with the problem of publication lag. Countries use different terms to identify the date that an inventor applies for a patent, usually some variation of "filing date" or "application date."[305] The respective Patent Offices use these dates for two common purposes: (1) if competing inventors file patent applications with identical claims on the same subject matter, the Patent Offices uses these dates to determine which inventor gets the patent; and (2) if the patent applications are selected for publication, the Patent Office uses these dates to determine when to publish the patent applications.[306] In the U.S., patent applications are typically published eighteen months after their "earliest filing date."[307] This earliest filing date may be the filing date of that patent application, or it may be the filing date of a previous patent application to which the current patent application claims priority.[308] In China, invention patent applications are published eighteen months after their "application date."[309] In India, patent applications are published eighteen months after the "filing date of the application."[310] Likewise, in the EPO, patent applications are published eighteen months after "the date of filing" or "the earliest priority date."[311]

302. *Patent Families*, *supra* note 300.

303. *See New Patent Search*, *supra* note 273.

304. *See DOCDB Simple Patent Family*, EUR. PAT. OFF., https://www.epo.org/searching-for-patents/helpful-resources/first-time-here/patent-families/docdb.html (last visited Nov. 27, 2020) [https://perma.cc/TB26-ZTAB].

305. *See infra* text accompanying notes 306–11.

306. 35 U.S.C. § 102(a)(2); 35 U.S.C. § 122(b)(1)(A).

307. § 122(b)(1)(A) ("Subject to paragraph (2), each application for a patent shall be published . . . promptly after the expiration of a period of 18 months from the earliest filing date for which a benefit is sought under this title.").

308. 35 U.S.C. § 119.

309. *China IPR SME HelpDesk: Patent[FAQs]*, EUR. COMM'N (Sept. 1, 2020), https://www.china-ipr-helpdesk.eu/content/patentsfaqs [https://perma.cc/YK5X-CC2Q] ("After successfully undergoing preliminary examination an invention patent will be published in the Invention Patent Gazette 18 months after the application date.").

310. The Patents Act, 1970, No. 39 of 1970, § 11A(2) (Sept. 19, 1970) (India) ("The applicant may, in the prescribed manner, request the Controller to publish his application at any time before the expiry of the period prescribed under sub-section (1) and subject to the provisions of sub-section (3), the Controller shall publish such application as soon as possible.").

311. EUR. PAT. OFF., EUROPEAN PATENT GUIDE: HOW TO GET A EUROPEAN PATENT 52 (Apr. 2020) http://documents.epo.org/projects/babylon/eponet.nsf/0/8266ED0366190630C12575E10051F40E/$File/how_to_

Publication lag artificially deflates the measured annual patent applications for recent years.[312] For example, this Note collected data until February 2020. As of that time, it is entirely reasonable that all applications filed in 2019 not be published yet because it had not been eighteen months since any date in 2019.[313] So too with 2018 applications.[314] An application with a priority date after August 2018, or actually filed August 2018 without an earlier priority date, would not be reflected in this data set.[315] But any applications filed in 2017 or with an effective filing date of 2017 ought to be published by the end of 2019.[316] When presenting and analyzing the results, this Note analyzes years up to and including 2017. As will be discussed in Section IV.C, this publication lag creates delays in innovation research, which affects the ability of innovators and innovation policy officers to monitor policy effects in real-time.

5. Statistical Significance

These experiments will rely on statistics, and thus a brief section to explain these terms is warranted. The experiments comprise several hypothesis tests, each which evaluates two mutually exclusive statements about a population to determine which statement is best supported by the sample data. For example, the statement that "the annual rate of climate patent applications filed in the U.S. is decreasing compared to the annual rate of climate patent applications filed in other countries," is mutually exclusive from the statement that "the annual rate of climate patent applications filed in the U.S. is *not* decreasing compared to the annual rate of climate patent applications filed in other countries." The latter statement is the null hypothesis—that there is no effect in the general population.[317]

A test result here is statistically significant when the sample statistic is extreme enough relative to the null hypothesis that this Note could reject the null hypothesis for the entire population.[318] For example, the sample statistic could be the difference in difference estimator between U.S. climate patents and other countries' patents. In a world where the null hypothesis is true, the DID estimator would be zero. In a world where the test hypothesis is true, the DID estimator is some positive or negative value. But there is always a chance that this Note obtains a DID estimator of a positive or negative value even though in the actual and entire population the DID estimator is zero, so this Note evaluates the statistical significance of the obtained DID estimators. That is, this Note evaluates how likely it is that the obtained DID estimator is a false positive.

get_a_european_patent_2020_en.pdf [https://perma.cc/DE55-XVFD] ("The European patent application is published as soon as possible after the expiry of eighteen months from the date of filing or the earliest priority date.").

312. *See* 35 U.S.C. § 122(b)(1)(A).

313. *See id.*

314. *See id.*

315. *See id.*

316. *See id.*

317. *See* COLONESCU, *supra* note 14, at 40.

318. *Id.*

Significance levels—commonly called alpha values—are commonly based on tradition.[319] The common alpha values are ".1," ".05," and ".01," which respectively translate to expecting a false positive result 10%, 5%, and 1% of the time.[320] This Note compares the test result to the significance level by generating a p-value, which is the probability of obtaining an equivalent test result even when the null hypothesis is true (in other words, the probability of obtaining a false positive).[321] When the p-value is greater than the significance level, the null hypothesis cannot be rejected, so the result is concluded to be not statistically significant.[322] When the p-value is less than or equal to the significance level, the null hypothesis is rejected—and the result is concluded to be statistically significant.[323]

E. Data Analysis and Results

First, this Section presents an overview of the results. Then, it will delve into the relevant details.

Overview of Experimental Results

Difference in Difference Estimators Overall			
	Climate Patent Applications in Non-U.S. Jurisdictions	All Patent Applications in the U.S.	Mechanical Engineering Patent Applications in the U.S.
U.S. Climate Applications over Application Years	-3644 (5955)	-202893 (192370)	-12250** (4132)
U.S. Climate Applications over Priority Years	-5685 (5564)	-155690 (144014)	-15382** (5714)

Difference in Difference Estimators by CPC class	
U.S. Climate Applications by Priority Year	Climate Patent Applications in Non-US Jurisdictions
Y02A: Technologies For Adaptation To Climate Change	-296.19 (386.13)
Y02B: Climate Change Mitigation Technologies Related To Buildings	-734.4 (534.6)

319. *See id.* at 35.
320. *Id.* at 33.
321. *Id.* at 40.
322. *Id.*
323. *Id.*

Y02C: Capture, Storage, Sequestration Or Disposal Of Greenhouse Gases	-75.90 (104.06)
Y02D: Climate Change Mitigation Technologies In Information And Communication Technologies	-1419.4 (561.58)
Y02E: Reduction Of Greenhouse Gas Emissions (Energy)	-1262.8 (2560.0)
Y02P: Climate Change Mitigation Technologies In The Production Or Processing Of Goods	-898.5 (1026.3)
Y02T: Climate Change Mitigation Technologies Related To Transportation	-1088.2 (1610.5)
Y02W: Climate Change Mitigation Technologies Related To Wastewater Treatment Or Waste Management	-61.33 (288.33)

Statistical Significance: * = (p<0.10), ** = (p<0.05), *** = (p<0.01)
Error range reported in ( )
Mechanical Engineering = CPC: F%

1. Summary of Results

This Note finds a relative decline in climate patent applications in this sample.[324] Overall, U.S. Climate Applications over Priority Years declined relative to Climate Applications in other jurisdictions, relative to all patent applications in the U.S., and relative to all Mechanical Engineering patent applications in the U.S.[325] These declines are present even accounting for the error ranges in each calculation.[326]

This Note cannot say for sure whether the Paris Withdrawal itself caused the relative decline in climate patent applications. The U.S.-to-foreign-country comparison is not statistically significant under traditional thresholds, so there is some probability that any underlying difference between the U.S. and the selected jurisdictions participating in the Paris Agreement did not cause the relative decline.[327] The U.S. Climate Applications and All U.S. Patent Applications comparison was also not statistically significant under traditional thresholds, so again, there is some probability that any underlying difference between climate patent applications and other U.S. patent applications did not cause the relative decline in U.S. climate patent applications.[328] But as noted earlier, U.S. patent applications in certain subject matters already faced a decline caused by the § 101 patent-eligibility controversy.[329] The U.S. Climate Applications and U.S. Me-

324. *See supra* Overview of Experimental Results.
325. *See supra* Overview of Experimental Results.
326. *See supra* Overview of Experimental Results.
327. *See supra* Overview of Experimental Results.
328. *See supra* Overview of Experimental Results.
329. *See* Cárdenas Rodríguez et al., *supra* note 16.

chanical Engineering Patent Applications comparison was statistically significant under a .05 threshold, which suggests that an underlying difference between climate patent applications and other U.S. climate patent applications caused the relative decline in U.S. climate patent applications.[330]

There are some caveats with the method here, but this Note identifies ways to address these caveats with future experiments. Removing data from 2018 and 2019 eliminated the problem of publication lag but reduced the sample size and the robustness of these experiments. Future experiments would ideally take into account more data from 2018 and 2019 once all such applications have been published. Furthermore, there is no guarantee that Mechanical Engineering Patent Applications are identically situated to Climate Patent Applications. Future experiments could thus compare U.S. Climate Patent Applications to all U.S. Patent Applications without the aforementioned business methods or medical diagnostic applications, rather than limiting to Mechanical Engineering Patent Applications. Finally, the difference-in-difference technique requires a parallel trend assumption, which was only satisfied in a subset of the experiments performed. Future experiments could also use other methods not reliant on the parallel trend assumption to compare these differences.[331]

Next, this Note examines in depth the experiments and results carried out to test the hypothesis, that the annual rate of U.S. green technology patents would decline more than it would have had the U.S. not withdrawn from the Paris Agreement.

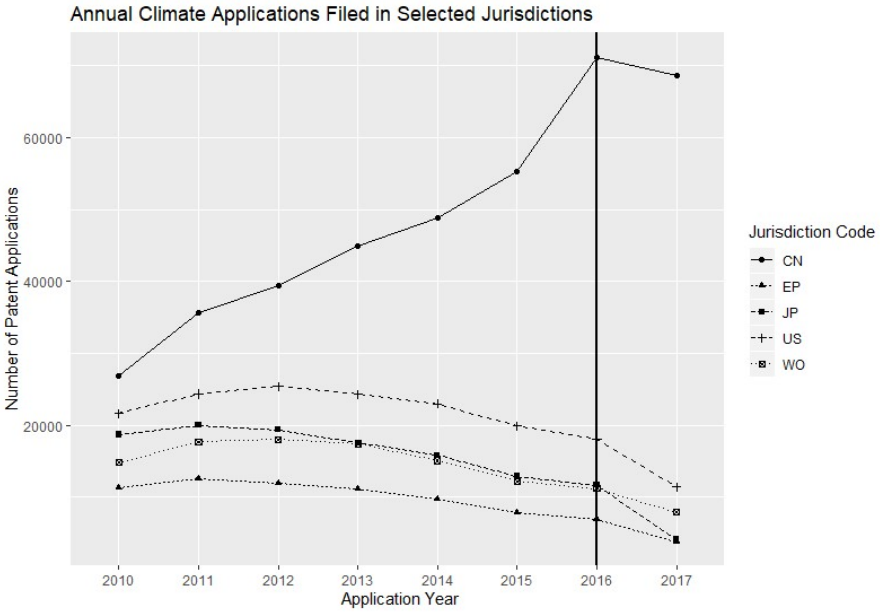
2. Comparing the U.S. to China, Japan, EPO, and WIPO: Examining by Application Year

This Note first compares the climate patents in the U.S., China, Japan, the EPO, and WIPO. Figure 1 shows an overview of annual climate patents (those with a Y02 CPC) filed in the selected jurisdictions.

330. *See supra* Overview of Experimental Results.

331. *See, e.g.*, Alberto Abadie, Alexis Diamond, & Jens Hainmueller, *Synthetic Control Methods for Comparative Case Studies: Estimating the Effect of California's Tobacco Control Program*, J. AM. STAT. ASS'N 493, 493 (2012).

FIGURE 1



First, China's climate patent behavior is markedly different from the other groups here. It rises as the others fall and then collapses to meet the others after 2016. Before 2017 (the application of the treatment), it is clear that China cannot satisfy the parallel trends assumption for a difference-in-difference analysis. China's magnitude of patent applications is also far greater than the others, and so this graph minimizes the difference between the other parties. A future experiment may apply other hypothesis method tests to this data—for instance, using the synthetic control method pioneered by Abadie to satisfactorily include China's patent applications without distorting the result.[332]

3. Comparing the U.S. to Japan, EPO, and WIPO, by Patent Priority Years

In this experiment, this Note compares the U.S.' patent applications to those of Japan, the EPO, and WIPO, and groups by the patent priority year. This experiment operates on the same dataset as the previous experiment.

332. *Id.* at 494.

FIGURE 2

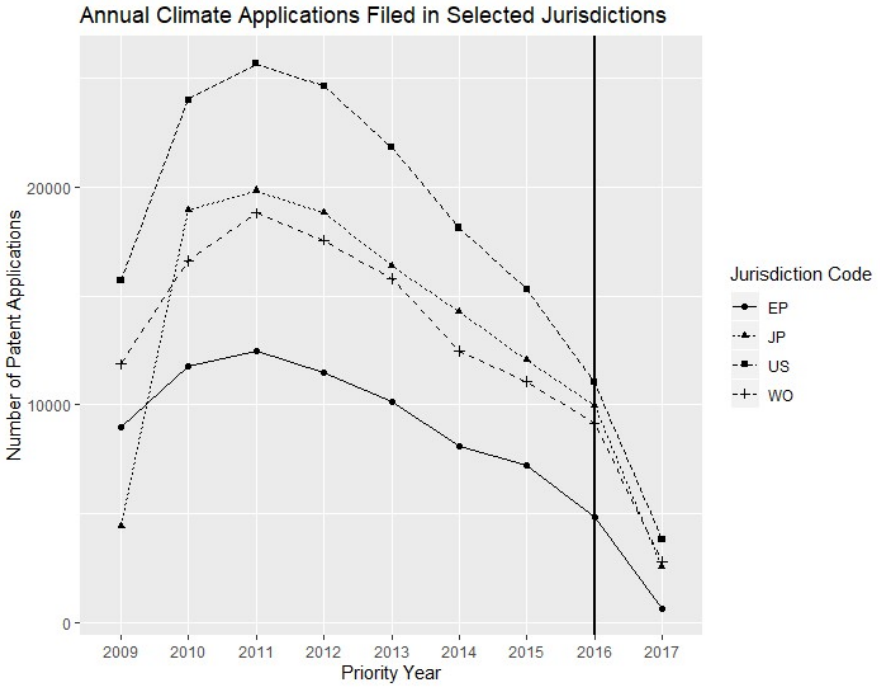


Figure 2 shows the climate patent applications per priority year for the U.S., Japan, the EPO, and WIPO. It is apparent that global patent applications declined between 2016 and 2017. This Note assumes that the parallel trends assumption has been cleared. Before 2017, the countries were largely following the same trend: rising and peaking in 2012, and then slowly falling. This figure also shows that the U.S. climate patent applications dropped with respect to other countries. The U.S., WIPO, and Japan converge in 2016 and 2017. At first, the U.S. is higher than WIPO and Japan, but after 2017, the U.S. is in between WIPO and Japan.

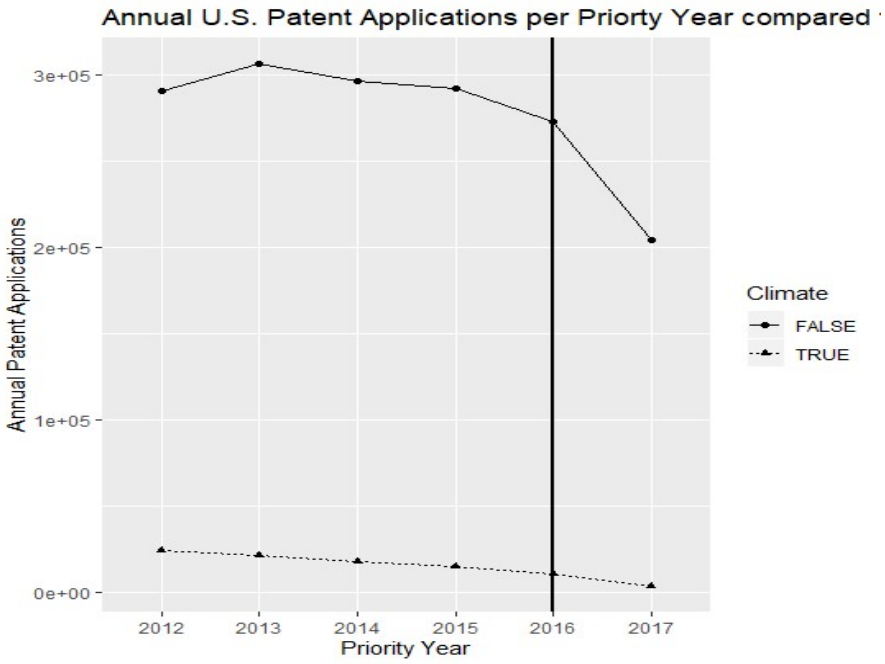
Using the same methodology as above, this Note generated the DID estimator for patent applications per country per priority years. The treatment groups were U.S patent applications; the control groups were Japan, the WIPO, and EPO patent applications. The treatment took effect in 2017. The vertical line in 2016 denotes that 2016 was the last year before the treatment took effect.

The experiment returned a DID of -5685 with a p-value of .31. Therefore, the U.S. Climate Patent Applications per Priority Year declined compared to other countries by 5685 patent applications, but this decline would have shown up 31% of the time even if the Paris Withdrawal or other event did not cause this decline. This is not statistically significant under the traditional thresholds of 0.1, .05, and .01. Thus, this difference does not support a hypothesis that the Paris Withdrawal announcement or another underlying cause slowed U.S. climate applications filed for the first time compared to those of Japan, the EPO, and EIPO climate applications filed for the first time.

4. Comparing U.S. Climate Patent Applications to All U.S. Patent Applications

This experiment compares U.S. Climate Patent Applications to all U.S. Patent Applications, per priority year. As explained above, this experiment attempts to control for the effect of U.S. patent law on U.S. climate patent applications.

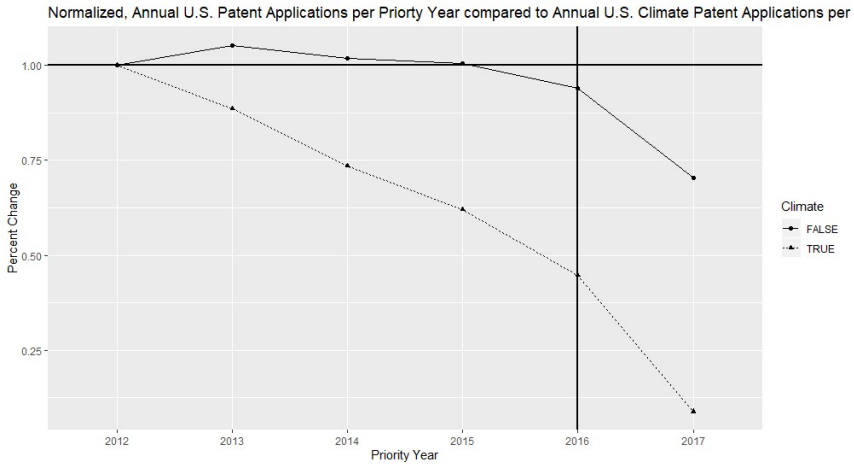
FIGURE 3



As above, this data presents a consistent decline in both classes of patent applications. Notably, the decline starts in 2015 for both classes of patent applications. That 2016 and 2017 features a decline is no surprise given the WIPO's report earlier.[333]

333. WORLD INTELL. PROP. ORG., *supra* note 15, at 7.

FIGURE 4



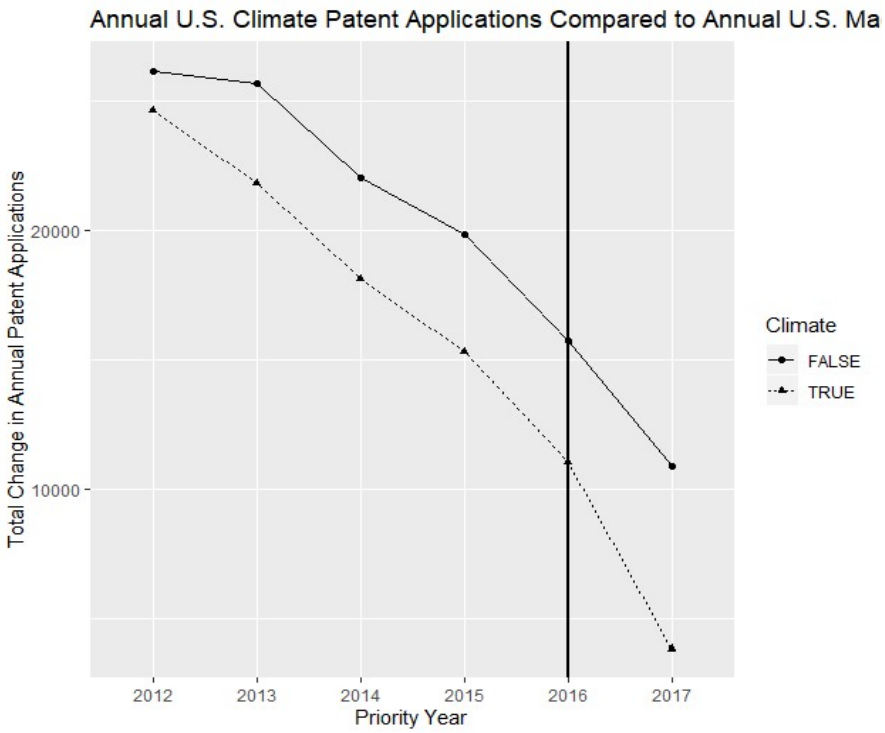
Additionally, a normalized view shows a similar story—both classes of patent applications declined. A normalized view of Figure 3 is presented above, which displays each class of patent applications' change over time, rather than total counts. This shows that between 2012 and 2016, the total number of U.S. patent applications per year rose, while U.S. climate applications fell, and then after 2016, both sets of applications fell dramatically. This view is helpful to sense the percentage difference, but cannot be the basis of a DID.

The results of a DID on these data set are as follows. The experiment returned a DID of -155690 with a p-value of .3, which is not significant under any threshold. This Note cannot conclude that U.S. climate applications fell at a lower rate than total U.S. applications. Yet, as repeatedly noted, this comparison does not factor in the disparate effect of the § 101 controversy.[334]

334. *Id.* at 5.

5. Comparing U.S. Climate Patent Applications to Mechanical Patent Applications

FIGURE 5



Visually, U.S. Climate Patent Applications per Priority Year and U.S. Mechanical Engineering Patent Applications per Priority Year are somewhat parallel before 2017. They both descend from a peak in 2012. From 2016 to 2017, Climate Patent Applications descend slightly more severely than Mechanical Engineering Patent Applications.

Under this experiment, the Climate Patents declined more than the Mechanical Engineering Patent Applications by 15,382 patent applications, with an error range of 5714. At either end of the error range, this DID is still a decline. This DID has a p-value of .0226, and so this estimated DID had only a 2.26% chance of occurring even if the Paris Withdrawal or any other event had not caused this declined. This is a statistically significant effect under the .05 and .1 thresholds.

6. Experimental Conclusion

As noted earlier, to prove that the Paris Withdrawal (or an attendant climate policy change by the U.S.) negatively affected U.S. patent applications on climate technology, this Note must show that (1) the Paris Withdrawal affected U.S. patent applications compared to other countries' patent applications, and (2) U.S.

patent applications on climate technology declined compared to U.S. patent applications related to other technologies.

Overall, this Note does not find a statistically significant relative decline in climate patent applications in each comparison.[335] In this sample, U.S. Climate Applications over Priority Years declined relative to Climate Applications in other jurisdictions, relative to all patent applications in the U.S., and relative to all Mechanical Engineering patent applications in the U.S.[336] These declines are clearly present, even after accounting for the error ranges in each calculation. It is unclear, however, whether this decline is fully attributable to the Paris Withdrawal. First, the relative decline between the U.S. Climate applications and the selected Foreign Climate applicants is not statistically significant under traditional thresholds; it has some probability of being a false positive.[337] In plain terms, it is not certain enough that this reported decline was caused by the Paris Withdrawal. Second, there may be other underlying causes in climate policies in 2017 that caused this relative decline.[338]

The relative decline between U.S. Climate applications and U.S. Mechanical applications (accounting for § 101 controversy) is statistically significant under traditional thresholds and presents only a 2.26% probability of being a false positive. So it is a clearer case that the reported decline here reflects an actual decline of U.S. Climate patent applications compared to all U.S. Mechanical patent applications. It is thus more likely that some underlying cause contributed to this decline.

IV. RECOMMENDATION

This Note finds that United State climate patent applications declined compared to climate patent applications in foreign countries, but this decline is not statistically significant—there is some probability that it is not caused by the Paris Withdrawal.[339] In the event that this decline represents an actual decline, it has the negative effect of reducing future commercialization of climate products, and the positive effect of expanding the climate technology public domain within the U.S. to make climate innovation and climate product commerce cheaper.[340] Whether the benefits of public domain expansion will outweigh the decline in future commercialization depends on access to the unpatented technology and the information disclosed about those unpatented inventions. Therefore, any recommendation in response to this relative decline must help increase the commercialization of climate patent applications without constricting the climate patent public domain within the U.S.

335. *See supra* Section III.E.1.
336. *See supra* Section III.E.1.
337. *See supra* Section III.E.1.
338. *See supra* Section III.E.1.
339. *See supra* Section III.E.1.
340. *See supra* Section III.A.1.

A. Rejoin Paris

First, this Note recommends the U.S. rejoin the Paris Climate Agreement. This move would be largely symbolic in nature, but that symbolism would signal a new interest in funding and supporting climate technology innovation within the U.S. More specifically, this move would augur additional federal funding, or additional venture capital or other private capital, thus removing some of the barriers to commercialization faced by inventors.[341] Of course, this move would not by itself solve all intellectual property problems—it is merely a start.

B. A New Green Fast-Track Program

The second recommendation is to recreate a Green Fast-Track Program. Dechezleprêtre noted that fast-track programs aided commercialization by decreasing the time required until inventors could license their patent applications or begin commercializing their inventions.[342] He also noted that these fast-tracked patent applications were cited more often than their contemporary non fast-tracked patent applications—which expands the public domain by limiting what an inventor can claim exclusive rights over.[343] This expansion would reduce the costs of climate innovation, increasing access to climate technology, and potentially reducing emissions.[344]

Eric Lane notes that a fast-track program requires examiners to more quickly examine certain applications while managing a large workload.[345] To strike this balance, offices impose process restrictions to limit the scope and complexity of patent applications.[346] These restrictions may include extra fees or a limit on the number of claims in a patent application.[347] As noted in Section II.G, however, these disparate programs have different subject matter eligibility schemes and different process restrictions. Thus, it is difficult for a green patent application to comply with multiple fast-track programs at once.[348] He proposes a global patent fast track system with a broad subject-matter eligibility scheme unrestricted by enumerated technology classification, and reasonable process restrictions such as claim limits and single-invention limits to reduce examiner workload and accelerate examination.[349] Any increase in harmonization is useful if it promotes the usage of these programs, or specifically if it promotes pursuing patent protection and commercialization in the U.S. Lane's suggestions, however, elide the low usage of the individual programs to start and also avoid the question of how to convince multiple countries' patent offices to change their rules simultaneously.

341. *See supra* Section II.E.2, III.A.1.
342. DECHEZLEPRÊTRE, *supra* note 163, at 11–12.
343. *Id.* at 12.
344. *See supra* Section III.A.2.
345. Lane, *supra* note 176, at 1170.
346. *Id.* at 1163.
347. *Id.* at 1160–61.
348. *Id.* at 1151.
349. *Id.* at 1160–61.

This Note instead recommends that the U.S. adopt a solution implementable by any single patent office, in conjunction with their extant rules. This program should be easily adoptable by any single country's patent and trademark office. This program should promote the commercialization of granted patents. This program should promote the disclosure of the inventions submitted. Furthermore, this program should avoid slowing down examination speed by overburdening patent examinations.

The first subsection proposes a statement and rules of this hypothetical patent acceleration program. The following subsections justify the individual provisions in this hypothetical program.

1. Model Rules for a New Green Patent Fast-Track Program

1. The U.S. Green Patent Fast-Track Program ("U.S. GPFP") is a system for accelerated examination of patent applications pertaining to green technology.
2. To qualify for the U.S. GPFP, an applicant shall certify that the patent application claims priority to a previous application and shall certify that the previous application was examined through a green patent acceleration program.
3. The certification shall identify the application number on the previous application, the intellectual property authority or the country in or for which the application was filed, the name of the green patent acceleration program, and the date of filing the application.
4. If the applicant does not certify that the patent application claims priority to a previous application, or does not certify that the previous application was examined through a green patent acceleration program, then the U.S. Patent and Trademark Office shall follow U.S. law to determine whether the patent application is eligible for accelerated examination.
5. The accompanying patent application shall contain two or fewer independent claims and ten or fewer total claims.
6. The accompanying patent application shall be published at the earlier of eighteen months after the earliest effective filing date or three months after the U.S. Patent and Trademark Office examiner sends a non-final Office Action, subject to exceptions under 35 U.S.C. § 122(b)(2).

2. Discussion

To borrow Eric Lane's terminology, rules two through four are implicitly "subject matter" rules.[350] Patent applications cannot add new information within their disclosure during examination, and patents can only claim priority if the

350. *Id.* at 1163.

subject matter is the same.[351] Therefore, the subject matter of the second patent application is the same as the subject matter of the previous patent application. Under this rule, if the subject matter of the previous patent application was appropriate for any country's green patent fast-track program, then it is appropriate for the U.S. Patent Office.

This rule is easily implementable by any Patent Office because it limits the costs that the Patent Office would sustain to verify subject matter eligibility, such as by determining what technical class an invention falls into.[352] Furthermore, an inventor that files an application in only one Patent Office will not face a sudden change in rules to comply with a global standard. In addition, by reducing the time needed to verify subject matter eligibility, this rule would shorten the examination process.

On its face, this rule may impinge the most-favored-nation principle of TRIPS—that any advantage, favor, privilege, or immunity granted by a member to the nationals of any other country shall be accorded immediately and unconditionally to the nationals of all other members.[353] After all, if this rule were accepted, the U.S. Patent Office may favor green technology patent applications from countries with fast-track programs compared to those from countries without these programs. But this rule does not treat the *nationals* of one country different than the nationals of another country. Any inventor, after all, may apply for a patent application in any country.[354] Thus, any inventor may apply to any of the green fast-track programs and consequently, apply to the United States Patent Office. This provision is thus acceptable under TRIPS.

The process restriction of rule five is meant to reduce the workload of an individual examiner, who must examine each individual claim to determine whether that claim covers patent-eligible subject matter, is novel, and is nonobvious in light of the field of previous inventions.[355] Typically, the USPTO expects three independent claims and twenty total claims and will charge an extra fee if either of these limits is breached.[356] Reducing the number of claims submitted will let a patent examiner examine the total patent application at a faster rate.

Limiting the number of claims in this application would not prejudice the inventor either, even though normal applications allow twenty claims or more. An inventor (or applicant) may file at least one continuation application based on the same disclosure, and these continuation applications can present different claims.[357]

351. 35 U.S.C. § 132(a) ("No amendment shall introduce new matter into the disclosure of the invention."); MPEP, *supra* note 203, § 608 ("No new matter can be added to an application after its filing date.").

352. Lane, *supra* note 176, at 1161.

353. TRIPS Agreement, *supra* note 153, at art. 4.

354. *See, e.g.*, 35 U.S.C. § 102 (making no distinction between a domestic applicant and a foreign applicant).

355. *See supra* Section II.F.2.

356. 37 C.F.R. § 1.16(h)–(i) (2018).

357. 35 U.S.C. § 120.

Under rule six, the patent application will be published at the earlier of eighteen months after the earliest effective filing date, or three months after the examiner sends a first office action.[358] But under 37 CFR 1.138, the applicant may still seek to abandon the application to avoid publication by submitting a declaration of express abandonment by four weeks before the projected publication date.[359] In this scenario, the inventor would have renounced exclusive rights, but would also have not disclosed to the world.

This rule is aimed to expand the climate technology public domain within the U.S. By publicly disclosing the invention, the inventor gives other inventors the chance to learn from the work and develop their own inventions.[360] In exchange for faster examination with no fees, the inventor must publicly disclose the invention more quickly to advance the progress of science. This earlier publication date also does not violate the U.S.' international obligations under TRIPS. Article 27 of the TRIPS Agreement does not restrict a sovereign state's ability to change its publication date.[361]

But the U.S. may well be opposed to forcing an earlier disclosure of its patent applications. Inventors may be less likely to seek a patent application if they are forced to disclose their invention to the public without knowing whether they have a chance at exclusivity or not. In such a case, inventors may prefer to rely on trade secrecy. Furthermore, the inventors may rely on "express abandonment" as outlined in 37 CFR § 1.138 to abandon exclusive rights in the invention in order to avoid disclosing it to the public.[362]

V. CONCLUSION

In conclusion, this Note finds little evidence that the Paris Withdrawal Announcement caused patent applications on climate technology filed in the U.S. to decline relative to patent applications on climate technology filed in any other country. U.S. patent applications on climate technology did decline relative to patent applications on climate technology filed in China, Japan, the European Patent Office, and the World Intellectual Property Organization. This relative decline is likely not wholly caused by the Paris Withdrawal.[363] Even so, it has a negative effect on climate change innovation in the U.S. because it augurs reduced commercialization and deployment for climate-change technologies.[364]

358. *See supra* Section II.F.2 (discussing Office Actions).

359. 37 C.F.R. § 1.138(c) (2018) ("An applicant seeking to abandon an application to avoid publication of the application (see 1.211(a)(1)) must submit a declaration of express abandonment by way of a petition under this paragraph including the fee set forth in § 1.17(h) in sufficient time to permit the appropriate officials to recognize the abandonment and remove the application from the publication process. Applicants should expect that the petition will not be granted and the application will be published in regular course unless such declaration of express abandonment and petition are received by the appropriate officials more than four weeks prior to the projected date of publication.").

360. *See supra* Section III.A.2 (discussing the benefits of the public domain).

361. TRIPS Agreement, *supra* note 153, art. 27.

362. 37 C.F.R. § 1.138(c) (2018).

363. *See supra* Part III.

364. *See supra* Section III.A.

This relative decline, however, also has a positive effect on climate change innovation in the U.S. by expanding the public domain of climate change technology and increasing U.S.' access to foreign climate innovation at a lower cost. To address this relative decline, the U.S. Patent and Trademark Office should open a new Green Fast-Track Program designed to increase the commercialization of climate technologies and to expand the climate technology public domain.[365]

365. *See supra* Section IV.B.