Digital transformations: an introduction

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Industrialized economies and societies have changed considerably in the last hundred years and they will likely change even more in the next hundred (Palacios-Huerta, 2013), but not because our planet or its inhabitants have radically morphed. What is rapidly changing – indeed improving, despite countless blunders – is our understanding and mastery of nature, including human nature (Ridley, 2011; Pinker, 2014). This is giving us a much better set of technological, institutional and cultural 'toolboxes' with which to enhance our common prospect and potential (Ogle, 2007; Arthur, 2009; Kelly, 2010; Henrich, 2015).

Today, all around us there are signs that we are entering an era of unprecedented technological and societal change. Online auctions, crowd-sourced encyclopedias, open source software and peer-to-peer sharing of music files were early heralds of a new way of organizing human interactions. More recently, scores of fertile new ideas have moved swiftly from futuristic dream to solid reality: think, for example, of Google Earth, free video calls, autonomous vehicles, smart contracts, multi-million-dollar crowdfunding campaigns, wireless 3D scanning of objects, 3D printing of customized human body parts, immersive virtual worlds and augmented reality. At the center of each of these new affordances and alluring possibilities sits a small but vibrant set of digital technologies: micro-processors, sensors, Internet networking, data storage and algorithms. Together, they allow us to datafy and digitize the world.

In what follows, after considering the characteristics that set digitization apart as a general-purpose technology, we will identify some of the benefits and challenges that we can expect from the digital transition in the coming years and we will highlight the institutional and cultural aspects that need to accompany the ongoing technological transformations. We will then introduce the chapters of this Handbook.

DIGITIZATION AS A GENERAL-PURPOSE TECHNOLOGY

The term 'digitization' is often understood in the narrow sense of 'datafication', that is, the capture of the measurable and computable elements

of objects, images, sounds, documents or signals as machine-readable data (Wikipedia, 2015). In this book, we use the term 'digitization' more broadly, to mean the full range of software-driven processes – all the way from datafication and computation to prediction, display, communication and action – that allow increasingly smart machines to intervene in the world.

Digitization is a powerful and versatile force, one of a few 'general-purpose technologies' whose widespread deployment marks an entire era (Bresnahan, 2010; Bekar and Haswell, 2014). Among general-purpose technologies, only electrification comes close to matching the ubiquity and transformational power that digitization portends (OECD, 2012). But digitization is different from electrification in several important respects.[1]

First, unlike electrification, digitization offers us the prospect of sharply increasing returns to learning. Whereas the core technologies underlying the production and deployment of electric power, electric motors and analog electronics, have been fairly stable for several decades, the core digital technologies have been rapidly evolving and they show no signs of slowing down. Seven impressive exemplars of the capacity of digital technologies to sprout new shoots in unforeseeable directions are the recent surges to prominence of big-data-crunching learning algorithms (Domingos, 2015), 3D printing (Russon, 2015), neuroprosthetics (Gay, 2015), distributed cryptoledgers (Swanson, 2014), cloud robotics (Pratt, 2015), CRISPR-based genome editing (National Institutes of Health, 2015) and secure multiparty computation (Zyskind et al., 2015). The confluence of these and other complementary advances will likely lead to a sustained and exponential growth of new knowledge and economic opportunity for the foreseeable future (Brynjolfsson and McAfee, 2014).

Second, and in consequence, digitization is even more protean and transformative than electrification. Electrification has given us a cornucopia of useful tools, from cinema and television to cardiac pacemakers and washing machines. Electricity already is the most ubiquitous source of mechanical tool power, and will likely become even more central to our economies as they move away from fossil fuels (Smil, 2010; Yergin, 2011). But as pervasive and critical as it is, on its own, electricity can only activate tools that process predictable flows and repetitive tasks. Digital technologies can do more than that. Much as our own brains take electricity's power to greater heights, so does the digitization of the world around us: it can give our tools and networks various degrees of autonomous agency and cognition (Arthur, 2010; Dormehl, 2014; Brynjolfsson and McAfee, 2014; Domingos, 2015). This trend becomes apparent if we compare a 1995 cellphone with a 2015 smartphone. While the former was a very limited and specialized appliance, the latter is a versatile platform

whose capabilities continue to multiply at a rather astonishing rate. Today we can hardly imagine what smartphones – or whatever they will be called by then – will be able to do thirty years hence.

Clearly, digital technologies are not mere infrastructural enablers of other technologies. There is nothing particularly infrastructural about a Spotify playlist, a computer-assisted discovery of a cancer tumor, a computer-assisted denial of credit, or the computer-generated scenes in James Cameron's *Avatar*. Digitization is poised to transform every layer of every vertical stack in a modern society, from education to health, from insurance to crime prevention and from dating to warfare (Mayer-Schönberger and Cukier, 2013; Hildebrandt, 2015; Lohr, 2015).

A critical element of the transformative power of digital technologies is their rising capacity to datafy all aspects of life on this planet. A growing array of sensors and algorithms are routinely and reliably capturing and dematerializing the computable essence of an ever-larger assortment of physical stocks and flows, whether texts, songs, 3D configurations, heartbeats, private transit flows or the migratory patterns of animals in the wild. Datafication renders stocks and flows more easily analyzable and optimizable, while turning their data and metadata into non-consumable goods – intermediate or final – that can be immediately and inexpensively shared at any scale. Datafication is thus becoming a new source of value and a key enabler of better tools, better theories and better institutions (Mayer-Schönberger and Cukier, 2013; Varian, 2014; Kitchen, 2014; Lohr, 2015).

Third, digitization is a synergy multiplier. By enabling more rapid and efficient sharing and exchange of data, information and knowledge at all scales, digitization amplifies the potential of markets and communities to harness new value from the collaborative efforts of large numbers of interconnected individuals, algorithms and machines (Malone et al., 2011; Avent, 2014). We see this on eBay and Wikipedia, in Linux and Apache software projects, in Google's free searches and Skype's free video calls, in Kickstarter's crowdfunding campaigns, in TopCoder's remarkable model of crowdsourced software production and so on. Soon, we will see it too in the seamless collaboration of clusters of connected robots and smart objects (Federal Trade Commission, 2015; Pratt, 2015).

Moore's law, predicting a steady doubling of computer power every two years, will only be part of the reason for this plethora of new digital possibilities. The convergence of inexpensive and powerful sensors, fully secured networks, extensive datafication, and parallel, cloud and cognitive computing will be even more critical to achieving further gains in efficiency and opportunity (*The Economist*, 2015; Kelly, 2015; Noor, 2015).

Fourth, more so than electrification, digitization ushers in a new stage of human–machine interactions, one that is both enticing and worrisome. In

this regard, the twin rise of learning algorithms and massive streams of raw data is a watershed development. Whereas classical computers were loaded with human-designed rules and programmed not to make mistakes, today's computers are increasingly loaded with algorithms programmed to learn from their mistakes and to reprogram themselves accordingly, on the basis of the processing of vast amounts of data. In this new regime, processing more abundant and diverse pertinent data not only changes the output of a computation, but also improves the algorithmic system that computes. Thus, whereas classically programmed machines at their best could only do flawlessly and faster what we already had understood and mastered on our own, learning machines will eventually help us to do, and hopefully to understand, what we could never do and understand on our own. But self-programming machines will also become progressively autonomous from their human creators, a prospect that is rich in puzzles and dilemmas. Our descendants will likely spend several decades working out the full consequences of this epochal shift (Domingos, 2015; Markoff, 2015).

Fifth, unlike electrification, digitization is subject to increasing returns to scale. Many digital platforms enjoy massive scale economies on the supply side, resulting from the zero marginal cost of reproduction and distribution of digital goods. In addition, software-driven multisided platforms, the workhorses of the digital economy, excel at bringing together a variety of agents with complementary resources and needs. Whether they are structured as pure markets, pure communities or mixed hybrids, their value-creation potential rises sharply as the volume of agents and interactions rises. This is so partly because the rising volume and variety of agents on each side of the platform create more value for agents on all other sides (for example, more rooms available for rent attract more clients to Airbnb, and vice versa), and partly because the reams of operational data constantly collected and analyzed allow the platform's learning algorithms to further personalize and optimize the flow of interactions (Evans, 2012; Hagiu, 2014; Varian, 2014). This, in turn, attracts new users to every successful platform. Thus, the digital economy is teeming with positive feedback loops that make its growth self-reinforcing.

Finally, whereas the electrified economy is a classic one of scarce resources and non-trivial costs across the board, free goods and services abound in the digital economy. This is partly due to the near-zero marginal costs of reproduction and distribution of digital goods, but also to the surge of multisided platforms driven by learning algorithms. Since they create value by bringing together symbiotic constituencies rather than by processing inputs into outputs, multisided platforms need not choose prices that closely track marginal costs. Instead, they often thrive through cross-platform subsidies aimed at luring in the most critical and/or most

price-sensitive constituencies, who will in turn entice the premium-paying constituencies (Evans, 2012; Hagiu, 2014; Edelman, 2015).

As for learning algorithms, by capturing and harnessing the latent externalities of otherwise dispersed and useless data, they can turn private data into a public good (Howard, 2012; Doctorow, 2013). Consider, for example, the two ways in which data-driven health services exploit the power of big data. Learning algorithms that deliver a precise diagnosis of an individual's illness owe their accuracy to the size and diversity of the entire database. But in addition, learning algorithms can go beyond individual diagnostics to make early predictions of potential epidemics, and such predictions will be useful the world over. The claim that 'big data can save lives' is already true, and will become even truer going forward (Topol, 2013, 2015a, 2015b).

Moreover, by turning private data into a public good, learning algorithms boost the case for public commons. We already have some substantial educational commons (Wikipedia, TED conferences, Kahn Academy, free MOOCs and so on), cultural commons (for example YouTube, Twitter, Pinterest) and industrial commons (for example Linux, Hadoop, Spark, Thingiverse, Fab Labs). But we have only started to explore the transformative potential of digital commons. In the future, for example, we are also likely to have public commons for free medical, financial and legal advice (Benkler, 2011; Bauwens et al., 2015).

BENEFITS AND CHALLENGES

We cannot know in any detail how digitization will impact human societies in decades to come. But it is clear that we have reasons for both optimism and concern.

On the upside, a wider and deeper deployment of digital tools is likely to afford us many social goods. Thus, for example, in a digital future we can reasonably hope for:

- Faster and more efficient value chains and markets for goods and services (Varian, 2010, 2014; Iansiti and Lakhani, 2014; Tabarrok and Cowen, 2015).
- Partially self-repairing and instantly upgradable smart machines, at any scale, from cars to dishwashers (Schatsky et al., 2014; Ramsey, 2015).
- The delegation to machines of many repetitive, exhausting, dirty or dangerous tasks (Deloitte, 2015; GE, 2015).
- Computer assistance that will help human experts to keep up with,

and make sense of, the flood of new knowledge constantly accumulating (Kelly, 2015; Noor, 2015), thus rendering their work more enjoyable, creative and scalable (Manovich, 2013; Chui et al., 2015; Markoff, 2015).

- A broader range of customized and affordable products and services, particularly in the fields of education, health, mobility, banking and insurance (Avent, 2014; Schatsky et al., 2014; Laurent et al., 2015).
- More transparent and less litigious business interactions, as digital tools allow us to reduce information asymmetries between buyers and sellers (Tabarrok and Cowen, 2015; Thierer et al., 2015).
- More rapid advances in science, thanks to a surge in computer-aided discovery (Kelly and Hamm, 2013; Nielsen, 2015).
- A global rise in entrepreneurship, as the confluence of cloud computing, open-source software, crowdfunding and artificial intelligence causes start-up costs to decline and upside opportunities to multiply (Siegele, 2014).
- A greener economy, as a result of the greater efficiencies afforded by digital technologies, notably as regards 3D printing, the sharing economy, the smart grid, smart cities, automated transportation, renewable energies and the Internet of connected objects and logistics (OECD, 2010; US Department of Energy, 2012; Iansiti and Lakhani, 2014; Chase, 2015).
- Larger and more global, effective and lasting public commons in the fields of science, education, health, culture, industry and legal advice (Benkler, 2011; Bauwens et al., 2015; Bollier, 2015).
- More targeted and innovation-friendly regulatory agencies, armed with open-data flows and learning algorithms, and capable of nudging private platforms and public markets to self-regulate themselves in efficient and transparent ways (O'Reilly, 2013; Pomeranc, 2014; Grossman, 2015).
- A shorter working week for most people and more widespread opportunities to put to good use their leisure time (Jones and Simon, 2001; Coote and Franklin, 2013).

On the downside, however, a digital future is likely to lead to new sets of social problems and challenges, such as:

- The specter of massive and persistent unemployment and underemployment. In a world of increasingly capable computers, robots and 3D printers, the range of human capabilities complementary to those of intelligent machines will continue to decrease, as the march of automation moves up into higher cognitive domains (Susskind

and Susskind, 2015). Moreover, even if they are not rapidly automated, all basic skills will be further commoditized as a result of the abundance of available workers, online and offline, at the click of a button (Autor and Dorn, 2013; Levy and Murnane, 2013; Brynjolfsson and McAfee, 2014; Spence, 2014; Thompson, 2015).

- A growing inequality of income and opportunity, as well-paid full-time jobs become progressively rarer and as the confluence of intelligent machines and global crowdsourcing platforms enhance the capacity of top talent to create and capture economic value, while further commoditizing most basic skills (Cowen, 2013; Brynjolfsson et al., 2014). For a rising number of people, poorly paid, contingent work will be the best they can aspire to (Standing, 2011; Avent, 2014).
- A society of ubiquitous surveillance, tracking, rating and ranking of human performances, profiles and reputations (Citron and Pasquale, 2014; Pasquale, 2015). This will be particularly worrisome in the context of increasingly scarcer full-time jobs. A work regime of constant corporate surveillance and relentless competition to hold on to precious jobs, let alone aspire to better ones, is not a reassuring prospect for anyone (Head, 2003; Bethune, 2014).
- The rise of data-driven platform monopolies. In a digital landscape already biased in favor of software-driven giant firms, the substantial scale economies and network effects arising from big data and machine learning will favor even more the growing dominance of incumbent platforms. In a world of learning algorithms, 'the guy with the most data wins' (Bruner, 2012). Since, by definition, new challengers start out with little or no data, it will become more difficult for any challenger to dislodge a dominant incumbent from a data-driven market – think of Google Search, Netflix, LinkedIn, Facebook, YouTube and so on (Newman, 2014; Radinsky, 2015).
- The rising complexity and opacity of algorithms. Algorithmic systems are progressively complex (for example Google Search is a suite of over 200 distinct and complementary algorithms) and fluid (each year, Google changes its suite of search algorithms some 500 to 600 times). In addition, a growing percentage of them are learning algorithms, and thus are only minimally designed: they reprogram themselves on the fly, as they process more data and discover new patterns in it. As a result, such algorithms, and the logic of their results, are increasingly opaque even to the people who originally programmed them, let alone outsiders allowed to take an occasional peek at them. This poses a fundamental problem: even if we are able to prove that a given set of algorithms is seriously biased, our capacity to correct it will be impaired by our limited understanding

of its logic (Barocas et al., 2013; Walchover, 2013; Dormehl, 2014; Auerbach, 2015; Zarsky, 2015).

SOCIETAL CHANGE: TECHNOLOGICAL, INSTITUTIONAL AND CULTURAL

In a 2001 article about the deployment and likely impact of computer-mediated management systems, Shoshana Zuboff offered the ever-turning kaleidoscope as a metaphor for technology-driven societal change. According to her, while most new technologies simply add new elements, colors and textures to the creative mix, a few new technologies – for example, the steam engine, electricity and the computer – instead turn the kaleidoscope's rim, thus enabling entirely new and surprising societal configurations (Zuboff, 2001).

The digital economy has been so slow and hesitant in coming that some authors dismissed its importance (Fingleton, 1999), or reckoned that the 2000–2003 'dotcom' collapse signaled that its best days were over (cf. Arthur, 2002; Newman and Zysman, 2006). But by most accounts, and as befits a major new technological complex (Hughes, 1987; Perez, 2003), digital technologies have simply proven to be late bloomers, and are now poised to give the societal kaleidoscope not one but several turns of the rim. As Zuboff wrote, however: 'Between the turning rim and the emergence of a new pattern, another force infuses the final configuration of elements with meaning. This is the human activity of choice. As the limits of the possible are newly defined, so too is the opportunity for choice multiplied' (Zuboff, 2001, p. 6). Transformative as it can be, technology is not a magic wand, and it is a costly and often-repeated mistake to think otherwise. Only when combined with suitable changes in culture and institutions can technology truly liberate and can its benefits be widely shared (Kling, 1991; Nelson, 2005; Arthur, 2009; Kelly, 2010).

Along these lines, in a recent open letter to the US White House, a large and varied group of American authors wrote:

> We believe that the digital revolution is delivering an unprecedented set of tools for bolstering growth and productivity, creating wealth, and improving the world. But we can create a society of shared prosperity only if we update our policies, organizations, and research to seize the opportunities and address the challenges these tools give rise to. (Brynjolfsson et al., 2015)

New technologies simply offer us a variety of new options, and it is up to us to choose the best course of action prudently, precisely because we

know that thereafter, to a large extent, our new tools, institutions and cultures will refashion us (Smith and Marx, 1994).

THIS *RESEARCH HANDBOOK*

More than sixty years into the gradual but relentless digitization of our societies, we need to step back and carefully assess the historic changes that are afoot. The recent shift from isolated programmable machines to connected and ubiquitous learning machines has raised the stakes and intensified the urgent need for enlightened analyses and choices. No social science on its own is sufficiently eclectic and encompassing for this task, but all of them in concert can begin to generate a better understanding of the challenges and opportunities that we face.

Since digitization is and will remain a moving target for the foreseeable future, analysts will always work under the uneasy impression that if they were to delay publication for a few weeks, they would end up writing a very different text. Even so, we believe that there has never been a better time to assemble and publish a research handbook on digital transformations. Five years ago, some of the most intriguing initiatives underway – for example, drones and other autonomous vehicles, virtual and augmented reality, Bitcoin's blockchain, Thingiverse and Kickstarter – were widely dismissed as being of dubious merit. And five years hence, the scope and diversity of digital transformations will be such that a single volume could hardly do them justice.

Many social scientists have welcomed the opportunity to study a vast array of institutional transformations driven by the extensive deployment of digital technologies, from health and education to urban life, and from homes and libraries to games and crimes. This Handbook offers a rich sample of some of the best scholarly work about the ongoing digital transformations. Our aim is to give the reader a sense of the variety, complexity and importance of such transformations. While the first part of the Handbook gathers a selection of sectoral analyses, the second part covers a diverse set of transversal topics. Although there are some cross-chapter references, each chapter is meant to be self-contained, and can be read as such. We now proceed to introduce each of the chapters in the book.

Many authors have argued that, in addition to being very expensive, US law schools are increasingly out of touch with the real demands of lawyers' jobs (n.b.: the situation is similar in other countries). In Chapter 1, and opening Part I of this book, David Thomson puts forward his case for a relatively simple way to reverse the trend: a greater reliance on online courses during the first year of law school, coupled with the use of the

freed resources to increase and improve experiential and personalized learning opportunities in subsequent years. More generally, Thomson's argument is one that often recurs in this volume: if incumbents are not nimble enough in harnessing digital technologies to reinvent themselves, outsiders will use those same technologies to undermine the incumbents' chances of survival and prosperity.

In Chapter 2, Ray Campbell places the predicament of law schools in the broader context of the challenges faced by the legal-services sector. Like other knowledge-intensive professionals, today's lawyers find themselves harnessing the power of machines that can vastly raise their short-term productivity, but that can also progressively undermine their professional monopoly on domain-specific knowledge over the long term. As Campbell shows, a multipronged siege of the legal elite is already in process: intelligent machines allow the delegation of less demanding tasks to lower-cost paralegals or even to software-enabled clients, but they may also end up taking over many of today's most knowledge-intensive tasks, as well as enabling better informed, more transparent and trustful transactions, thereby decreasing the need for litigation or regulatory micromanagement. Campbell goes on to discuss some of the ways in which law schools could adapt their own curricula and methods to better fit these new realities.

In Chapter 3, Fazal Khan reports on the future uses of smart machines in medicine. On the whole, he is optimistic about the likely impact of current and future advances in artificial intelligence. He foresees the coming of a less centralized and error-prone, as well as more personalized, preventive and affordable set of medical services. But he sees a major obstacle in the way: the threat of litigation hanging over potential providers of new medical tools whose complete accuracy and reliability cannot always be guaranteed. Khan closes by suggesting an array of possible solutions to this problem.

In Chapter 4, Deborah Lupton calls for a more critical assessment of the likely consequences of digital health technologies and data. She argues that we need to be more mindful of the risk of abuses and misuses of health data, particularly as they may lead to exclusionary practices that would only exacerbate the disadvantages already faced by vulnerable individuals.

The recent financial crisis has highlighted the inadequacies of some of our institutions, and has energized a loose coalition of entrepreneurs and large IT firms to try to reform – and perhaps reinvent – the current financial system. The timing is ideal, as the maturing and spread of smartphones, cloud computing and learning algorithms has resulted in a plethora of data-driven platforms hoping to 'unbundle' three of the main functions of traditional banks: payments, credit and investment. In Chapter 5, David

Arnold and Paul Jeffery assess the ongoing banking transformation from the vantage point of Clayton Christensen's theory of disruptive innovation. They conclude that, despite some current regulatory impediments, banks are likely to lose some of their traditional functions – particularly in less developed countries – and that this unbundling will create a more decentralized and competitive market for financial services.

Many authors have argued that the current regime of academic research and publication is suboptimal (Nielsen, 2012; Ioannidis, 2014). In Chapter 6, Sascha Friesike and Benedikt Fecher identify some of the dysfunctional incentives and institutional rigidities that currently inhibit the full use of digital tools to improve the productivity and social impact of academic research. They then suggest ways in which universities, research institutions and funding bodies could modify the incentives regime so as to enable scholarly research to become more collaborative and transparent, and hence more diverse, inclusive and valuable.

In Chapter 7, Kyle Courtney and Emily Kilcer survey various initiatives to reform the university library, with a view to ensuring its continued relevance in the digital age. Open access, cross-disciplinary pedagogies and innovative ways of repurposing library space are some of the promising avenues that they explore.

Some of today's youth probably wonder how previous generations managed to find suitable mates without the help of accessible, affordable and addictive online-dating platforms. They might also be shocked to learn that a few years back, online dating was still widely seen as a last resort for people who could not get a date in the 'real world'. In Chapter 8, Andreas Schmitz and Doreen Zillmann report on the cross-disciplinary field that studies how such platforms function, how they are evolving in the age of the smartphone, and how they are reinventing the old and vital art of romance. Schmitz and Zillmann conclude, among other things, that the current transition from web-based to app-based dating platforms could overturn some of the established assumptions about this recent, but already global, phenomenon.

The spirit of sharing and collaboration is alive and well today not only in online communities such as Wikipedia, Linux and PatientsLikeMe, but also in the Maker movement, which inspires people to share tools, designs and common spaces for the manufacturing of physical products. In Chapter 9, Joel West and Anne Greul explore the Maker movement's past history and current dynamics, and they ponder whether the face-to-face, hands-on collaborative interactions so cherished by 'makers' will survive the digital transition. As they note, it is ironic that the Maker movement has enthusiastically embraced the 3D printer, a new tool likely to eventually remove the human agent – even the independent tinkerer – from

the actual making of many physical objects. If so, the *Maker* movement might soon disappear or turn into the *Designer* movement. But as West and Greul also note, even if it is transformed or short-lived, the Maker movement will still be consequential, as it continues to spawn hundreds of innovative start-ups across the world (Siegele, 2014).

In Chapter 10, Marcus Foth, Andrew Hudson-Smith and Dean Gifford distance themselves from the top-down approach to smart cities marketed by some large IT firms, and propose a more organic, transdisciplinary and inclusive approach to 'smart citizenship'. Using the 'Smart London' initiative as an example, they explore the potential of social and civic capital as pertinent measures of quality of city life and as guides to future policy alternatives.

In Chapter 11, and opening Part II of the Handbook, Marc Pilkington surveys the promise and puzzles surrounding blockchain technology. A type of encrypted ledger that enables any individual or machine to interact and transact with other parties without needing to trust them, the blockchain appears to be the perfect tool for disintermediating transactions and streamlining a large variety of economic processes. In his chapter, Pilkington explains the principles of the blockchain, describes its different types and explores some of its current and future applications.

The 3D scanning and printing of solid objects is a powerful change vector that further blurs the boundary between the physical and the digital. Long in gestation, it is now rapidly advancing and is poised to transform the global manufacturing and logistics landscape (D'Aveni, 2015). While the impact of 3D printing on the progressive displacement of humans from the factory floor is a source of concern for some analysts (Brynjolfsson et al., 2014), its potential to bring about a more frugal and greener economy is cause for optimism for others (US Department of Energy, 2012). In Chapter 12, Lucas Osborn focuses on the equally profound implications of 3D printing for our understanding and protection of intellectual property, particularly its impact on patent law. He concludes that 3D printing will demand a major reevaluation of the intellectual property regime's underlying assumptions and goals, so as to steer clear of both underprotective and overprotective laws.

In Chapter 13, and in contrast to those who see the progressive erosion of privacy as simply the necessary price to pay for higher levels of public safety or private efficiency, Neil Richards and Jonathan King argue for a rethinking of privacy protection in terms of the rules we use to regulate private information flows. They propose a thorough reassessment of such rules in light of the enduring human values of identity, equality, security and trust.

The proliferation and success of crowdwork platforms are fueling a

surge of online and offline freelance work. While the high end of this market is ever richer in opportunity for top talent, the low end of the market leaves many laborers vulnerable to abuse by less-than-ethical employers who often operate at a global scale. In Chapter 14, Miriam Cherry and Winifred Poster take a hard look at this problem. They conclude that our current regulations are not well suited to curb abuse and they call for more ethical and socially responsible labor practices for crowdwork, particularly regarding fair wages, transparent contracts and the unbiased assessment of work quality.

Crowdfunding – the financing of new projects by open, indeterminate crowds of funders – is changing the worlds of venture capital, art promotion, civic initiatives, credit and philanthropy. In Chapter 15, Stéphane Onnée and Sophie Renault report on the crowdfunding phenomenon and expound on its principles, typology, trends, potential and regulation. They also sketch out some promising avenues for further research.

In Chapter 16, Amy DuVernet, Alberto Asquer and Inna Krachkovskaya explore the realm of gamification, that is, the application of gaming elements (for example, an immersive storyline, clear and flow-inducing goals and an optimal combination of competitive and collaborative incentives) to non-game contexts. Gamification is a potent but ambivalent instrument: at its best, it can be positively life-changing (Freedman, 2012); but at its worst, it can be a tool for corporate surveillance and manipulation (Eggers, 2013). Though gamification is currently being used in a wide variety of fields, DuVernet et al. focus on education and business training. They document the fact that, as practiced today, gamification yields very uneven results, and they advocate a more systematic use of evidence-based design and deployment of gamification initiatives. In closing, they note that rapid developments in artificial intelligence could further transform the gamification field in coming years.

In Chapter 17, Kenji Kushida covers the field of innovation policy. He underlines the trends that are making an already difficult task more challenging still, as the surge of asset-light and data-rich, software-driven platforms causes traditional boundaries (for example, between industrial sectors or between tradable and non-tradable goods and services) to become more fluid, and business opportunities to become more global and footloose. On the positive side, Kushida highlights the fact that policy makers and regulators too can reap the benefits of the new crop of digital technologies. Nothing but their imagination could keep them from developing their own set of asset-light and data-rich, software-driven platforms capable of delivering a more surgical, evidence-based and responsive type of industrial policy.

Along with ubiquitous sensors, smartphones and learning algorithms,

cloud computing is a pillar of the data-rich world we are entering. In the cloud, computing is supplied and consumed as an on-demand service at any scale and location desired. In Chapter 18, John Newman explains the role of cloud service contracts in fashioning the new digital infrastructure and explores the impact that the emergence of the Internet of connected objects may soon have on the evolution of cloud services and contracts.

In Chapter 19, Simonetta Vezzoso turns to policy issues concerning industrial competition. In her survey, she underlines the pro-monopoly bias of giant software-driven platforms in a world increasingly dependent on big data, and she offers guidance for regulatory solutions to this problem.

In the twentieth and final chapter, Eric Jardine shows that not all cybercrimes are alike and he argues that cybercrime policies should be more finely crafted to counter specific crimes. He suggests that the choice of appropriate policies to tackle a variety of crimes (for example, illegal marketplaces, child abuse sites, data breaches and identity theft, ransomware and distributed denial of services attacks) will depend upon how criminals choose to leverage the Internet infrastructure and online applications for their illegal schemes.

CONCLUSION

Despite its wide and interdisciplinary assortment of contributions, a common message emerges from this book: the urgent need to rethink, recalibrate and perhaps reinvent our organizations, institutions, policies and cultures, so that they may better allow us to thrive in a world populated by growing numbers of intelligent machines.

With this work, we cannot pretend to have done more than scratch the surface of a broad and rich set of topics. But we hope that our tentative efforts will help other researchers to further explore some of the issues and discussions that we have here reported on. We also trust that entrepreneurs, policy makers and other stakeholders will find these academic exchanges useful in framing their own thinking and actions toward a better society, one as fit for humans as for their ever-more-intelligent machines.

NOTE

1. Broadly speaking, microelectronics can be considered a branch of electrical engineering. But computer engineering is not reducible to microelectronics, as software, hardware architecture and network architecture are also critical elements of it (Ince, 2011).

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