The Simple Economics of Artificial Intelligence

By Matthew Bunch

SUMMARY

The second in the Waterloo Symposium on Technology and Society (WSTS) series welcomed Avi Goldfarb, Rotman Chair in Artificial Intelligence and Healthcare, and professor of marketing at the Rotman School of Economics. This keynote lecture, held at the Balsillie School of International Affairs on May 15, 2019, recast the rise of artificial intelligence (AI) as a drop in the cost of prediction. This wide-ranging talk highlighted the recent explosion in AI start-ups as well as the deepening AI capabilities of major tech companies such as Amazon, Facebook and Google, and argued that despite the hype and unease surrounding AI, development and adoption of this technology is guided by simple economics. Like other new technologies, the emergence of AI as an important force in economic and social development has been accompanied by hype, fear, and broad acceptance. The fear is economic – where negative impacts on jobs and economic systems will displace humans – and social – where access to the benefits of AI and the control and value of data are real concerns. Despite the fears, and regardless of the hype surrounding the possibilities of AI, this technology is becoming ubiquitous, deeply important to the functioning of society, and increasingly inexpensive. However, the policy implications for the development and application of AI technologies are broad, and complicated by overlapping and competing national and international jurisdictions, regulations, and interests. This paper will explore the most salient concerns arising from the development and application of AI, the economic forces driving its development, and the potential negative consequences of these technologies.

The Waterloo Symposium on Technology and Society seeks to promote public discourse in Canada and beyond on the societal challenges and opportunities created by innovations in four primary areas: artificial intelligence, robotics, big data and social media.
INTRODUCTION

The rise of Artificial Intelligence (AI) has profound implications for human social and economic development and has been shaping society for decades. AI is a cluster of technologies, such as machine learning, facial recognition and natural language processing, that are increasingly present in roles traditionally occupied by humans. The recent acceleration in the development and adoption of AI has been driven by simple economics: it got cheaper.

On May 15, 2019, the Centre for Security Governance hosted the second WSTS. The first in the WSTS series featured a keynote lecture on “Robotics and the Age of Automation” where futurist and New York Times bestselling author, Martin Ford, explored the disruptive potential of robotics and AI on society and the economy. In this second symposium, Avi Goldfarb recast the rise of AI as a drop in the cost of prediction. Despite the novelty and disruptive potential of AI, it is still driven by economics — where reductions in cost result in more investment and application. Since the 1970s, expectations about the transformative potential of AI have been high, but periods of “AI winter” have persisted. Since 2012, however, dramatic reductions in the cost of computing and a corresponding rise in the quantity of data available to developers has driven advances in AI systems.

To highlight the recent and explosive rise of AI start-ups, Goldfarb pointed to his own experience with the Creative Destruction Lab (CDL), an organization that helps science-based start-ups scale and commercialize. In 2012, when the CDL was launched, its membership included one company (Adamwize) that described itself as an AI company. In 2019, more than half of the 175 companies at the CDL were AI companies. This is an example of how AI is increasingly attractive at the start-up level, but it is also a major component of the business model for major tech companies such as Alphabet (Google), Amazon, and Facebook. Moreover, social and economic policy has not kept pace with AI. As discussed below, a few very large tech companies dominate the development of AI because they monopolize access to talent, investment, and the technologies necessary to exploit the potential of AI.

Despite the novelty and disruptive potential of AI, it is still driven by economics, where reduction in cost results in more investment and application.
This paper will summarize Goldfarb’s main arguments and highlight key insights from the expert panel discussion that followed the lecture. In addition, the paper will draw on analysis from other experts who are engaged in this debate. This paper is organized into three sections. First, the hype and the fear that have accompanied the development of AI are discussed, as is the broad acceptance of these technologies in society. The second section of the paper outlines the economic factors driving investment and development of AI. In the final section, some of the negative consequences of AI are examined and policy implications are raised.

KEYNOTE SPEAKER:

AVI GOLDFARB

Avi Goldfarb is the Rotman Chair in Artificial Intelligence and Healthcare, and Professor of Marketing at Rotman. Avi is also Chief Data Scientist at the Creative Destruction Lab, Senior Editor at Marketing Science, and a Research Associate at the National Bureau of Economic Research. His research on the economics of technology has been discussed in White House reports, Congressional testimony, European Commission documents, the Economist, the Globe and Mail, the National Post, CBC Radio, National Public Radio, Forbes, the Atlantic, the New York Times, the Financial Times, the Wall Street Journal, and elsewhere. Along with Ajay Agrawal and Joshua Gans, Avi is the author of the Globe & Mail bestselling book Prediction Machines: The Simple Economics of Artificial Intelligence.

PANELISTS:

Andrew Bailey: Associate Professor of Philosophy and Associate Dean (Research and Graduate Studies) in the College of Arts at the University of Guelph. He is a member of The Guelph Centre for Advancing Responsible and Ethical Artificial Intelligence.

Carla Fehr: Associate Professor of Philosophy at the University of Waterloo where she holds the Wolfe Chair in Scientific and Technological Literacy.

Mark Crowley: Assistant Professor in the Pattern Recognition and Machine Intelligence group in the Department of Electrical and Computer Engineering at the University of Waterloo.
Prior to the keynote address, the second Waterloo Symposium on Technology & Society welcomed representatives from Huron Digital Pathology to discuss their application of AI technology in the specific area of medical pathology. They offered a case study of real-world AI-driven disruption in action. Huron CEO Patrick Myles and AI Advisor Hamid Tizhoosh demonstrated how Huron’s Scan, Index, and Search solution for pathology – combining award-winning whole slide imaging hardware with powerful image search technology to connect pathologists, researchers, and educators with the expertise of their colleagues – could dramatically accelerate diagnosis and accelerate disease research worldwide.

Images: hurondigitalpathology.com

Pictured (left to right): Mark Crowley, Carla Fehr, Avi Goldfarb, Andrew Bailey and Mark Sedra.
HYPE, FEAR, AND C3PO

The emergence of AI has been accompanied by a great deal of hype, and as Goldfarb suggests, any discussion on AI has to begin there. Goldfarb suggested that because of its already widespread use across industry and society, “it seems that no matter what business you are in or what organization, [AI] is something that you do and you have to understand going forward” (Goldfarb 2019). Expectations of the transformative potential of AI are high, and it is widely anticipated that AI will make human lives better, but any excitement is tempered by anxiety about negative and unintended consequences.

Humans have accepted that machines can be stronger and smarter than we are, although the latter appears to generate more concern than the former. Anxiety about the rise of AI is often expressed in the media and popular culture, and dystopian predictions about the negative implications of AI are common. There are typically two scenarios depicting our relationship to AI. The first is the optimistic scenario. C3PO, the humanoid robot (a “droid”) from the 1977 movie Star Wars, represents the optimistic scenario. C3PO does two things better than humans: he/it translates very well (the reason C3PO exists in the movie), and he/it listens to humans. This example highlights AI technologies that support human values and needs – they do what we ask them to and we benefit. The second, more often found in science fiction and other narratives, is the pessimistic scenario where machines do not listen to humans and pursue their own goals and values. This is a fear of artificial general intelligence (AGI) and refers to AI that is not task-oriented. This fear was articulated as early as 1956 at the Dartmouth College Conference on Artificial Intelligence, which initiated AI as its own research discipline (this was a series of workshops and studies conducted over a period of several months). Since that conference, AGI has “always been 20 to 50 years away” (Goldfarb 2019). The proposal for the Dartmouth study stated that “The study is to proceed on the basis of the conjecture that every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it” (Moor, 2006). As noted below, the nature of machine intelligence, judgment, and decision making remains an important topic for debate today.

The fear associated with AI is bound up with general anxiety about the role of machines. In the inaugural keynote address of the WSTS series, Martin Ford noted that improvements in machine technology since the beginning of the industrial revolution have been accompanied by fear that machines would displace humans as labour. Like Ford, Goldfarb points out that this has not happened yet. In fact, in another reference to science fiction, the 1999 film The Matrix depicts a dystopian future where AI appears to have run amok in pursuit of its own goals and values. However, in this movie scenario humans still play an important role: they act as batteries for the machines. All the humans have jobs and are therefore working people.

Anxiety about the rise of AI is often expressed in the media and popular culture, and dystopian predictions about the negative implications of AI are common.
A subtler concern is in regard to machine judgment. In the 2004 film *I Robot* (based on the 1950 Isaac Asimov novel of the same name), an AI makes a decision that saves the life of the protagonist while allowing a young girl to die. The protagonist believes the AI made the wrong “judgment” when it calculated its decision. Because it was a robot (an AI), we are able audit the decision. AIs (computers) are essentially adding machines; the AI in *I Robot* acted based only on arithmetic – it lacked judgment. This metaphor is prescient because today we are building AI algorithms that have real and widespread impact on human lives – ranging from human resources wherein AIs vet job candidates, to automated cars, to autonomous weapons systems. For all of these systems humans have built the algorithms that guide AI activity. In the *I Robot* scenario, however, at the centre of the plot is an AI that appears to independently generate its own goals and values, although it is not clear whether this is actually the case. Ultimately, a human built and programmed that AI, and the AI acted according to its programming. Goldfarb argues that in current realities, AI systems do not make decisions independently; rather, they act according to the programming afforded them by humans.

Despite fears about the presence of machines and machine learning, humans have accepted these technologies. There is, however, a reason that we are talking about AI now (2019) rather than in 2009. This is because a particular branch of computer science, machine learning, has “gotten much, much better” (Goldfarb 2019). Investment in AI companies is high. The number of actual AI companies is unclear, but according to the Artificial Intelligence Index, investment in AI in 2019 was over US$70 billion, with start-up investment of US$37 billion (Artificial Intelligence Index, 2019). In addition, AI is already in widespread use in a host of industries and in the context of direct human experience.

**THE DEMAND CURVE SLOPES DOWNWARDS**

The development of machine learning and AI is driven by simple economics. The cheaper something becomes, the more we do it. This central economic principle – the demand curve slopes downwards – simply means that when the price of something is low, we buy more of it; when the price of something is high, we buy less of it. A significant drop in the price of a particular commodity or technology can result in innovative and unexpected applications, and sometimes in new industries.

**It’s the Economy, Stupid**

As early as 1995, amid growing hype for digital technologies, people began to describe the Internet not as a new technology, but as a new economy with new rules. However, economists were quick to point out that it was not a new economy, it was the old economy, but the cost of certain things had changed. In order to understand the consequences of the Internet, it is important to understand the things it makes cheaper. Once you understand that AI makes searching cheaper, communication cheaper, and copying cheaper, you can then “pretty much map out what would happen” (Goldfarb 2019). In the 1998 book, *Information Rules*, Carl Shapiro and Hal R. Varian argued that once you understand that searching and copying are cheap, you can predict all the things that are going to happen in the next 20 years. The authors asked, “what does cheap copying mean?” They found that two policy issues were immediately apparent. The first is copyright. Cheap copying means that for cultural industries, such as music and film production, consumers may stop paying for
these products, which would be bad for the industry. The second issue is privacy. Inexpensive copying means an erosion of privacy as information can be broadcast cheaply and without regard for geography. Both of these issues can be predicted as a consequence of cheap copying.

A Drop in the Cost of Prediction

To further explore this simple economic principle (the demand curve slopes downwards) and how it impacts society, Goldfarb pointed to another transformative technology, semi-conductors, where a reduction in the cost of semi-conductors resulted in a rise in computing. He reminds us that computers do one thing, arithmetic, and they do it very well. Because arithmetic became very cheap, the number of applications for computing increased. As a result, many tasks were reframed as arithmetic problems. For example, photography has traditionally been a chemical problem (KODAK was a chemical company), but once arithmetic became cheap enough, it became feasible to make photography an arithmetic problem.

For any discussion on AI, one should think about a drop in the cost of prediction. In the context of machine learning, “prediction” refers to “filling in missing information” (Goldfarb 2019). Access to greater amounts of information assists in decision making and, as we will see below, decision making is valuable. Prominent examples where drops in the cost of prediction resulted in the uptake of AI include the banking and insurance industries, where algorithms have replaced the humans who made predictions about risk and ascribed cost to it. Human prediction and machine prediction are substitutes for each other. From an economics point of view, tea and coffee are substitutes for each other, so as coffee gets cheaper, we buy less tea. Therefore, as machine learning gets less expensive, the aspects of work that are prediction will not be conducted by humans. Cream and sugar are compliments to coffee, so when coffee becomes cheap we buy more cream and sugar. It is important to understand what compliments to machine learning will become more valuable. However, machine learning, while becoming less expensive, requires significant resources to develop, implement and scale.

Why Prediction is Valuable

We predicted Neptune. Scientists collected and analyzed the data relating to the motion of the planets in the solar system and used arithmetic to predict the existence of Neptune. Today (2020), the input of more and better data allows us to accurately predict the existence of planets hundreds and thousands of light years away. Effective prediction systems depend on good data, and investment in good data can result in better decision making. Like prediction, each bit of data has little intrinsic value – in fact, data is subject to diminishing returns – but it makes prediction, and therefore decision making, better. Similarly, prediction has little intrinsic value, but it has valuable input to decision making. As Goldfarb pointed out, “the current generation in AI/machine learning is transformative because it allows for better decision-making, and decision making is what matters.” He further noted that the vast majority of AIs consist of “tools for tasks.” The largest prediction machines – such as Amazon, Facebook, and Google – are tools for tasks. Sometimes, however, an AI goes beyond being a tool for a task; it may result in a drop in cost that results in a change in strategy. If the drop in cost is dramatic enough, it can result in a whole new industry or commercial opportunity.
In 2017, The Economist Magazine declared that “the world’s most valuable resource is no longer oil, but data.” At that time the five most valuable companies in the world – Alphabet (Google), Amazon, Apple, Facebook, and Microsoft collectively amassed over US$25 billion in net profit in the first quarter of 2017 (The Economist, 2017). The need for huge amounts of data in machine learning means that the largest companies have an advantage, and there is a risk that larger firms may misuse data or skew the market intentionally or unintentionally (Farboodi et al., 2019). Fears of the misuse of data are well founded, as was evident in the recent criticisms of Facebook and its involvement in the Cambridge Analytica scandal. Data itself is of little value (it is often considered “intangible” by tech firms), but the kinds of uses machine learning creates for data are of measurable, often very great value. The issue isn’t the data; the issue is platforms.

BIAS, INEQUALITY, AND PRIVACY

There are real concerns about the negative consequences of AI. As we have outlined above, the seat of decision making in AI systems has provoked serious debate; at the same time, these technologies are increasingly present in roles where autonomous action is taken and the lives of human beings are impacted. Existing and potential negative consequences for AI include the introduction of bias into algorithms, social and economic inequality, limitations in the access to the benefits of AI, and in privacy issues.

Bias

Bias may be present intentionally or unintentionally, but it is generally accepted that bias will likely be present in AI in some form. A real-world example, raised in the panel discussion following Goldfarb’s address by Carla Fehr, concerned a human resources AI that Amazon had introduced into its candidate screening process. Amazon discovered that because the AI had been trained on a small pool of successful candidates, most of whom were male, the AI was biased toward males.

In 2015, in advance of a planned hiring spree, Amazon created computer models focused on specific jobs and locations, and trained algorithms to recognize terms that appeared on candidates’ resumes. It was discovered that the AIs assigned little significance to skills that were common across all IT candidates, and instead favoured verbs commonly found on the resumes of male applicants while penalizing resumes that included the word “women’s” (Dastin, 2018). In addition, the AI recommended unqualified candidates for all manner of positions, and its judgments appeared almost random. The result was that Amazon abandoned that particular AI project. Regardless, 55 percent of US human resources managers in 2017 expected AI to be a regular part of their work in the next five years (ibid.).

Facial recognition software has difficulty recognizing non-white skin tones and gender, and researchers are working to correct this bias by generating data sets of diverse faces.
Similarly, facial recognition software has difficulty recognizing non-white skin tones and gender, and researchers, notably MIT-trained computer scientist Joy Buolamwini, are working to correct this racial bias by generating data sets of diverse faces. It will be increasingly important for developers to identify and counter bias in all its forms, some of which may be difficult to recognize, and even small amounts of bad data can be corruptive. Moreover, bias can be present where human well-being is directly impacted by AI systems — such as in automated cars, banking and insurance industries, human resources, policing, university admissions, and automated weapons systems.

**Inequality**

An important challenge in AI research is inequality. Who will benefit from AI? How will those benefits be shared? The hype surrounding AI and machine learning includes an expectation that these technologies will make us better off: it will make us wealthy, support a welfare state, education, and care for the elderly. However, the benefits of AI may be limited to a small number of people. Benefits might be limited to skilled workers rather than unskilled, or benefits may go to those who could invest in AI in the first place. Income inequality can be exacerbated if middle-skilled, middle-wage jobs are replaced by skills-based technological jobs; the labour market can be hollowed-out in what has been termed “the barbell” effect (Naudé, 2019). As we saw above, control of important commodities such as data, skilled labour, and large markets will be areas where the development of effective policy will be essential if the benefits of AI are to be equitably shared.

Will a small number of large companies dominate the marketplace because they have the resources to collect and leverage massive amounts of data? Goldfarb suggests that because the value of data has decreasing returns, the advantage to large companies will be in their ability to invest in machines and human talent. Wim Naudé (2019) noted that “only a few countries are responsible for virtually the entire current AI-boom: 93 percent of venture capital goes to firms in only three countries/regions: the USA, China and the EU... And within these countries, a few very large high-tech companies dominate.” In 2017, the five largest high-tech digital-based companies — Apple, Alphabet (Google), Amazon, Facebook, and Microsoft — spent US$73 billion on AI research and development. Research and development in AI is difficult, expensive and subject to decreasing returns. Smaller and start-up firms are at a significant disadvantage.

**Privacy**

Data is essential for building prediction machines and machine learning, and there are important questions about the nature, source, and ownership of data. This issue is about privacy and the economic and social costs associated with it. While it lacks an agreed definition and is often considered an intangible commodity, in the context of information technology “privacy” generally refers to the ownership, use, and regulation of data. Moreover, privacy retains a social connotation where individuals expect freedom from undue scrutiny by state and private actors. The costs associated with privacy are therefore complex.
The storage of data is of increasing concern as the cost of storage is reduced to almost imperceptible levels. As a result, data persistence, data repurposing, and data spillover have increasing economic consequences that affect the behaviour of consumers and private companies alike (Tucker, 2017). Ginger Zhe Jin (2018) points out that “AI enhances the expected value of data, firms are encouraged to collect, store and accumulate data, regardless of whether they will use AI themselves.” Similarly, while the cost of accumulating and storing data is low, the cost of data deletion is high. Storage incurs a risk that data may be compromised by nefarious actors; this can be disastrous for individuals, but for many large firms the cost of risk is low. For example, in 2018 the cost of data breaches was a total of US$3.8 billion, while the companies associated with those breaches each generated between US$100 million and US$25 billion in annual revenues (Forbes, 2019).

A response to this problem is the regulation and governance of data, but this has implications for international trade, domestic policy, and intellectual property. As data becomes increasingly regulated, it will be more difficult for companies to use data to innovate, create wealth, and compete on a global stage. A key point is that there are trade-offs between privacy, innovation, and competition as things we value. Moreover, AI allows for greater amounts of surveillance of individuals and populations. The implications for human security, policing, and other social enforcement activities are significant. There are serious contemporary concerns about AI facial recognition software, such as Clearview AI, that are generating significant debate as the technology is deployed by law enforcement agencies. The cost of generating data is low, but other aspects of privacy are increasing in cost and value. For consumers, there can be a direct monetary consequence to protection of privacy; this may include purchasing protection for data or purchasing services to protect privacy of personal movement and freedoms.

CONCLUSION

Is this the end of jobs? The simple answer is no. What emerged from this talk were more complex questions regarding the impact of AI on human well-being and the policy implications arising from the development and widespread adoption of AI systems. AI has the potential to impact society in deep and profound ways. Goldfarb suggests the “correct” question has to do with inequality. The question is not whether machines will make us better off, but whether these technologies will concentrate wealth among a small number of people. He suggests that the policy challenge is not figuring out where and what kind of jobs there will be, but how to distribute the benefits of technology fairly.

There is a lack of an economic and social policy framework for AI in Canada and internationally, and policy implications are broad. Important issues include enabling beneficial AI research, governance, and regulation of data, labour, surveillance, personal liberty, use of autonomous AI systems, and even the development of AGI and computer superintelligence. In the context of this paper, several key policy issues are highlighted:

• **Autonomous AI** systems already impact human well-being in areas where algorithms act in roles that humans have traditionally occupied. There is a need to develop policies to
guide use of AI in specific areas, such as banking and insurance industries, human resources and autonomous weapons systems that already employ AI at, or close to, the root of decision-making processes.

- **Copyright** issues that result from cheap copying are a present-day concern; the ability for consumers and corporations to reproduce and distribute materials is challenging national and international copyright law and has important implications for privacy. In the context of a rapid development in information sharing technologies, there is a need to protect intellectual property while allowing for equitable and affordable access to information.

- **Inequality** in the division of benefits from AI is a complex problem, as is access to the technology itself. The benefits of AI in areas such as health care are tangible, but not enjoyed equally by all persons. Ensuring access to the benefits of AI will be essential as these new technologies unfold and generate revenue. As noted above, large tech firms have disproportionate access to vast amounts of data, and it is increasingly difficult for start-up enterprises to enter and compete in a marketplace.

- **Privacy** for individuals and organizations is a primary concern. There is a need to develop affordable mechanisms that define and protect privacy across national and international jurisdictions. Emerging policies, such as the European General Data Protection Regulation law on data protection and privacy, which is the first large-scale effort to offer consumers legal protection of personal data. Policies can be developed that ensure AI systems are transparent, that data collection is ethical, appropriate, and limited, and that consumers are able to opt out or delete data.

Policy development in relation to AI is largely responsive to the emergence and rapid uptake of the technology. However, since we can predict that AI will be increasingly present (often invisible) in all aspects of society, developing policy that anticipates AI issues, problems, and opportunities is critically important. Goldfarb’s remarks show us clearly that regardless of any hyperbole or anxiety, the development of AI and its integration into society is driven by economics. Certain aspects of AI, machine learning, prediction, and the collection of data, have experienced significant reductions in cost. Goldfarb concluded his remarks with an optimism regarding the potential of AI — as long as it remains in the domain of machine learning and prediction. It allows us a framework to understand what to worry about.

> “But once we get to [artificial general intelligence] all bets are off.”

Since we can predict that AI will be increasingly present (often invisible) in all aspects of society, developing policy that anticipates AI issues, problems, and opportunities is critically important.
CONCLUDING REMARKS BY

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Savvas Chamberlain, CEO of Exel Research, delivered concluding remarks following the keynote address. He reflected on the continued and accelerating advances in computing – particularly where the integration of conventional and quantum computing is concerned – and cautioned that computing power will inevitably eclipse human intellectual capacity. To emphasize the commercial importance of advances in computing, he pointed to his own experience as CEO of the digital imaging company DALSA, where reductions in the cost of computing resulted in increases in revenue and corporate growth. Savvas ended his remarks by asking the audience to consider how society will cope with the social and economic inequality that may accompany the widespread application of AI and machine learning.

Savvas Chamberlain is the founding sponsor of the WSTS. The symposium series reflects his long-term interest in the opportunities and challenges created by the technological revolution gripping our world. Savvas is a member of the Order of Canada and a fellow of the Royal Society of Canada. He is a distinguished professor emeritus and holds an honorary doctorate from the University of Waterloo, was awarded the Ontario Premier’s Catalyst Award for lifetime achievement in innovation and was elected a fellow of the Canadian Academy of Engineering. In addition to his achievements as a scientist, inventor, academic, and entrepreneur, Savvas is a philanthropist. In 2011, he established The Savvas Chamberlain Family Foundation and supports a number of causes in the Waterloo region and beyond.

View video content from the event at secgovcentre.org
WORKS CITED


REFERENCES (continued)


End Notes

i. For a summary report of this keynote lecture see Mark Sedra (2019).

ii. An “AI winter” is a period where interest and investment in AI has stagnated or slowed because of limitations in technology or cost.

iii. Launched in 2012, the CDL works with seed-stage, science-based start-ups that have the potential to scale into large companies. CDL has recently expanded with offices in the United States and Europe. For more information see: https://www.creativedestructionlab.com/.

iv. The number of actual AI companies is distorted because many companies calling themselves AI are not actually doing AI. Venture capitalists are attracted to AI, so there is an incentive for companies to call themselves AI. As a result, estimates of investment into AI are inflated (Mallazzo, 2019).

v. Rodney Brooks (2017) suggests that “machine learning is very brittle, and it requires lots of preparation by human researchers or engineers, special-purpose coding, special-purpose sets of training data, and a custom learning structure for each new problem domain.” He further argues that machine learning cannot be equated with “sponge-like” human learning – which can make progress in new domains or tasks without the need for surgical alteration, while machine learning is entirely task-oriented.

vi. Joy Buolamwini runs the Gender Shades Project, now part of the Center for Civic Media at the MIT Media Lab.

vii. Data Persistence: Data, once created, may potentially persist longer than the human that created it, given the low costs of storing such data. Data Repurposing: It is not clear how such data could be used in the future. Once created, such data can be indefinitely repurposed. For example, in a decade’s time, parking habits may be part of the data used by health insurance companies to allocate an individual to a risk premium. Data Spillovers: There are potential spillovers for others who did not take the photo. The photo may record other people and they may be identifiable through facial recognition; incidentally captured cars may be identifiable through license plate databases. These other people did not choose to create the data, but my choice to create data may have spillovers for them in the future (Tucker 2017).
About the series

The Big Idea Brief series tackles the big public policy issues of the day. It distills those issues into a concise and accessible read, offering ideas on how pressing challenges can be addressed. The series seeks to inform and drive vibrant public discourse, a key to policy innovation and healthy democratic institutions.

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