BOSTON TECH HUB FACULTY WORKING GROUP

Annual Report

2018–2019

HARVARD Kennedy School
BELFER CENTER
for Science and International Affairs
Technology & Public Purpose Project

Harvard John A. Paulson
School of Engineering
and Applied Sciences

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FWG participants explore private sector investment in emerging technologies and the impact investing practices have on the development of these technologies.

Foreword

In 2017, we decided to convene some of the world's leading minds in the sciences, law, economics, and humanities to discuss the direction of technology and its unbounded opportunities. The decision rested on a key principle: **Boston provides the ideal environment to develop not only leading-edge technology, but also civically informed solutions for today's tech dilemmas.** Because rapid innovation in technology can circumvent the values of privacy, inclusion, transparency, and security, public purpose needs to be valued as a fundamental requisite of innovation. By recognizing its potential for both good and bad, technology can be guided toward the greater benefit of society.

With its rich history and vast resources, Boston is the perfect place to take the lead.

Throughout most of our nation's history, Boston has been at the epicenter of America's technological progress. The industrialization of New England—and the diversity of its sunrise industries—concurrently impacted the development of its universities. Beginning as early as the mid-1800s, Harvard and later MIT embarked on a mandate that stretched beyond the role of a traditional liberal arts institution and looked toward the development of practical innovations. The two universities became closely intertwined with commercial enterprise, and today's leaders in technology can often be traced back to these origins.

Boston's success and technological prowess are also predicated on a close relationship with government. Over the last century, federal research dollars have flooded into the city's basic science research, but particularly toward unprecedented advances in the applied sciences. In biotech, energy, materials, robotics, space, defense and other industries, both Harvard and MIT are well positioned to solve the country's most demanding technical and policy challenges. The invaluable connection between Boston and Washington D.C. aligns technologists with honorable work and a duty to secure a positive future for their inventions.

The Faculty Working Group set out to explore today's unique challenges. In the fall, we focused on new technologies, or their novel applications, including: **do-it-yourself medical devices**, **solar geoengineering, quantum computing**, and **remote sensing**.

In the spring, we put forward potential solutions for current dilemmas and discussed topics such as: **reinstating the Office of Technology Assessment**; **the role of venture capitalists in weighing public purpose when investing**; **the right approach for sharing intellectual property**; and **the role of international norms for emerging technologies**.

Each session addressed a new frontier in technology that our society is only beginning to grapple with or struggling to adapt to. The participants included interdisciplinary faculty scholars, technologists, and other stakeholders from across Harvard and MIT, as well as government and industry. The discussions that arose from these sessions frame the key takeaways in this report.

A critical challenge of our time is making technological change positive for all. The fate of our collective future requires that experts—in academia, government, or industry—apply their knowledge in the service of civic duty and public purpose. The brightest and most creative problem solvers seek the hardest, most interesting problems. In Boston, this has been a tradition.

Sincerely,

Ash Carter
Frank Doyle

FWG Members and Guests

Chairs

Ash Carter – *Director, Belfer Center, HKS; Faculty Director, Technology and Public Purpose Project, Belfer Center, HKS; Board Member and Innovation Fellow, MIT; Former U.S. Secretary of Defense*

Frank Doyle – *John A. Paulson Dean, John A. & Elizabeth S. Armstrong Professor of Engineering & Applied Sciences, Harvard John A. Paulson School of Engineering and Applied Sciences*

Harvard Kennedy School

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Matt Bunn	*Professor of Practice*
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Bruce Schneier	*Adjunct Lecturer in Public Policy*
Kathryn Sikkink	*Ryan Family Professor of Human Rights Policy*
Nick Sinai	*Adjunct Lecturer in Public Policy*
Susan Winterberg	Fellow, Technology and Public Purpose Project, Belfer Center

Harvard John A. Paulson School of Engineering and Applied Sciences

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Eyal Dassau	*Director, Biomedical Systems Engineering Research Group*
Paul Karoff	*Assistant Dean for Communications and Strategic Priorities*
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Vikram Mansharamani	*Lecturer*
Venkatesh Narayanamurti	*Benjamin Peirce Research Professor of Technology and Public Policy; Former Dean, SEAS*
Salil Vadhan	*Vicky Joseph Professor of Computer Science and Applied Mathematics*
Jim Waldo	Chief Technology Officer, Gordon McKay Professor of Practice of Computer Science, SEAS; Professor of Policy, HKS

Harvard Business School

Tom Eisenmann	*Howard H. Stevenson Professor of Business Administration; Faculty Co-Chair, Rock Center for Entrepreneurship*
Joseph Fuller	*Professor of Management Practice in General Management*
Nien-he Hsieh	*Associate Professor of Business Administration*
Karen Mills	*Senior Fellow*
Mitch Weiss	*Professor of Management Practice*

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Urs Gasser	*Professor of Practice; Executive Director, Berkman Klein Center*
Hannah Hilligoss	Senior Project Coordinator, Cyberlaw Clinic

Harvard Medical School

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Angela DePace	*Associate Professor of Systems Biology*

Harvard University

Isaac Baker	*Imagery Analysis Manager, Harvard Humanitarian Initiative*
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Clare Ploucha	*Administrative Program Manager, Max Planck/ Harvard Research Center for Quantum Optics*
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Dan Schrag	*Sturgis Hooper Professor of Geology; Professor of Environmental Science and Engineering*
Chris Stubbs	*Dean of Science*
George Whitesides	*Woodford L. and Ann A. Flowers University Professor*

MIT

Hal Abelson	*Professor of Computer Science and Engineering*
Danielle Braje	*Assistant Group Leader, Quantum Information & Integrated Nanosystems Group, MIT Lincoln Laboratory*
Erik Brynjolfsson	*Director, MIT Initiative on the Digital Economy; Professor at MIT Sloan*
Nazli Choucri	*Professor of Political Science*
John Deutch	*Emeritus Institute Professor*
Bernadette Johnson	*Chief Technology Ventures Officer, MIT Lincoln Laboratory*
Jeantine Lunshof	*Research Scientist/Ethicist, MIT Media Lab*
Andrew McAfee	*Co-Director, initiative on the Digital Economy; Principal Research Scientist, MIT Sloan School of Management*
Katie Rae	*CEO & Managing Director, The Engine*
Sara Rendtorff-Smith	*Applied Research Lead, Data Driven Governance and AI Policy, Probabilistic Computing Project*
Larissa Rudenko	*Visiting Scholar*
Daniela Rus	*Director, CSAIL and Andrew and Erna Viterbi Professor of Electrical Engineer and Computer Science*
Andre Uhl	*Project Lead, The Council on Extended Intelligence, MIT Media Lab*

U.S. Government

Tatjana Curcic	*Program Manager, DARPA Defense Sciences Office*
Roberto Diener	*Senior Lead Scientist, Booz Allen Hamilton (DARPA)*
Bill Foster	*Representative (D-IL), U.S. House of Representatives*
Patrick Gault	*Senior Geospatial Analyst, USAID*
Jeff Kojac	*Department of Navy Lead (Colonel), Joint Artificial Intelligence Center*
Jake Taylor	*Assistant Director for Quantum Information Science, White House Office of Science and Technology Policy*

Industry & Non-Profit

Jeff Bussgang	*General Partner, Flybridge*
Steve Holtzman	*President and CEO, Decibel Therapeutics*
Eric Lander	*President & Founding Director, Broad Institute*
Anja Manuel	*Founding Partner, RiceHadleyGates LLC*
Eric Schmidt	*Technical Advisor, Alphabet*
Jay Schnitzer	*Chief Technology Officer, The MITRE Corporation*
David Sullivan	*Director of Learning and Development, Global Network Initiative*
Kara Swisher	*Editor-at-Large, Recode*
Bina Venkataraman	*Director of Global Policy Initiatives, Broad Institute*

Kara Swisher, co-founder and editor-at-large of Recode, questions whether Big Tech firms are ready to take responsibility for the outcomes of emerging technologies.

Introduction

The historic arc of technological progress is in constant flux. Technological innovation has no innate or pre-determined nature; humans are the ultimate decision makers in how technology is developed, deployed and managed. The opportunities for doing evil are no less frequent than those which advance humanity forward toward the benefit of society. As such, each era of technological advancement has required the collective action of citizens, experts, and policymakers to put forward their values and new laws to govern newfound technologies and to manage their consequences.

However, even with the right intentions, the *act* of embedding public purpose is not simple. How can we advance technology while also ensuring that it remains socially coherent and adherent to our common values?

Over the course of the past year, the Boston Tech Hub Faculty Working Group set out to define the challenges and identify opportunities for technologists and policymakers to work together and shape a technology's progress in a measured way. The participants identified points of transaction—issuing and renewing federal funding, securing licensing, evaluating patents, enabling tech transfer, applying to an incubator or accelerator, training venture capitalists, increasing government capacity, and others—that could serve as avenues for public purpose to enter the design and application of technology.

Summary

The pervasiveness of consumer technologies and their applications is redefining long-standing notions of public purpose values like privacy, security, equity, and access

- The ubiquity of many new consumer technologies has introduced tech into areas of life where it was previously limited. The proliferation of data and sensors has given consumers access to troves of new information, but they have also forced society to redefine notions of public purpose in the context of these new technologies.
- While the values of public purpose are long-standing, their traditional conceptions are no longer exhaustive. Private companies and governments have equally become privy to troves of new consumer data without the means to properly account for this phenomenon. For instance, as the Supreme Court ruled in 2018 in *Carpenter v. United States*, the ability to continuously monitor an individual's movement through their cellphone location has transformed commonly held expectations of privacy.
- New digital or biomedical technologies are providing individuals with greater—but often inequitable—access to leisure, healthcare, and safety. Certain populations, however, remain excluded due to cost barriers, geographic location, or other factors.

Congress' structural organization, lack of funding, and narrow talent pipeline pose challenges for addressing issues arising from new technologies in a timely and effective manner.

- New technology issues pose an institutional challenge for Congress. Most often, the majority party leadership's agenda takes precedence over the Senate's Commerce, Science, and Transportation Committee and the House's Science, Space and Technology Committee. As such, pressing technology policy questions are not always prioritized or addressed in a timely manner. Over the last few decades, Congress has also become more partisan and polarized, meaning that even previously non-partisan issues have become more contested among members of both chambers.

- Congressional committees, legislative branch support agencies, and personal offices have witnessed reduced levels of funding over the last five decades. In 1995, Congress de-funded the Office of Technology Assessment, an in-house support agency tasked with conducting forward-looking analyses of frontier technologies and offering policy options to Congress. As a result, Congress has become more reliant on external actors with their own agendas, such as corporate lobbyists, for issue-area expertise. The rising influence of outside interests has reduced the amount of legislation that is directly accountable to the American public.

- Over the past 25 years, as the pace of technological change has accelerated, Congress has slashed the number of expert staff members on committees and in legislative support agencies. The branch's 20th-century hiring model—which prioritizes starting young and hiring from within existing networks—discourages STEM graduates from working on Capitol Hill.

There are limited enforcement mechanisms to protect public purpose, even as the need for them is increasingly recognized.

- Emerging technologies and new applications of existing technologies are often running into conflict with the principles of bias, privacy, transparency, access, and equity, among others. Some companies, such as Alphabet's DeepMind or OpenAI, have set forward general principles to ensure their work is safe, transparent, and socially accountable. However, beyond these measures of self-regulation, there are limited enforcement mechanisms or authorities to ensure that both the development, and later, the deployment of technology, adheres to these principles.

- At a national level, there are several inflection points that could serve as avenues for incorporating public purpose into technology development in the United States. While government agencies and research institutions publish general mission statements, these are not currently measured or enforceable. Early in the development process, technologists at universities or government labs could be held to more concrete requirements for receiving federal funding or later, the transferring of licenses to private entities. For instance, term sheets could require hiring a risk officer, ensuring key employees obtain security clearances, or creating governance, oversight, and accountability mechanisms on a sponsoring organization's board of directors.
- At an international level, the tech community faces challenges historically similar to those in the human rights, arms control, and biotechnology fields. For some technologies, there are global bodies in place with established and trusted processes. Gene editing, for instance, is being addressed by groups like the World Health Organization However, the lack of policy at a national level complicates international coordination in other domains. Currently, a handful of private companies have market capture for numerous technology issues and have different obligations than national governments. For example, while the U.S. government advances its own initiatives in quantum computing, many of the leaders of this technology are currently private companies conducting internal research and development (R&D).

Venture capitalists and entrepreneurs have untapped potential to shape technological development, but lack expertise and incentives to conduct rigorous public purpose evaluations.

- The rapid growth model of venture capital investments often forces firms to prioritize the commercialization of specific technology applications. Prior to funding entrepreneurs, investors need to consider the hidden risks and unintended consequences of their portfolio firms and how they will safeguard against these risks.

Hiring regulatory or public purpose expertise can help investors navigate underlying externalities.

- More fundamentally, the market incentives of companies at various stages of maturity must increasingly reflect the assumption that financial success need not be at odds with implementing risk measures and safeguards. Companies should be incentivized to fund products and services with high societal impact, without insurmountable expectations of their returns and with proper support.
- Entrepreneurs require additional support tools and mentorship to conduct in-depth analyses of first- and second-order effects of a technology's impact. Incubators and accelerators, which are socially-minded or follow longer funding cycles, can provide entrepreneurs with support resources beyond their operational needs. Similarly, active management from VC partners or specialized board members can assist in this process as well.

International collaboration and international competition are not mutually exclusive. Scientific sharing and progress can continue, even as defensive measures are implemented to protect national interests.

- International collaboration among scientists, through shared research and publication, has been critical to advancing knowledge in nearly all scientific disciplines. However, countries—especially the U.S. and China—are not only strategic rivals; they often have significantly different views about the role and importance of privacy, free speech, data ownership, and others. The divergence of national values complicates the development of international norms.
- Increasingly, the United States has been using entities such as the Committee on Foreign Investment in the United States (CFIUS) and the Department of Commerce's Bureau of Industry and Security (BIS) Entity list to limit intellectual property (IP) sharing,

technology transfers, and exports to protect national security, foreign policy goals, and economic advantage.

- While the United States' defensive measures to China's technological prowess are worthy efforts, Washington should take advantage of American innovation and reinvest in R&D. According to the National Science Foundation, today's federal spending on basic and applied science amounts to approximately 1.7% of all federal spending and 0.3% of U.S. GDP—figures that greatly pale in comparison to when America's investment in science peaked in 1965 totaling at 3.6% of federal budget spending. On important scientific frontiers, such as most cited AI research, China is already poised to surpass the United States in the near future—Washington should heed these warnings and act to secure America's competitiveness.

The Boston Tech Hub Faculty Working Group was able to collaborate on issues ranging from technological development to shaping market forces and clearing bureaucratic hurdles. The confluence of experts from various disciplines discussing a wide range of technologies produced a litany of insights and potential solutions, as well as many questions on how to seize them for the greater good. Regardless of any member's professional origins, the group's ability to actively debate and share information brought otherwise untapped knowledge to the surface.

In the Fall 2019 semester, these sessions will continue. A new set of technologies, both timely and forward-looking, will include **facial recognition, gene drives, space technologies, and life extension.** We look forward to further expanding our network in the Boston area and beyond, bringing together individuals dedicated to working on collective solutions to the most pressing issues of our time.

Nien-He Hsieh, Professor of Business Administration at the Harvard Business School, stresses how corporations can pursue social purpose to realize societal goals.

BOSTON TECH HUB FACULTY WORKING GROUP

Session Briefs

Fall 2018

BOSTON TECH HUB FACULTY WORKING GROUP

FALL SESSION 1 • SEPTEMBER 27, 2018

DIY Medical Devices

BRIEF BY:

Bogdan Belei

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DIY Medical Devices

The Boston Tech Hub Faculty Working Group, hosted by former Secretary of Defense and Harvard Kennedy School Belfer Center Director **Ash Carter** and Harvard SEAS Dean **Frank Doyle**, will convene its first fall session on the topic of Do-It-Yourself (DIY) medical devices.

This session will examine the lack of formal approvals and safety evaluations in the development. Of DIY medical technologies and will evaluate the current status quo across the DIY medical technology community. There will also be discussion of solutions to promote the development of safe and effective technologies for medical care.

Context:

- **Current FDA evaluation process:** The Food and Drug Administration (FDA) is mandated to evaluate medical technologies using the 'safety' and 'effectiveness' dual standards. While the FDA is committed to helping patients gain access to new medical devices, some industry experts have criticized the FDA's lengthy approval process, which they argue prevents innovative medical devices from reaching the market in a timely manner.
- **Lengthy existing approval process:** Due to the current lengthy approval process, some individuals have resorted to developing their own medical devices by exploiting vulnerabilities in existing medical devices. The development of emerging DIY medical technologies has been facilitated by public access to open source hardware, open source code, mobile devices, and new user interfaces, among other factors.
- **Unregulated risks of DIY medical devices:** Many DIY devices, which are developed outside of the regulatory process, are unrestricted by testing trials and safety standards. Subsequently, they introduce unregulated risks that could lead to serious injury or death in patients who choose to develop their own device or administer their own medication (or parents who choose to develop a device for or administer medication to their child).
- **Updating the FDA assessment system:** The FDA is creating a new assessment system for medical device innovation by modernizing clinical trials, streamlining the FDA's organization and processes to accelerate regulatory science, and expanding the FDA's capacity to analyze complex real-world data streams to detect early safety and efficacy signals. However, any improvements to the assessment system will not impact DIY medical technologies without outreach or another approach that extends to the community currently operating outside the bounds of government oversight.

Discussion Questions:

- How can technologists and industry experts promote the development of safe and effective DIY medical technologies?
- How can policymakers develop an effective process to incorporate DIY medical devices into the existing regulatory system?
- How can policymakers develop and update liability guidelines?

Readings:

Gottlieb, Scott. "Implementing the 21st Century Cures Act: A 2018 Update from FDA and NIH," Testimony before the Subcommittee on Health, Energy and Commerce Committee, U.S. House of Representatives, July 25, 2018. Accessible online.

Greenan, Matthew and Robert Town. "FDA and the Regulation of Medical Device Innovation: A Problem of Information, Risk, and Access," Wharton University of Pennsylvania: Public Policy Initiation, Volume 4, Number 2, February 2016. Accessible online.

Kresge, Naomi and Michelle Cortez. "The $250 Biohack That's Revolutionizing Life with Diabetes," Bloomberg Businessweek, November 5, 2018. Accessible online.

Piller, Charles. "An Anarchist is Teaching Patients to Make Their Own Medications," Scientific American, October 13, 2017. Accessible online.

BOSTON TECH HUB FACULTY WORKING GROUP

FALL SESSION 2 • OCTOBER 16, 2018

Solar Geoengineering

BRIEF BY:

Lizzie Burns

Fellow at Harvard's John A. Paulson School of Engineering and Applied Sciences and Program Director of Harvard's Solar Geoengineering Research Program

David Keith

Gordon McKay Professor of Applied Physics at Harvard's John A. Paulson School of Engineering and Applied Sciences and Professor of Public Policy at Harvard Kennedy School

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Solar Geoengineering

The Boston Tech Hub Faculty Working Group, hosted by former Secretary of Defense and Harvard Kennedy School Belfer Center Director **Ash Carter** and Harvard SEAS Dean **Frank Doyle**, will convene its second fall session on the topic of solar geoengineering and the question of whether serious research efforts in this field should be undertaken around the world. This session will discuss current knowledge about solar geoengineering and explore how a more vigorous research effort might reduce uncertainties.

Context:

- **Overview of solar geoengineering**: Solar geoengineering (SG) is the deliberate, large-scale alteration of earth's radiative balance with the goal of reducing some of the risks of accumulating greenhouse gases. The direct costs of implementing some methods of global SG is low—on the order of 10 $bn/year—which would include both deployment and some additional monitoring and science.
- **Potential benefits of solar geoengineering**: Early evidence suggests that SG could sharply reduce many of the impacts of climate change— from extreme temperatures and storms to rising seas and changes in water availability. SG cannot be a perfect substitute for cutting emissions, but it's plausible that a combination of emission cuts and SG can achieve significantly lower climate risk this century than emissions cuts alone. It is expected that deployment of SG would roughly halve the increase in global temperature. Yet, these benefits come with novel technical, environmental, and policy risks.
- **Existing efforts on solar geoengineering**: SG is controversial. Concerns include the prospect that increased visibility of SG will provide ammunition to forces that oppose emissions cuts—the so called 'moral hazard"—and the challenges of governing a technology with global impacts that can be deployed unilaterally. At present, perhaps because of the controversy, there is very little research taking place on SG. Current global funding is about 10 $m/year, including Harvard's Solar Geoengineering Research Program which is now funded at over 2 $m/year. There are increased calls for research by, for example, the National Academies (NAS), the U.S. Global Change Research Program (USGCRP), and the American Geophysical Union (AGU) along with major environmental groups such as the Environmental Defense Fund (EDF) and the Natural Resources Defense Council (NRDC), and the American Geophysical Union (AGU), along with major environmental groups such as the Environmental Defense Fund (EDF) and the Natural Resources Defense Council (NRDC).

  In 2017, Janos Pasztor, former UN Assistant Secretary-General for Climate Change under Secretary-General Ban Ki-moon, launched the Carnegie Climate Geoengineering Governance Initiative (C2G2) which seeks to catalyze the creation of effective governance for climate geoengineering technologies by shifting the conversation from the scientific and research community to the global policy-making arena. This effort is moving fast, and it may lead to a UNGA resolution or creation of a world commission.

Discussion Questions:

- How can research be accelerated while minimizing the extent to which that research can be used as a tool oppose emissions mitigation?
- What early steps by the U.S. are appropriate to lay the groundwork for international governance of SG?
- What is the appropriate role for universities and private philanthropies in SG research?

Readings:

Irvine, Peter, Kerry Emanuel, Jie He, Larry Horowitz, Gabriel Vecci, and David Keith. [Under review] "Halving warming with idealized solar geoengineering moderates key climate hazards," *Nature Climate Change*, Volume 9, April 2019. Accessible online.

Keith, David. "Toward a Responsible Solar Geoengineering Research Program," *Issues in Science and Technology*, Volume XXXIII, Number 3, 2017. Accessible online.

Keith, David and Peter Irvine. "The Science and Technology of Solar Geoengineering: A Compact Summary," Governance of the Deployment of Solar Geoengineering Workshop, Harvard Project on Climate Agreements, September 24, 2018. Accessible online.

Parson, Edward. "Climate policymakers and assessments must get serious about climate engineering," *Proceedings of the National Academy of Sciences of the United States of America (PNAS)*, August 15, 2017. Accessible online.

Pasztor, Janos, Cynthia Scharf, and Kai-Uwe Schmidt. "How to govern geoengineering?" *Science*, Volume 357, Issue 6348, July 21, 2017. Accessible online.

Pierrehumbert, Raymond. "The trouble with geoengineers 'hacking the planet,'" *Bulletin of the Atomic Scientists*, June 23, 2017. Accessible online.

BOSTON TECH HUB FACULTY WORKING GROUP

FALL SESSION 3 • OCTOBER 30, 2018

Quantum Computing

BRIEF BY:

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Quantum Computing

The Boston Tech Hub Faculty Working Group, hosted by former Secretary of Defense and Harvard Kennedy School Belfer Center Director **Ash Carter** and Harvard SEAS Dean **Frank Doyle**, will convene its third fall session on the topic of quantum computing.

This session will examine where quantum computing stands today, the different sectors involved in the advancement of this field, its potential practical applications in the future, and how to safeguard against potential security risks.

Context:

- **Applications of quantum computing**: There is substantial uncertainty surrounding the ultimate commercial applications of quantum computing. A full-size quantum computer will be able to factor very large numbers quickly, which will in-turn lead to significant breakthroughs in cryptography—both the destruction of certain types of encryption and the development of new kinds of encryption. Quantum computing and access to early quantum hardware will also likely improve classical algorithms in optimization, machine learning, chemistry, and materials science. Additionally, it will enable the simulation of quantum systems, which will allow researchers to study interactions between atoms and molecules in new ways. This would eventually significantly advance industries including pharmaceuticals, chemicals, and energy. Quantum computers may demonstrate significant speed-up on optimization problems—finding the best solution from all feasible solutions—which could accelerate progress in several fields, notably artificial intelligence. While all these theorized applications would be transformational, most experts agree that much like previous technological breakthroughs, the most revolutionary applications of quantum computing likely have not yet been imagined.
- **Security considerations**: Although many of the applications of quantum computing remain unknown, there are already anticipated and pressing security concerns, including cryptography and rapid development in machine learning and artificial intelligence. Major advancements in machine learning and AI could lead to security and economic concerns, including issues surrounding transfer of work. Governments—most notably the American and Chinese governments—are already trying to update encryption standards to enable future secure communications and to prevent the retroactive decryption of information that was encrypted before the advancement of quantum computing technology. Quantum computing would also directly impact security in the commercial sector, with new cybersecurity approaches needed for e-commerce.
- **Still-developing science underpinning quantum computing**: Much of the science and engineering that underpins quantum computing is still being developed. The primary hurdle to the development of

quantum computing is determining how to control scalable quantum systems with high precision—how to harness qubits and manipulate them to behave in specific ways. There are also different physical systems that could be leveraged to create a quantum computer, including trapped ions, neutral atoms, photons, spins in solids, or the electric current in a superconductor. Although practical quantum technologies have already been developed, including sensors, actuators, and other devices, a full-fledged quantum computer that out-performs a classical computer on large-scale problems is likely still decades away. Additionally, much more work is needed on the role for quantum networking—both for nearer-term crypto-infrastructure and longer-term opportunities for a quantum internet.

- **Cross-sector effort**: Funding and research contributing to the development of quantum computing is provided by a range of actors including venture capitalists, industry, government, private foundations, and academia. Within the U.S. government, the primary funders of quantum computing research are the National Institute of Standards and Technology (NIST), National Science Foundation (NSF), Department of Energy (DOE), and defense and intelligence entities. While the U.S. government has provided millions of dollars for this research, the Chinese government is currently building a $10 billion National Laboratory for Quantum Information Sciences, projected to open in 2020. The White House recently released a national strategic plan for quantum information science that emphasizes the need to maintain a strong workforce and scientific front to enable future impacts of quantum computing to be realized and captured. It also calls for collaboration across sectors to provide critical infrastructure, determine how quantum computing impacts different agency mission spaces, and identify how quantum computation might impact national security.

Discussion Questions:

- How can technologists and industry experts promote the development of transformative quantum computing technologies while maintaining their benefit to society and national security when most practical applications of quantum computing remain unknown?
- How can policymakers encourage or incentivize effective collaboration between academia, industry, and government labs in the development of quantum computing?
- How should information sharing to promote scientific advancement and economic growth be balanced with intellectual property and national security concerns?
- How can policymakers and technologists work to secure previously public-key encrypted information and processes before quantum computing advances to a point of rendering some public-key cryptography practices ineffective or obsolete? What are the secondary and tertiary consequences of updating our public-key infrastructure both domestically and internationally?

Readings:

Castelvecchi, Davide. “Here’s what the quantum internet has in store,” *Nature*. October 23, 2018. Available online.

“National Strategic Overview for Quantum information Science,” *National Science & Technology Council: Subcommittee on Quantum Information Science*. September 2018. Accessible online.

Nielson, M.A. “Introduction to quantum information theory,” Center for Quantum Computer Technology and Department of Physics, University of Queensland. May 28, 2018. Accessible online.

“Quantum spring: The race is on to dominate quantum computing,” *The Economist: Business*. August 18, 2018. Accessible online.

Schneier, Bruce. “Cryptography after the Aliens Land,” *IEEE Security & Privacy*, Volume 16, Issue 5, September/October 2018. Accessible online.

BOSTON TECH HUB FACULTY WORKING GROUP

FALL SESSION 4 • NOVEMBER 27, 2018

Remote Sensing

BRIEF BY:

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Remote Sensing

The Boston Tech Hub Faculty Working Group, hosted by former Secretary of Defense and Harvard Kennedy School Belfer Center Director **Ash Carter** and Harvard SEAS Dean **Frank Doyle**, will convene its fourth and final fall session on the topic of remote sensing.

This session will examine current applications of remote sensing, the evolution of the industry due to other technological advancements in fields like quantum computing and machine learning, and how to continue to safeguard against potential security and privacy risks.

Context:

- **Defining remote sensing:** Remote sensing is the process of observing, measuring, or sensing to acquire information about an object or area without making physical contact with it. Satellite- or aircraft-based sensors are used to detect propagated signals. There are two kinds of remote sensing: 1) passive remote sensing in which a sensor detects the reflection of sunlight from an object (e.g. photography or infrared) and 2) active remote sensing in which a signal is emitted from a satellite or aircraft and a sensor then detects the reflection of that signal from an object (e.g. RADAR or LiDAR).
- **Enhancing remote sensing with other technological advances:** Remote sensing technology is not new. This technology was used as early as the 1840s when people took photos of the ground from balloons. Satellite remote sensing dates to the earliest days of the space age. Major advancements in the field have been enabled by other recent emerging technologies.

  The advent of the internet, expanding computer power, and the proliferation of data have coalesced and created substantially larger data sets, as well as new datasets, that can be leveraged by analysts. Different kinds of data from remote sensing, including optical, radar, or laser, can now be combined with data from non-remote sensing sources—such as internet textual data, census data, and health-care data—to solve specific real-world problems. In addition to increased access to big data, machine learning applied to remote sensing allows users to rapidly draw out actionable insights.

  Quantum sensing leverages the quantum nature of matter to measure qualities of an object with the highest relative and absolute accuracy. Of the quantum technologies being pursued right now, quantum sensing receives less hype, but is arguably the most advanced. There are numerous applications for quantum sensing including radar, navigation, ghost imaging, and detailed mapping (especially of features like hidden natural resources). Quantum communications technologies, a related field, will be critical for ultra-secure communication networks and a possible space-based quantum internet.

- **Expansion of commercial applications:** There has been exponential growth in commercial remote sensing. Over the last eight years, the number of remote sensing licenses has grown by almost a factor of ten—from 26 to 227.[1] Companies like EarthNow are preparing to launch satellites that will provide continuous global video of the Earth in real-time, commercially accessible on smartphones. Access to remote sensing products are already available on smartphones through GPS navigation, Google Earth, etc. HawkEye360 is a remote sensing start-up that will soon be launching satellites (via SpaceX) that identify and geolocate radio frequency signals of ships, and eventually trucks, allowing an algorithm to then real-time track them globally. These are just two examples of the more than 220 different commercially licensed applications of remote sensing that have significantly changed the landscape in terms of capabilities, as well as public access and use, of remote sensing-enabled tools.[2]
- **Updating regulation:** Although the commercialization of remote sensing has recently accelerated, current regulation dates to the 1990s and early 2000s. The Trump administration recently issued Space Policy Directive 2, which calls for new regulations for commercial remote sensing. The new regulations are expected to be released any day now, but industry leaders are already celebrating the update, anticipating that new regulations will be less onerous and more business-friendly. Historically, the U.S. government has been able to limit imagery services for national security or foreign policy reasons. The increasing commercial access to launching satellites and remote sensors, as well as the increasing size and importance of the international remote sensing industry, could challenge the U.S. government's ability to place restrictions on remote sensing products and companies in the future.
- **Technological challenges for remote sensing:** Although the remote sensing industry has advanced significantly in recent years, there remains several significant technological challenges for the industry. Leveraging heterogeneous big data from multiple sources can result in computational or methodological challenges that arise from processing scalability, noise accumulation, spurious correlation, incidental endogeneity, and measurement errors. Additionally, as companies and agencies increasingly rely on algorithms to help sort through large amounts of remote sensing data, algorithmic bias becomes a significant concern—especially as action-oriented recommendations are derived from such processes. Data storage is also a concern for the remote sensing industry as traditionally structured database management systems are increasingly unable to meet the requirements of managing big data.
- **Leveraging remote sensing for good**: Although advancements in remote sensing—especially commercial advancements—raise concerns such as protection of individual privacy, who should have access to remote sensing data, the lack forensic standards for use of remote sensing in demonstrating human rights violations, etc., there are also numerous beneficial applications of remote sensing. These applications include: environmental monitoring, forecasting to predict natural disasters or surveillance to guide rescue and recovery efforts after a natural disaster, tracking—proactively or

1 Foust, Jeff. "Revised remote sensing regulatory rule nears release," *Space News*, October 26, 2018. Accessible online.

2 Mosher, Dave. "SpaceX is about to rocket a fleet of satellites into space that will hunt smugglers, pirates, and other 'dark ships,'" *Business Insider UK*, November 15, 2018. Available online.

retroactively—human rights violations, and identifying potential groundwater reservoirs or deposits of other natural resources, among others.

Discussion Questions:

- How can policymakers better regulate the rapidly expanding commercial remote sensing industry? How should they promote the development of remote sensing-enabled technologies and applications that are beneficial in both economic and humanitarian terms, while also protecting national security and privacy?
- How should we determine which data from remote sensing should be publicly accessible and which data should have restricted access? How can we encourage expanded access to remote sensing data that benefits society—natural disaster response, humanitarian monitoring, etc.—while simultaneously preventing that data from being used for more nefarious purposes?
- At a time when large data from remote sensing and non-remote sensing sources are being combined, resulting in novel actionable observations to address real-world problems, can policymakers and industry officials proactively prevent the discovery of sensitive or individual-identifying information? How should policymakers and industry officials work to prevent these situations—or if they cannot be prevented, what procedures should be in place to respond to such situations?

Readings:

Hsu, Jeremy. “The Strava Heat Map and the End of Secrets,” *Wired*, January 29, 2018. Accessible Online.

Mcphee, Devon. “New method could lead to more powerful quantum sensors,” Phys Org, November 2, 2018. Available online.

Mosher, Dave. “SpaceX is about to rocket a fleet of satellites into space that will hunt smugglers, pirates, and other ‘dark ships,’” *Business Insider UK*, November 15, 2018. Available online.

“New quantum technology to counteract GPS hacking,” *Financial Express*, November 25, 2018. Accessible online.

Routh, Adam. “We’ll need more than Trump’s Space Policy Directive to fix commercial remote-sensing regulations,” *Space News*, July 10, 2018. Available online.

BOSTON TECH HUB FACULTY WORKING GROUP

Session Briefs

Spring 2018

BOSTON TECH HUB FACULTY WORKING GROUP

SPRING SESSION 1 • JANUARY 29, 2019

How Could Reinstating the Office of Technology Assessment and Other Mechanisms Help Congress Effectively Respond to Emerging Technologies?

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How Could Reinstating the Office of Technology Assessment and Other Mechanisms Help Congress Effectively Respond to Emerging Technologies?

The Boston Tech Hub Faculty Working Group, hosted by former Secretary of Defense and Harvard Kennedy School Belfer Center Director **Ash Carter** and Harvard SEAS Dean **Frank Doyle**, will convene its first session of the spring semester on the topic of the Office of Technology Assessment (OTA) and other mechanisms to help Congress effectively respond to emerging technologies.

This session will examine Congressional science and technology (S&T) capacity needs and how these needs are shaped by the current, rapidly evolving emerging technology landscape. This session will also explore the S&T-relevant resources that currently exist for Congress, and how the past work of OTA and similar efforts might be adopted to strengthen Congressional decision-making today.

Context:

- **Need for S&T advice to Congress**: Congress' recent inability to effectively engage on issues surrounding emerging and disruptive technologies has been evidenced by ill-informed questioning of Silicon Valley leaders and a reliance on lobbyists to draft and review technical legislation. Perhaps this should be unsurprising, as there are few in Congress with science and/or technology backgrounds. In the 115th Congress, there were only three scientists—a physicist, a microbiologist, and a chemist—and only a handful of engineers and medical professionals.[1] In the most recent election, seven new members with S&T backgrounds were elected, but members of Congress with an S&T background remain a significant minority. Staffers with an S&T background are an even greater minority. Of the more than 3,500 legislative staff on the Hill, it is estimated that less than one percent have formal technical training.[2] Since the late 1970s, across all legislative areas, there has been a general trend away from content expertise on the Hill. There has been a notable decline in committee staffing, in staffing of Congressional support agencies, and in the number of committee and subcommittee hearings.

- **History of OTA:** OTA was established in 1972. From 1972–1995, it served as an independent Legislative Branch support agency, staffed by technical experts from various disciplines. In its time, it was the only agency solely dedicated to conducting policy assessment of S&T issues for Congress. OTA's mission was to provide deep technical expertise on a wide range of issues that Congress faced. It published more than 750 technical assessments, memos, reports, and background papers on science and technology-related topics. OTA had three defining features: (1) there was bipartisan oversight of the agency; (2) OTA's experts

1 "Membership of the 115th Congress: A Profile," Congressional Research Service, December 20, 2018. Accessible online.

2 Moore, Travis. "Solving the Tech Deficit on Capitol Hill: A Call for Applications," *Lawfare*, August 22, 2018. Accessible online.

conducted consultations with all stakeholders, ensuring as many points of view as possible were considered; and (3) their final products provided policymakers with options and accompanying detailed assessments and projections, as opposed to a single policy recommendation for which OTA advocated.

In 1994, Republicans took control of Congress for the first time in 40 years. Guided by Newt Gingrich's "Contract with America," which promised to cut congressional spending, Republicans pushed to substantially reduce funding to congressional support agencies—including a complete de-funding of OTA. At the time it was defunded, OTA had a staff of around 200 people and a budget of $22 million—roughly $35 million in today's dollars and less than 0.001 percent of the $1.5 trillion federal budget at the time.[3] The law that established OTA was never repealed—OTA funding was just eliminated. Thus, OTA still exists on paper and reinstating the agency only involves re-funding it.

- **Other S&T resources for Congress:** Since the defunding of OTA, Congress has found other sources of S&T assessment, although none are as comprehensive or singularly dedicated to being a resource on S&T policy issues for Congress as OTA once was. When OTA was defunded, some believed that the Congressional Research Service (CRS) would absorb its mission. This did not happen and CRS still does not have a significant technology assessment capability, although CRS does produce some work on S&T topics for Congress. A small technology assessment program was established at the Government Accountability Office (GAO) in 2002, but it has only generated a few reports per year. More recently, Congress tasked GAO with developing a new, expanded structure to generate substantially more S&T assessments for Congress, and GAO's Comptroller General thus directed the stand-up of a full GAO mission team, Science, Technology Assessment, and Analytics (STAA). However, it remains to be seen how successful this effort will be.

  External entities have also sought to provide S&T expertise to Congress. Academia, other research groups like the National Research Council, and a range of think tanks all produce reports, briefings, and Congressional testimony to help advise Congress on S&T issues. Industry representatives and lobbyists often work to inform—and influence—Congressional staffers and members on technical issues. There are also fellowship programs that place people with technical backgrounds within Congressional offices. These fellowship programs include the American Association for the Advancement of Science (AAAS) and TechCongress.

- **Current views on S&T advice (and OTA) within Congress:** Support for OTA's reinstatement has been a largely partisan issue to date. However, support for reinstating OTA has been steadily growing in the House. The 2011 House vote to reinstate OTA was 176 to 235 with 11 Republican yes votes and 17 Democratic no votes.[4] The most recent vote for reinstating a minimum level of funding for OTA--$2.5 million—in 2018

3 Graves, Zach and Kevin Kosar. "Bring in the Nerds: Reviving the Office of Technology Assessment," R Street Policy Study, January 2018. Accessible online.

4 "Final Vote Results for Roll Call 627," Office of the Clerk, U.S. House of Representatives, July 22, 2011. Accessible online.

was an improved 195 to 217, garnering 15 Republican votes and losing only 6 Democratic votes.[5] The new Democratic majority in the House, in addition to several vocal Republican supporters of OTA, could produce more favorable conditions for successfully reinstating OTA in the new Congress.

Republicans often express concerns about the cost of an additional Congressional support agency focused on S&T issues and some express skepticism about if such a body is necessary. There is also a sense among some Democrats and Republicans that staffers are stretched so thin to cover large portfolios that they do not need a significant depth of understanding about S&T issues—especially given that S&T issues are not a priority for many members of Congress. Thus, many legislative staffers, members of Congress, and external OTA supporters acknowledge that if OTA was reinstated, it would need to be significantly reformed. The S&T landscape of today is markedly different than it was in 1995 when OTA was shuttered. Most commonly, people note that the pace of legislating today requires far more agile "quick response" resources that are brief and delivered on a tight timeline. (As opposed to the months- or years-long products delivered by OTA in the past.) Other than a need for more rapidity in a re-funded OTA's processes, there is not yet clear consensus about what other changes would be necessary to make a new OTA, or similar body, successful.

Discussion Questions:

- Of the existing S&T resources for Congress, what are the most effective in influencing and improving S&T decision-making by members of Congress?
- How do we get members of Congress to prioritize S&T issues? If they are not learning from existing S&T resources, why would they engage more with a re-funded OTA?
- Does the interconnectedness of S&T policy with other U.S. policy impact the kind of S&T assessment that Congress needs? (For instance, cooperating with China on issues like quantum computing, AI, or solar geoengineering could have economic, military, and geopolitical implications that a traditional S&T assessment might not consider.)
- How much technical expertise is needed to craft effective policy for S&T issues? Does there need to be a primary, unbiased source of S&T information for Congress (i.e. OTA) or would improving the existing array of options be sufficient to improve Congress' ability to engage on S&T issues?
- If OTA was reinstated, what would be an optimal structure and what kinds of products should it produce? Are there S&T topics it should prioritize?

5 "Final Vote Results for Roll Call 255," Office of the Clerk, U.S. House of Representatives, June 8, 2018. Accessible online.

Readings:

Carter, Ash. “How A Divided Congress Could Unite Around Tech: It’s time to bring back the Office of Technological Assessment,” *Politico*, December 6, 2018. Accessible online.

Graves, Zach and Daniel Schuman. “The Decline of Congressional Expertise Explained in 10 Charts,” Tech Dirt, October 18, 2018. Accessible online.

Keiper, Adam. “Science and Congress,” *The New Atlantis*, Fall 2004/Winter 2005 Edition. Accessible Online.

Pascrell Jr., Bill. “Why is Congress so dumb? We lawmakers dumped our in-house experts. Now lobbyists do the thinking for us.” *The Washington Post*. January 11, 2019. Accessible online.

BOSTON TECH HUB FACULTY WORKING GROUP

SPRING SESSION 2 • FEBRUARY 19, 2019

Does Venture Capital Have a Public Purpose Responsibility for Tech Startups?

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Does Venture Capital Have a Public Purpose Responsibility for Tech Startups?

The Boston Tech Hub Faculty Working Group, hosted by former Secretary of Defense and Harvard Kennedy School Belfer Center Director **Ash Carter** and Harvard SEAS Dean **Frank Doyle**, will convene its second session of the spring semester. This session will explore private sector investment in emerging technologies and the impact investing practices have on the development of these technologies.

Many emerging and disruptive technologies enter the market as start-up companies backed by venture capital (VC) firms. These technologies often deliver better and more affordable products to consumers, and provide improvements to critical public goods such as a free press, public transportation, and housing. However, new technologies also often result in the unintended and/or unanticipated disruption of critical public services, as well as undesirable applications of services by users. Today a new generation of start-ups are building the next round of disruptive technologies and services. These include blockchain, genome editing, quantum computing, space-based technologies, advanced artificial intelligence (AI), Internet of Things (IoT), and neurotechnologies—just to name a few—all of which have enormous market potential, but will also have transformational impacts on society.

A sustainable and peaceful future will depend on whether the next generation of innovators are able to anticipate and mitigate the challenges these technologies will bring, and this session will examine how VCs fit into this landscape.

Context:

- **VC funding for emerging technologies:** Many technologies first become publicly available through the commercial market, launched by start-up companies that are backed by VC firms. These companies can be based globally, but the highest concentration of VC-backed technology start-ups are in the U.S.—California-based companies receive the most VC dollars by a significant margin, followed by Massachusetts-, New York-, and Washington-based start-ups.[1] VCs invest in companies with technologies that span a range of industries, with an especially high concentration in digital technologies, biotechnologies, and energy. VC investment in technology companies has been rapidly expanding. For example, from 2013 to 2017, investment in AI companies increased by a factor of 4.5.[2]

1 Soper, Taylor. "With $57.5B invested so far in 2018, VC funding for U.S. startups reaching 'unprecedented levels,'" Geek Wire, July 8, 2018. Accessible online.

2 Shoham, Yoav, Raymond Perrault, Erik Brynjolfsson, Jack Clark, James Manyika, Juan Carlos Niebles, Terah Lyons, John Etchemendy, Barbara Grosz and Zoe Bauer, "The AI Index 2018 Annual Report", AI Index Steering Committee, Human-Centered AI Initiative, Stanford University, Stanford, CA, December 2018. Accessible online.

- **Existing responsible investing practices:** Consideration of environmental, social, and governance (ESG) metrics—also known as 'sustainable investing,' 'ESG investing,' and 'responsible investing'—is a rapidly growing practice among investors in publicly-held firms. According to research by Morgan Stanley, as of July 2018, $22.8 trillion ($1 of every $4 under professional asset management globally) is invested sustainability. Additionally, 70% of institutional investors (pensions, endowments, etc.) now incorporate ESG as part of their investment process.[3] There are different methods of incorporating ESG metrics into investment practices. For example, 'restriction screening' is the process of excluding entire product categories (e.g. weapons or fossil fuels) or methods (e.g. animal testing) from an investment portfolio. Another practice, 'ESG integration,' involves screening companies through measuring their performance on the most 'material' ESG issues for the industry, such as carbon emissions, data privacy, or protection of human rights in global supply chains.

- **Factors that preclude consideration of public purpose from current VC investment decision-making:** There are a number of reasons why ESG and other public purpose considerations have not yet been incorporated into VC investment decision-making. The VC fund business model typically operates on a high-risk, high-reward approach: if a VC invests in 20 companies, they are prepared for 19 to fail as long as one succeeds, covering their investment in all the companies.[4] In order to achieve this, they look for a company that has potential to disrupt or dominate a market, or rapidly scale to become a 'unicorn' with a $1 billion valuation. There is a lack of ESG data, empirical research, and ESG evaluation tools specific to early stage companies.

  Additionally, there are several core beliefs and biases common among VCs and entrepreneurs that have limited the uptake of societal considerations. The traditional gender imbalance in the VC community—in 2016, only eight percent of partners at top VC firms were women—impacts VC decision-making. Extensive research has demonstrated that women bring different views to investment vetting, and more diverse VCs consider a broader range of metrics when making investment decisions.[5] VCs also generally have a demonstrated preference for younger entrepreneurs over older, more experienced founders. These more-funded, but less-experienced entrepreneurs typically have less knowledge of regulatory environments and/or less prior experience conducting risk analysis and considering ESG metrics. Thus, the younger founders often have less experience considering the impacts of their products or services on their industry or society more broadly.[6] Many VCs also actively screen for founder personality profiles that demonstrate high levels of optimism and confidence. While these traits often correspond with positive qualities such as persistence through obstacles, empirical research demonstrates that these qualities also correspond with an inability to change course when ideas are not working and an inclination to introduce riskier products.[7]

3 "Sustainable Signals: Asset Owners Embrace Sustainable Investing," Morgan Stanley, 2017. Accessible online.

4 Strebulaev, Ilya, Theresia Gouw Ranzetta, and David Hoyt, "Venture Capital Deal Sourcing and Screening," *Harvard Business Review*, September 6, 2012. Accessible online.

5 Wendy DuBow and Allison-Scott Pruitt, "The Comprehensive Case for Investing More VC Money in Women-Led Startups," *Harvard Business Review*, September 18, 2017. Accessible online.

6 Azoulay, Pierre, Benjamin Jones, J. Daniel Kim, and Javier Miranda, "Age and High-Growth Entrepreneurship," NBER Working Paper No. 24489, April 2018. Accessible online.

7 Zhang, Stephen, & Cueto, Javier. (2017). The Study of Bias in Entrepreneurship. *Entrepreneurship Theory and Practice*, Volume 41, Number 3, 419-454. Accessible online.

- **Impact of current VC investment practices:** The current VC model encourages risk-taking and the 'move fast and break things' mentality among technology start-ups. VCs expect technology start-ups to grow at a significant rate with the ultimate goal of selling or going public relatively quickly to produce high returns for the investors. This kind of intensive pressure to rapidly scale—'blitzscaling'—can encourage entrepreneurs to push products to market even if they are illegal or unproven in their technical or financial feasibility. This has resulted in high profile cases of fraud such as Theranos, which scaled its blood testing products before validating efficacy. (It should be noted that Theranos did not receive VC funding—instead, their funding came from private placements.) In cases of social media platforms, this resulted in rapid growth of users on platforms without safeguards against abuses of 'bad actors.' In other cases—including Uber and Lyft—it has resulted in tactics to subsidize company operations to achieve market domination without profitability—with the goal to cash out at an IPO, before passing the risk of unprofitable business models on to public market shareholders.[8] In October 2018, a four decade record high was reached of IPOs for companies with no profits (83 percent)—exceeding the previous record of 81 percent just before the dot-com crash in 2000.[9]

Discussion Questions:

- Is the current VC financing model sustainable in the long-term? Is it good for society? What types of investment models for early stage technology ventures would provide better financial returns and societal impacts?

- Which factors should matter most for responsible investment in emerging tech VC funds?

- Do VCs and entrepreneurs building products with emerging technologies have a responsibility to anticipate potential abuses by users and take proactive measures to safeguard against harms before selling to the mass market?

- How does the education of MBAs and science and engineering students need to change to ensure the next generation of VCs and company founders are more thoughtful in their approach to managing societal impacts?

8 O'Reilly, Tim, "Blitzscaling: The Fundamental Problem with Silicon Valley's Favorite Growth Strategy," Quartz, 2019. Accessible online.

9 Shoop, Chad, "Dot Com Bubble 2.0?" Banyan Hill, 2018. Accessible online.

Readings:

Carreyrou, John, “Hot Startup Theranos Has Struggled With Its Blood-Test Technology,” *Wall Street Journal*, October 16, 2015. Accessible online.

Griffith, Erin. “More Start-Ups Have an Unfamiliar Message for Venture Capitalists: Get Lost,” *New York Times*, January 11, 2019. Accessible online.

Tavares, Rodrigo. “10 reasons startups should be socially responsible from birth,” Green Biz, March 20, 2018. Accessible online.

Wilson, Robert M. “Technology and ethics: what should investors consider?” Principles for Responsible Investment, December 19, 2018. Accessible online.

BOSTON TECH HUB FACULTY WORKING GROUP

SPRING SESSION 3 • MARCH 26, 2019

What is the Right Approach for Sharing Intellectual Property Around Emerging Technology?

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What is the right approach for sharing intellectual property around emerging technology?

The Boston Tech Hub Faculty Working Group, hosted by former Secretary of Defense and Harvard Kennedy School Belfer Center Director **Ash Carter** and Harvard SEAS Dean **Frank Doyle**, will convene its third session of the spring semester. This session will explore the limits and advantages of intellectual property (IP) sharing for emerging technologies.

For the purposes of this discussion, we are referring to IP broadly defined: proprietary algorithms, data collected, a complete developed product, etc. This brief focuses on tech companies, research centers, and labs that decide to limit access to certain types of IP in the name of protecting overall public good. This brief uses artificial intelligence (AI) algorithms as a primary example, but we expect discussion to encompass other technologies as well. This session will also examine the implications of alleged Chinese theft of emerging tech IP.

Context:

- **Menu of Approaches for Limiting Access to IP:** There are an array of different methods and tools that companies, universities, governments, and individuals can use to protect or limit access to IP for emerging technologies. These include withholding research or data from publication, classifying projects and methods so only individuals with specific security clearances can access them, applying for copyrights or patent protections, requiring that employees or researchers sign non-disclosure agreements, implementing certain privacy and differential access protocols, and introducing government policies that place strategic limits on tech transfer or exports of certain technology products or processes. (An example of this final approach is the Department of Commerce's recent efforts to develop criteria for emerging technologies that are critical to national security and might therefore be included in future export control regulations.)

- **Arguments in Support of Limiting Access to IP:** Those who want to limit access to emerging technologies often cite concerns about national security, 'bad actors' misusing technology for nefarious purposes, or the threat a technology could pose to a specific value du jour, such as privacy, defending against fake news, etc. (Many companies also cite business or economic reasons for wanting to protect their IP, but this concern is not the focus of this discussion.)

  Several organizations within the AI community, for instance, have recently taken steps to intentionally limit access to IP due to some of these concerns. Most recently, OpenAI announced that they would not release their trained model text generator, citing concerns about the "malicious applications" of the technology.[1] Instead, the research company released a much smaller model and a technical paper. Last November, the Machine Intelligence Research Institute (MIRI) announced a shift to a "nondisclosed-by-default" research policy. Under this policy, MIRI will only publish research after an active decision to do so—usually based on an anticipated safety upside resulting from publication. When making this announcement, MIRI cited concerns about potential existential risk posed by future AI research, as well concerns about researchers' ability to accurately predict/forecast what research could be most dangerous for society at this relatively early stage. Several private sector companies are also limiting IP around AI: in January, Google released a policy paper announcing limits on sharing their AI research software and code (due to fears of misuse), and Alphabet and Microsoft are now including warnings in their annual reports to investors about the potential ethical and legal complications that AI might cause.

- **Arguments Supporting Open Access to IP:** Proponents of maintaining widespread sharing of emerging technology IP often make several key arguments. They counter concerns of bad actors misusing a technology by arguing that making research, code, etc. public allows other researchers, journalists, and ethicists to examine the technology and identify possible issues (and help develop countermeasures). Many also suggest that research advancements happen more quickly when academics and other researchers share their work. There are also economic development arguments in support of open access to tech IP: new technology can create entire new industries when shared, and tech advancements can be harnessed or adapted to benefit emerging economies and countries. Numerous people have argued that limiting access to IP is ineffective. They suggest that another group will figure out a way to develop the same technology and release it, or an individual/group who disagrees with the decision to limit access could relatively easily release the information on the internet.

  Many universities and federal agencies that fund research have open access policies. Such policies are underpinned by the understanding that part of the mission of universities is to generate and disseminate knowledge. Thus, the policy of these universities is to ensure that their research (peer-reviewed journal articles) are available for anyone to "read, download, copy, distribute, print, search, or link to the full texts of these articles, crawl them for indexing, pass them as data to software, or use them for any other lawful purpose." Similarly, these universities emphasize that code should be open-source and that data should be "findable, accessible, interoperable, and reusable."[2] MIT and Harvard both have open access policies. Some government agencies have similar open access or public access policies—the National Institutes of Health (NIH) is a prominent example.

- **China and Emerging Tech IP:** There has recently been substantial international focus on China and emerging tech IP. Technological progress is a major tenant of China's long-term strategy—some

1 "Better Language Models and Their Implications," OpenAI, February 14, 2019. Accessible online.

2 "About Open Access," MIT Open Access Task Force. Accessible online.

believe that appropriating made-in-America tech is a key component of this strategy. China seeks to acquire foreign tech IP through some illegal tactics, including industrial espionage and cyber theft, but also through legal tactics such as acquisitions and early-state investments in start-ups. China also forces joint ventures: companies that want to produce or sell in the Chinese market are often encouraged or required to form a joint-venture with a Chinese firm. This process results in foreign companies turning over tech IP to Chinese partners. In November 2018, China passed a cybersecurity law that required data localization, providing China with access to foreign data, encryption, and source codes. China's tech IP acquisition efforts are largely focused on AI, robotics, augmented and virtual reality, and financial tech.

In an effort to counter Chinese tech IP acquisition, the U.S. passed the Foreign Investment Risk Review Modernization Act (FIRRMA) in August 2018. FIRRMA expanded the jurisdiction and powers of the Committee on Foreign Investment in the United States (CFIUS), the U.S. interagency committee that conducts national security reviews of foreign investment, to include review of U.S. businesses working on critical technologies. Specifically, CFIUS now has the ability to restrict Chinese investment in U.S. tech companies, including start-ups. The Trump Administration has also been publicly critical of China's unfair practices surrounding tech IP.

Discussion Questions:

- Are there categories of IP for which access should generally be limited? What characteristics of such IP make it potentially threatening to public good?
- Who is responsible (and best positioned) to evaluate which technology IP should be limited to protect public good? Government agencies that fund research? Researchers? Patent holders? The company that leverages the technology to produce a product for the market?
- What is the government's role in ensuring that the process of tech transfer continues to serve public good?
- Is limiting tech IP enough to protect public purpose? If not, what are the other processes that need to accompany it and who is responsible for those other needed steps?

Readings:

"Draft Recommendations of the MIT Ad Hoc Faculty Task Force on Open Access to MIT's Research," MIT Open Access Task Force, March 16, 2019. Accessible online.

Mak, Aaron. "When Is Technology Too Dangerous to Release to the Public?" *Slate*, February 22, 2019. Accessible online.

Soares, Nate. "2018 Update: Our New Research Directions" [Excerpt], Machine Intelligence Research Institute, November 22, 2018. Accessible online.

Tucker, Patrick. "This Pentagon Paper Explains Why the Trump Administration Is Reigning In Tech Trade with China," *Defense One*, April 6, 2018. Accessible online.

BOSTON TECH HUB FACULTY WORKING GROUP

SPRING SESSION 4 • APRIL 23, 2019

Where, If Anywhere, Can Effective International Norms be Developed for Emerging Technologies?

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Where, if anywhere, can effective international norms be developed for emerging technologies?

The Boston Tech Hub Faculty Working Group, hosted by former Secretary of Defense and Harvard Kennedy School Belfer Center Director **Ash Carter** and Harvard SEAS Dean **Frank Doyle**, will convene its fourth and final session of the spring semester. This session will explore current efforts to establish norms for emerging technologies, and how these efforts might be informed by previously established global norms in human rights, arms control, and biotechnology.

Context:

- **Historical Precedents:** There are several examples of previously established international norms or agreements that might inform our discussion of similar efforts for emerging technologies. One of the most well-known international norms is the UN Universal Declaration of Human Rights. Written by a commission following the atrocities of WWII, the declaration includes 30 articles that affirm a variety of rights. The rights detailed in the Declaration were not legally binding, but they have been elaborated in subsequent treaties, national constitutions, economic transfers, etc. The process of developing the Declaration ultimately served as the foundation for the International Covenant on Economic, Social and Cultural Rights and the International Covenant on Civil and Political Rights, multilateral treaties adopted by the UN General Assembly in 1966 (in force from 1976). Each of these treaties is monitored by a committee at the UN and give legal status to most of the Declaration of Human Rights.

  While the Declaration of Human Rights was reactive to conditions in WWII, the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) was a more proactive effort by the global community. There have been numerous treaties and regimes relating to disarmament, arms control, and nonproliferation of weapons of mass destruction, more countries have adhered to NPT than any other arms limitation or disarmament agreement. NPT was initially pursued because nuclear weapons technology was reaching the point where it could become widespread: the science behind building nuclear weapons was in publicly available literature, nuclear technology was beginning to be pursued by private companies, and materials like plutonium were becoming more accessible. Even so, after this kind of agreement was initially proposed, it took four years before countries entered negotiations in earnest, and another two years of negotiations before they developed an agreement that non-nuclear powers were willing to sign. The treaty is reviewed every five years and has been strengthened over time through measures such as export controls and enhanced verification measures.

  An often-cited agreement by people thinking about norms for emerging technologies is the Asilomar

Conference on Recombinant DNA. This norms-creation effort was led by the scientists doing work in this field as opposed to state actors. Named for the conference center in California where scientists, lawyers, journalists, and officials met in 1975, Asilomar set safety guidelines for those using recombinant DNA technology. These research guidelines eventually formed the basis for official government policy on the subject. Many argue that the conference was such a success because organizers intentionally limited the questions being discussed to safety: they grounded discussions in risk assessments and how to mitigate this risk.

- **Current Discussions about Norms for Emerging Technologies:** Cyber norms are the closest parallel to traditional arms limitation or disarmament agreements. Countries have had some success in establishing a norm against commercial cyber espionage during the past few years—this was an important push for the Obama administration—but there has been uneven adherence to these agreements. In late 2017, the private sector took a leading role in working on cyber norms when Microsoft proposed the Cybersecurity Tech Accord, an industry effort—there are now more than 70 tech company signatories to the agreement—to get companies to support certain principles, particularly around protecting customers and users from cyberattacks.[1] The Digital Geneva Convention, initially championed by Microsoft, was a call for a global treaty to protect the public from nation-state threats in cyberspace. This evolved into the Paris Call for Trust and Security in Cyberspace, an effort promoted by France starting in 2018, that is now supported by states, companies (including the Cybersecurity Tech Accord), civil society, etc.[2]

  More recently, artificial intelligence (AI) has become a focus of global norms creation. Movements at the national level have spurred global efforts. In the U.S., Congress recently introduced legislation—the Algorithmic Accountability Act—that seeks to regulate AI. Under this law, tech companies would be held accountable for their algorithms and would be required to audit their AI systems for bias, etc. and correct any issues they find. The UK, France, Australia, and other countries have also recently drafted or passed similar legislation. Building on this national-level momentum, the Organisation for Economic Co-operation and Development (OECD) is preparing to release recommendations about how to develop ethical AI. The OECD seeks to increase dialogue and engagement around these issues, as well as identify and establish best practices.

  In reaction to He Jiankui's November 2018 announcement that he had created the world's first gene-edited babies, experts and researchers are increasingly calling for international guidelines or a regulatory framework for human germline editing, although there is still significant disagreement about where boundaries should be established. Much like the Asilomar agreement from the 1970s, a group of leading researchers have called for a time-limited global moratorium on all clinical uses of

1 Kilovaty, Ido. "Are Tech Companies Becoming the Primary Legislators in International Cyberspace?" *Lawfare*, March 28, 2019. Accessible online.

2 "Cybersecurity: Paris Call of 12 November 2018 for Trust and Security in Cyberspace," *France Diplomatie*, 2018. Accessible online.

human germline editing while an international framework can be developed. Some researchers note that not only are norms and standards needed to set limits, but there is also need for a mechanism for scientists to raise concerns about research that might not be conforming to accepted norms or standards. National and international institutions are also getting involved in efforts to establish norms for human germline editing. The National Institutes of Health (NIH) has called for a moratorium on editing heritable genes. The World Health Organization (WHO) has an expert advisory committee that is currently working to develop recommendations about a possible global regulatory framework or other governance mechanisms for gene editing under the WHO.

Human rights norms in the technology sector have also emerged from non-governmental initiatives. The Global Network Initiative, formed in 2008 by technology companies, civil society organizations, and investors, sets standards for how companies can respond to government requests and demands for user data or censorship in ways that are consistent with international human rights law.

- **Tech Norms Built from Sub-Global Action or Policy:** There have been efforts at the regional level around emerging technologies that some speculate could ultimately set international standards and norms. The European Union's General Data Protection Regulation (GDPR), for example, is a landmark privacy bill that governs the management of personal data of EU citizens. Because international companies had to widely adapt to and adopt these new standards, many suggest that GDPR will serve as the de facto baseline for international privacy standards moving forward. (Similar arguments have been made about the impact of California's Consumer Privacy Act.)

  In early April, the EU published a set of principles with the goal of making AI more ethical. Although the EU is not home to any of the major players in AI—all nine of the major companies are based in either the U.S. or China—the EU has repeatedly stated that they want to be a leader in ethical AI, and these principles have been perceived as a significant step in that direction. Importantly, these AI guidelines are not legally binding, so it remains to be seen if they will be adopted by technology companies and the rest of the international community.

  At an even more local level, U.S. state policy has influenced broader regulations and norms. California is considered a norm-setter for emissions standards. The Clear Air Act includes an exemption for California to set their own more rigorous standards, so the state has regularly pushed to reduce vehicle emissions by even more stringent standards than the rest of the country. Not only has this pushed federal regulators to strengthen emissions standards over time, but other states can and have opted to follow California's emission regulations. (Twelve states and Washington, DC, have adopted California's current more stringent standards.) Another example is Arizona introducing autonomous vehicle testing more rapidly than the rest of the U.S. This has accelerated broader discussions about regulation, expectations, and norms for autonomous vehicles. Some argue that testing in Arizona will expedite the adoption of autonomous vehicles in other cities as well.

- **Challenges to Establishing Global Norms for Emerging Technologies:** There are numerous challenges to establishing global norms for emerging technologies. For some technologies, there are already global bodies in place with established and trusted processes for engaging new issues. Gene editing, for instance, is being addressed by groups like the World Health Organization. For other technologies, however, there are no global institutions with a clear mandate for addressing them. Policy on digital platforms currently faces this challenge. (And this is not only a problem at the international level. Individual countries often do not have agencies or entities with clear jurisdiction for emerging technologies, which complicates international coordination.) The complex and rapid pace of emerging technologies exacerbates the challenges posed by unclear jurisdiction and institutional coordination. Often, government officials lack the technical knowledge to craft effective, sophisticated policy. This has become a notable issue recently for government officials trying to develop policies for AI.

  Widely varying values among major global players also complicates establishing norms for emerging technologies. Countries—especially the U.S. and China—have significantly different views about the importance and role of privacy, free speech, data ownership, etc. Additionally, a handful of private companies have market capture and power comparable to a large country for numerous technology issues. For instance, there are nine companies globally that dominate AI. However, these companies do not have the same obligations to citizens as a national government does. This can further complicate and frustrate efforts to form global agreements.

Discussion Questions:

- What lessons can be drawn from past historical agreements that apply to today's technologies? Will most norms need to be reactive (like the Declaration of Human Rights) or are there some emerging technologies where there is impetus for the global community to be more proactive (like NPT)?

- Can and should the global community establish collective norms that govern countries with vastly different cultural, social, and economic values? How do we preserve national sovereignty over issues like political rights and civil liberties within technologies that transcend borders?

- Are norms rigorous enough to shape the direction of technological development? Or are binding agreements with corresponding enforcement mechanisms needed? Which entities would be best suited to monitor and enforce—global institutions, superpower countries, the private sector, etc.?

- How should the global community involve private sector companies in discussion of norms? Do different governance structures impact this? (For instance, the U.S. takes a hands-off approach to industry while China imposes policy decisions and shapes the direction of many of its companies.)

Readings:

Berg, Paul. "Asilomar 1975: DNA modification secured," *Nature*, September 17, 2008. Accessible online.

Feldstein, Steven and David Sullivan, "Protecting Civilians in Cyberspace: Ideas for the Road Ahead," *Just Security*, July 3, 2018. Accessible online.

Finnemore, Martha. "Cybersecurity and the Concept of Norms," Carnegie Endowment for International Peace, November 30, 2017. Accessible online.

Lander, Eric, Francoise Baylis, Fend Zhang, Emmanuelle Charpentier, Paul Berg, Catherine Bourgain, Barbel Friedrich, J. Keith Joung, Jinsong Li, David Liu, Luigi Naldini, Jing-Bao Nie, Renzong Qiu, Bettina Schoene-Seifert, Feng Shao, Sharon Terry, Wensheng Wei, and Ernst Ludwig Winnacker. "Adopt a moratorium on heritable genome editing," *Nature*, March 13, 2019. Accessible online.

Pielemeier, Jason. "AI & Global Governance: The Advantages of Applying the International Human Rights Framework to Artificial Intelligence, United Nations University: Centre for Policy Research, February 26, 2019. Accessible online.

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