Routledge Studies in Labour Economics

THE DIGITAL TRANSFORMATION OF LABOR

AUTOMATION, THE GIG ECONOMY AND WELFARE

Edited by
Anthony Larsson and Robin Teigland

ROUTLEDGE

The Digital Transformation of Labor

Through a series of studies, the overarching aim of this book is to investigate if and how the digitalization/digital transformation process causes (or may cause) the autonomy of various labor functions, and its impact in creating (or stymieing) various job opportunities on the labor market. This book also seeks to illuminate what actors/groups are mostly benefited by the digitalization/digital transformation and which actors/groups that are put at risk by it.

This book takes its point of departure from a 2016 OECD report that contends that the impact digitalization has on the future of labor is ambiguous, as on the one hand it is suggested that technological change is labor-saving, but on the other hand, it is suggested that digital technologies have not created new jobs on a scale that it replaces old jobs. Another 2018 OECD report indicated that digitalization and automation as such does not pose a real risk of destroying any significant number of jobs for the foreseeable future, although tasks would by and large change significantly. This would affect welfare, as most of its revenue stems from taxation, and particularly so from the taxation on labor (directly or indirectly). For this reason, this book will set out to explore how the future technological and societal advancements impact labor conditions.

The book seeks to provide an innovative, enriching and controversial take on how various aspects of the labor market can be (and are) affected by the ongoing digitalization trend in a way that is not covered by extant literature. As such, this book intends to cater to a wider readership, from a general audience and students, to specialized professionals and academics wanting to gain a deeper understanding of the possible future developments of the labor market in light of an accelerating digitalization/digital transformation of society at large.

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Contents

Figures

Tables

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Foreword

Galaxy incognito

We are on an express train headed for the hubbub of future life. To be "disrupted" is the new normal in almost any human activity. Public, private and even non-profit organizations are today used to the fact that anything can – and indeed will – happen.

This book directly and indirectly addresses one of the most fundamental questions of our time – digitalization and its impact on employment and working conditions. Work is an old, well-known concept, but digitalization is not. We are still grappling with what it is both in philosophical and practical terms. And above all we struggle to understand what impact digitization will have on some of the most fundamental human activities. Work and the labor market certainly being one of them.

When Marshall McLuhan, the Canadian-born professor and communication theorist, described modern communication as expanded consciousness in his 1962 book, *The Gutenberg Galaxy*, he was almost prophetic. Our societies are defined by communication or the absence of it. Everything is communication. Today, we know that even we ourselves are information and data. Ask any friendly, local genetic researcher and they will tell you that we are physical manifestations of code. But if everything is information and anything can be digitalized, it should come as no surprise that almost any human institution is at risk of disruption. The labor market is not in any way an exception, nor is it protected. And it is one of the cornerstones of any society.

Digitalization alters and redefines. Whether it is "Labor", "Work", "Who owns what", "What is valuable or not", etc. It could today be argued at least theoretically that Karl Marx finally turned out to be right. We, the people, now own the critical resources of production. New fortunes are being created by brains, knowledge and information, not by muscle power or machinery. Maybe that is how it always been. Now, though, we can see that it is our intellect that is the most important production resource. The other production resources are indeed necessary but certainly not sufficient. The problem is this is not "the workers' heaven" Marx prescribed and foresaw. It is indeed something completely different. Digitization has transformed our planet into a flying bazaar. Everything can be bought and sold. Zeros and ones too.

The most critical production resource of our time – our intellect – is subject to a massive digitalization and hence the labor market is subject to a complete and fundamental redefinition. Some kind of fundamental deregulation beyond politics and driven by technology. Few, if any, of our traditional perspectives, concepts or institutions can and will encompass the labor market of tomorrow. The digitalized labor market lowers transaction costs and offers opportunities to reorganize anything we do. What is transport or taxi in an "uberified" world? Who are the winners and the losers when national boundaries increasingly provide limited protection for jobs? What is public and what is private when self-organized – for profit or not – systems conquer some of the public domains?

And how do we ensure basic rights and minimum pay when "gigification" of traditional jobs short circuits labor market institutions and sets more and more people on the one hand free and on the other hand makes their life more uncertain?

It is this new galaxy incognito – unknown galaxy – that this text brings us into.

Enjoy and buckle up. Bumpy ride ahead.

Dr. Kjell A. Nordström
Valencia, Spain, May, 2019

Letter from the editors/ acknowledgements

This edited volume constitutes the final phase of the research project, "The Innovative Internet", funded by the Internet Foundation in Sweden (IIS – Swe: *Internetstiftelsen i Sverige*). Released as part of the book trilogy by the same name, this volume concludes the research project preceded by *The Rise and Development of FinTech: Accounts of Disruption from Sweden and Beyond* (2018) (ISBN hardback: 978-0-8153-7850-1; ISBN eBook: 978-1-351-18362-8), and *Digital Transformation of Public Services: Societal Impacts in Sweden and Beyond* (2020) (ISBN hardback: 978-0-367-33343-0; ISBN eBook: 978-0-429-31929-7), both published by Routledge under Open Access.

The premise of the first book was to discuss the conditions in which financial technology (FinTech) could prosper and the ramifications that followed along with it. Having explored the impact of the digital transformation of the financial sector, the next books in the trilogy were set to explore the digital transformation of the public sector and the labor market respectively. However, the initial plan did not involve a trilogy at all. In fact, from the outset, this phase of the project had begun as a small-scale plan for a shorter report on the future of labor and the working conditions of tomorrow. Following the completion of the FinTech book, we soon discovered a need to cover the future of welfare and the public sector as well, as this is an area that is seeing rapid and profound effects of the digital transformation. Consequently, the project shifted focus, at least initially. However, the research project soon began expanding to also include the original plan of the digitalization of the labor market and a decision was made to write and release the books in separate installments.

We would like to take this opportunity to extend our deepest gratitude to IIS, and in particular to Danny Aerts and Jannike Tillå, who have supported us throughout the project while also allowing us full freedom to take ownership of our research and its direction. This volume would not have been possible without the experiences, insights and expertise from our dedicated team of co-authors, consisting of academics and their sponsors, practitioners, and industry experts. To all the contributors we have had the privilege to lead and guide, throughout this process, we wish to express our sincerest thanks for being the foundation of this book! We would also like to thank Executive Director Johan Söderholm at the Stockholm School of Economics Institute for Research (SIR) as well as Senior

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We hope that you, the reader, will have as much satisfaction in reading this book as we had in bringing it together. As an Open Access volume, we invite you to spread and redistribute this book freely to any and all interested parties you may encounter.

Stockholm, September 27, 2019.
Anthony Larsson, Ph.D.
Editor-in-Chief
Robin Teigland, Professor
Editor

1 A journey of a thousand miles

An introduction to the digitalization of labor

Anthony Larsson

1. Introduction

It is held that the ancient Chinese philosopher Lao Tzu (604–531 BC) once said "a journey of a thousand miles begins with a single step" (Keyes, 2006, p. 107). In the same way, mankind has always looked for practical solutions to various problems throughout history, one step at a time, eventually advancing far beyond his original intention.

The extensive technological developments throughout the twentieth century have set the tone for how the future labor market of the twenty-first century has developed and will continue to develop. For instance, the Third Agricultural Revolution would increase agricultural production worldwide, and especially so in the developing world. During this period, many new technologies and techniques would develop, such as chemical fertilizers and agro-chemicals, along with controlled water-supply/irrigation and new methods of cultivation, including mechanization (Farmer, 1986; Esteva, 1996). This was followed by the scientific-technical revolution (circa 1940–1970) (Šmihula, 2010). This was subsequently followed by the digital/information and telecommunications revolution, also known as the "Third Industrial Revolution" (circa 1975–2010) (Esteva, 1996; Kheinman, 1978; Melnikov and Semenyuk, 2014; Vickery, 1999). These eras brought not only technological advancements that sought to improve people's everyday lives, but they would also fundamentally change the economics of society and the way in which the labor market operated. For instance, bureaucracy began expanding and industries began developing information-generating activities, specifically the so-called "Research and Development" (R&D) functions (Veneris, 1990). Moreover, information has become a factor of production much in the same way as with the case of capital, labor, property, economics etc., while also becoming a "commodity", i.e., a product/service that customers are willing to purchase on the open market. As information acquires a "use value" and "exchange value", it also nets itself a price (Repo, 1986; Vargo, Maglio and Akaka, 2008; Eggert et al., 2018).

Progressing beyond the "Third Industrial Revolution", is the "Information Age", or the "Fourth Industrial Revolution", also known as "Industry 4.0" (circa 2010s–present). Significant of this era are the emerging technology breakthroughs and developments in fields such as robotics, artificial intelligence (AI), nanotechnology, autonomous vehicles, biotechnology, Internet of Things (IoT), smartphones, Blockchain and 3D printing etc. (Walwei, 2016). The "Information Age" is intrinsically different from the technological eras, as the previous eras were mainly characterized by advancements in various types of technologies. As for the "Information Age", its main advances lie not so much in the emerging of new technology per se, but rather in new means of communication and connectivity (Schwab, 2016; Schwab and Davis, 2018). Specifically, these new forms of communication technologies enable billions of more people worldwide to connect via the web, drastically improving the efficiency of business and organizations, while promoting better asset management by improved information access (Wisskirchen, 2017).

The definition of AI has many different variations. For instance, the Government of Canada (2019, para.28) defines AI as:

> Information technology that performs tasks that would ordinarily require biological brainpower to accomplish, such as making sense of spoken language, learning behaviours, or solving problems.

The European Commission (2018, para.6), on the other hand, (having gone through some minor revisions in the past few years) has a somewhat lengthier definition:

> Artificial intelligence (AI) refers to systems that display intelligent behaviour by analysing their environment and taking actions – with some degree of autonomy – to achieve specific goals.
>
> AI-based systems can be purely software-based, acting in the virtual world (e.g. voice assistants, image analysis software, search engines, speech and face recognition systems) or AI can be embedded in hardware devices (e.g. advanced robots, autonomous cars, drones or Internet of Things applications).

Naturally, other variations may occur in different countries around the world. Interestingly, while the Canadian definition stresses the complexity of the system in assisting humans with chores, the European definition places more emphasis on the intelligent and autonomous design and behavior of the system. In this way, the European definition of AI accounts for the possibility of an evolution of the behavior of AI, in a way that follows technological advancement. That is to say, AI is not a "fixed construct", and to that end, this definition better encompasses the relevance of AI in the scope of this book.

It is, in this context, appropriate to also mention the terms "digitization", "digitalization" and "digital transformation", as they have become frequently used "buzzwords" in many different businesses. However, the terminologies are sometimes erroneously used interchangeably. The first term, "digitization, entails the conversion of analogue material (such as images, video and/or text etc.) into a digital format (Larsson and Viitaoja, 2017; Feldman, 1997; Brynjolfsson and McAfee, 2014). The second term, "digitalization", refers to a process wherein the use of digital/computer technology (also mobile applications) is adopted, alternatively, increased by an actor (Wachal, 1971; Castells, 2010). More often than not, the digital technology implemented with the intent of establishing a communication infrastructure that connects various activities of the actor's various processes (Van Dijk, 2012; Larsson and Viitaoja, 2017). "Digital transformation", on the other hand, is a considerably broader term that signifies customer-driven strategic business transformation requiring far-reaching and cross-cutting organizational change in addition to the implementation of digital technologies (Bloomberg, 2018; Cochoy et al., 2017). Due to its scope, digital transformation is in reality not a matter of implementing *one* project, but rather a *whole series* of different projects, effectively necessitating the organization to deal better with change overall. In this way, digital transformation in and by itself essentially makes organizational change a core competency inasmuch that the venture seeks to become customer-driven end-to-end (Bloomberg, 2018).

For this reason, "digitalization" and "digital transformation" are the two most useful/significant terms when explaining the changes and impact that digital technology has had on society at large. That is to say intelligent algorithms make our day-to-day tasks easier, and it is in many cases near impossible to imagine how we could manage without them. The use of AI and robotics continues to gain momentum at a rapid pace, which prompts the question as to what the future of labor will look like once fully evolved. Extant literature suggests that digitalization has opposing effects on labor markets and that as such, it is still not clear what effects a digitalized society will ultimately have on the labor market (Bührer and Hagist, 2017). Will mass unemployment, poverty and social distortions be a given consequence of this development or may there be a different outcome?

This book will seek to explore these issues and many more through a series of different studies by scientists and industry professionals from Europe and the United States, with deep insight into their respective areas. It is true that the chapters in this volume are to a large extent inherently based on a speculative and/or predictive premise, given the fact that much of the digital transformation is still happening and is nowhere near completed and/or optimized. However, while the authors have sought to interpret near- and far-future developments, they have availed themselves to uphold scientific rigor by following proper academic protocol. This means using citations and basing their point of departure in extant issues/problems and undertaking due analytical procedure and research rather than conveying conjecture or personal opinions. As such, the chapters offer an array of methodological and thematic studies, with some studies presenting original, empirical material while others are more theoretically rooted, with some additional chapters basing their foundation on various forms of literature reviews or departing from the authors' personal, "best practice" experiences. To this end, the studies covered throughout the different chapters have based their assumptions in referenced facts, but while doing so, the studies may at times also transcend the conventional academic comfort zone by offering some foresight in how their subject area could transpire based on the current and expected developments due to digitalization and digital transformation.

The overall premise of this book takes its point of departure from a 2016 OECD report that targets the rapid structural transformations that have followed the digitalization process throughout the OECD countries (Berger and Frey, 2016). Specifically, this report lends support to the aforementioned academic notion that the impact digitalization has on the future of labor is ambiguous. That is to say that there is accumulating anecdotal evidence suggesting that the potential scope of automation has expanded beyond mere routine work, which would make technological change potentially increasingly labor-saving. On the other hand, there is evidence suggesting that digital technologies have not created new jobs on a scale that it replaces old ones.

Adding to this, an additional 2018 OECD report indicated that digitalization and automation as such does not pose a real risk of destroying any significant number of jobs for the foreseeable future (Nedelkoska and Quintini, 2018). Nevertheless, the report did contend that tasks by and large would change significantly, which in turn affects welfare, as most of its revenue stems from taxation, and particularly so from the taxation on labor (be it directly or indirectly). Taking its point of departure from the findings uncovered in these reports, the structure of this book seeks to explore some overarching themes in which digitalization and digital transformation can be expected to impact the labor conditions to some degree or another. The themes investigated are as follows:

1.1. Practical utilization of new technologies

These chapters discuss how the development of new technology can be applied in practice to enable people to work in ways they have not previously been able to.

1.2. The role of the digital welfare state

These chapters discuss how the transformation of labor markets affects the welfare state and the tax revenue system.

1.3. Digital disruption of status quo

These chapters discuss how digitalization and the digital transformation may be used by different groups or actors in ways to advance their positions on the labor market, or alternatively, how these developments may disrupt the status quo prompting these groups or actors to change their mode of operation in the future.

2. Chapter overviews

2.1. Practical utilization of new technologies

2 Alexander Bard, Jan Söderqvist and Anthony Larsson – *Behind the history of labor: technology as the driving force*

This chapter explores the factor(s) that drive the organization of labor and how technology is used as a driving force, even in those instances where it may cause society to surrender its extant norms and routines. The chapter provides a narrative/philosophical discussion behind the historical development behind labor, while discussing the importance of communication and the exchange of information driving this development. The study postulates two research questions. RQ 1*: Is there a new paradigm shift taking place in the future organization of labor?* RQ 2: *In the event that a new paradigm shift can be expected, is it compatible with contemporary social norms or can such a paradigm shift of labor organization be expected to also transform the essence of society itself?*

3 Jochem van der Zande, Karoline Teigland, Shahryar Siri and Robin Teigland – *The substitution of labor: from technological feasibility to other factors influencing the potential of job automation*

This chapter provides a comprehensive yet perspicuous introduction to the area by illustrating an overview of how digitalization and automation, along with the three underlying technologies of artificial intelligence, machine learning (a subcategory of AI), and robotics may be used in the future to perform wide varieties of routine and non-routine work tasks. The chapter seeks to understand to what extent these technologies and digital developments have the potential to replace human capabilities in the workplace. The chapter proceeds by discussing the factors that influence the pace and scope of job automation.

4 Alex J. Wood, Mark Graham and Mohammad Amir Anwar – *Minimum wages for online labor platforms? Regulating the global gig economy*

This chapter investigates how the rise of the "gig economy" has served to enable internet users to find new job opportunities that have previously been unavailable to them. The authors describe the emergence of the phenomenon called "online labor platforms", which effectively constitutes a global remote gig economy that provides clients to access world-wide labor power. The authors provide a detailed account of how these platforms work, while providing some original empirical research by interviewing 250 remote gig economy workers across ten countries and four continents along with platform CEOs and government and trade union officials. In addition, a survey encompassing 679 Asian and African workers has been conducted in addition to an analysis of transaction data and observation studies.

5 Antoine Maire – *The digital disruption of science: governments and scientists toward an "Open Science"*

This chapter explores how digitalization affects the life cycle of research from a "bottom-up" approach. The study applies a qualitative approach using two case studies in order to investigate the European and the French policy toward the digitalization of science. The author argues that while digitalization is crucial to improve the competitiveness of a research community, it has led government institutions to take direction. The author discusses how this new direction is used in order to frame innovative policies to encompass and foster the evolution toward digitalization further.

6 Victor Erik Bernhardtz – *Black boxes of cognitive computers and the impact on labor markets*

This chapter considers two major changes to labor brought on by digitalization. The first is investigating how tools used in production can be connected to the internet and/or local networks in order to create opportunities for data gathering. The second is investigating the potential of improved and customized cognitive computing systems in analyzing gathered data in a more optimal manner than humans can. This chapter is thus a literature study of, and a theoretical discussion on, the impact of digitalization on the labor market. The chapter seeks to address various concepts and issues while investigating if digitalization can be integrated into existing labor markets while at the same time avoiding deterioration of labor quality.

7 Fernanda Torre, Robin Teigland and Liselotte Engstam – *AI leadership and the future of corporate governance: changing demands for board competence*

This chapter investigates how corporate boards, a subset of labor, are developing their capabilities to better govern and leverage AI in their innovation and sustainability efforts, while also having a defining impact on organizations' future labor. Corporate boards make complex strategic decisions in uncertain environments, such as mergers and acquisitions, new product launches, and digital transformation, and as such are not expected to be replaced by automation within the foreseeable future. The authors present preliminary results from a research project that includes a systematic literature review and expert interviews, while also touching on how AI could change the future of board work. Two areas for capability development at the board level are identified: (1) AI operational capabilities, including the guidance of gathering, harvesting and analyzing big data; innovating using AI; and implementing a digital business ecosystem, and (2) AI governance capabilities, including the stewarding of managing data, ethics and black box decision making; staying ahead of AI security threats, and leading the digital business ecosystem. The authors proceed to present their tool for board capability development: the "Boards 4 AI Leadership Matrix". This tool is intended to facilitate the development of the two aforementioned competence areas. The chapter also touches on how AI may change the future of board work, such as new board processes and augmenting board tasks.

2.2. The role of the digital welfare state

8 Mårten Blix – ***Polarization, tax revenue and the welfare state: digital disruption or still standing strong?***

This chapter seeks to investigate the resilience of the welfare state in the face of rapid technological change, using Sweden as a case study. The author contends that while labor markets have become more polarized in other countries, the effects in Sweden have thus far been limited. The author analyzes the reason for why Sweden's labor market has been less polarized, while discussing how the country's social safety net and institutions have worked in the country's favor, but that digitalization at the same time poses a risk due to the taxation system and the shortage of skilled labor in various key segments.

9 Bent Greve – ***Welfare states and digitalization***

The chapter looks closer at how the digital transformation of the labor markets can entail a risk of fewer people managing to sustain stable jobs, while the income of citizens continues to influence the welfare states and their development. The author illustrates the differences in impact of changes on the labor market and discusses the welfare states' ability to finance their sustenance in the future.

10 Anthony Larsson and Dominika Sabolová – ***"Gig patients": health and dental care in the gig economy***

The "gig economy" provides for a new style of employment where workers (referred to as "giggers") sustain themselves by performing a number of "gigs" on a freelance basis (often for several different employers). This has given rise to a new phenomenon referred to as "gig patients", which entails "giggers" who cannot afford to take time off to seek medical or dental assistance until it is absolutely necessary, by which time the treatments needed are often extensive and expensive. These patients will put themselves in debt with no feasible way of paying their medical bills in full, which in turn affects the welfare system. Thus, this chapter seeks to investigate the wider ramifications that "gig patients" could have to the welfare society and the future of labor.

2.3. Digital disruption of status quo

11 Anthony Larsson and Pernilla Lilja – ***GDPR: what are the risks and who benefits?***

In this chapter, the authors investigate the ramifications of the General Data Protection Regulation (GDPR) on the future labor market. The overarching research question this chapter seeks to answer is: *In what way may GDPR influence the* *labor market of tomorrow, and what businesses are at risk?* That is to say, can GDPR help stimulate certain types of business and will it have a stymieing effect on other types of business ventures? This chapter serves as a theoretical/speculative study that endeavors to look at some of the available literature and best practices in order to anticipate the future role of GDPR in a labor market that is becoming increasingly digitalized.

12 Edward Castronova – *Players for hire: games and the future of low-skill work*

In this chapter, the author uses different trends from automation and video game revenue models to make various predictions about the future of low-skill work based on a five-year, a ten-year, and a twenty-year time-frame. Specifically, the author argues that within five years, there will be game companies who pay players in some way to play their games. Within ten years, paying for players will become a standard revenue model in the game industry. Within twenty years, game playing will be a significant source of income of the low-skill workforce. The author contends that "wage-playing" will be the primary means by which the extreme gains of the wealthy will trickle down to the poor, while analyzing the ramification this development has in the broader spectrum in regards to the future labor market.

13 Mark Graham and Mohammad Amir Anwar – *The global gig economy: toward a planetary labor market*

This chapter discusses the emergence of a "planetary labor market" for digital work. Building on a five-year study of digital gig work in some of the world's economic margins, the authors illustrate that a planetary labor market does not dismiss the notion of geography, but rather exists to take advantage of it. That is to say, digital technologies have been deployed in order to bring into being a labor market that can operate at a planetary scale, and has particular affordances and limitations that rarely bolster both the structural and associational power of workers. In this study, the authors seek to understand how gig work platforms are generating online labor markets that help clients/employers reconfigure the geography of their production networks for almost zero cost while risks are shifted towards workers, who can sell their labor power globally, but still are tethered to the locales in which they go to bed every night.

14 Anthony Larsson and Yamit Viitaoja – *Identifying the digital gender divide: how digitalization may affect the future working conditions for women*

This chapter draws upon existing research and studies, as well as on the authors' "best practice" insights in investigating the popularly-termed "digital gender divide" and how digitalization and the digital transformation impact on the future prospects for women on the labor market. Providing an analytical commentary on the present situation, this chapter discusses the relative lack of women in the Western countries undertaking science, technology, engineering and mathematics (STEM) subjects. This in turn leads to a lower turnout for women working with information and communication technology (ICT) related jobs. The authors explore the possible reasons behind this development while providing insights to how women can secure a more prominent role overall in a future digitalized labor market.

15 Anthony Larsson, Nicole Andersson, Peter Markowski, Malin Nilsson and Ivy Mayor – ***Consulting in the digital era? The role of tomorrow's management consultants***

This chapter draws upon extant literature as well as the authors' own "best practice" experiences in exploring some of the most pressing issues of the digitalization process of management consulting of today. The chapter pursues the following two research questions: RQ 1: *How may digitalization influence the consultant's role of tomorrow?* RQ 2: *How may the profile of the "typical consultant" change in the future?* In seeking the answers to these questions, the authors anticipate how the role and profile of management consultants may come to develop in the near future as digitalization and the digital transformation ensues.

16 Anthony Larsson and Linn Lindfred – ***Digitalization, circular economy and the future of labor: how circular economy and digital transformation can affect labor***

This chapter seeks to investigate how labor would be affected by a transition to a circular economy facilitated through digitalization. This study introduces a premise under which the introduction of a circular economy would become realized. The chapter discusses how this transformation would affect businesses, labor, industries, and society at large, while illustrating how digitalization is a tool to facilitate such a transformation. The authors do not seek to prognosticate answers or provide a "one-size-fits-all" solution, as a potential future circular scenario involves major uncertainties. Moreover, there is lack of real case studies on which to base predictions. Rather, this chapter offers a conceptual study that seeks to draw upon available literature and research findings in order to answer how the labor conditions are affected when digitalization is used to achieve circular businesses and societies in different ways.

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Part I

Practical utilization of new technologies

2 Behind the history of labor

Technology as the driving force[1]

Alexander Bard, Jan Söderqvist and Anthony Larsson

1. Introduction

The first formations of organized work likely began even before the evolution of Homo sapiens (Kranzberg and Hannan, 2017). In fact, throughout history, labor has been a necessity for the perseverance of mankind and for the formation of society at large. At the same time, the development and organization of labor has in no small part been bolstered by improvements to the tools and equipment used. The development of technology has in turn had profound impact on the advancement of labor (and vice versa). Most prominently, it has led to an increase of production while lessening the amount of effort needed from the individual in order to carry out specific work tasks, ultimately leading to various degrees of automation in certain sectors. In its purest form, automation would entail the elimination of all manual labor through the use of automatic devices while at the same time ensuring accuracy and quality. However, automation also means eradicating various forms of labor and effectively making certain types of professions obsolete. Regardless, mankind has always turned toward improvements in technology as a means of advancing their society, even if it means the destruction of certain aspects and norms of the existing society. This raises a question of what it is that drives the organization of labor and how technology is used as a driving force, even if/when it causes society to surrender its previous norms and routines. This chapter seeks to explore this issue through a thought-provocative narrative/philosophical discussion behind the historical development of mankind's relationship with technology, its role in the development of the modern-day working society, and its integral place or role to human nature. Specifically, this chapter seeks to answer two research questions:

RQ 1: *Is there a new paradigm shift taking place in the future organization of labor?*
RQ 2: *In the event that a new paradigm shift can be expected, is it compatible with contemporary social norms or can such a paradigm shift of labor organization be expected to also transform the essence of society itself?*

2. Early days of labor

During the early stages of civilization, labor was restricted to menial tasks aimed at taking care of the bare necessities of human needs, such as food, shelter, child care, protection etc. It is likely that a division of labor emerged once certain members within the society showed some kind of proficiency or aptitude for a particular task, such as hunting, fishing, gathering crops etc. Occasionally, prehistoric humans would organize certain types of tasks such as foraging, hunting and, eventually, even agriculture. As such, division of prehistoric labor is confined to a restricted geographic area as populations were sparse and insular. Division of labor was generally organized according to differences in age and sex. Since the oldest members of a community would often lack the strength and agility to hunt or forage, they would often conduct more sedentary tasks, while the youngest members would be taught simple food-gathering techniques. While the male members of the group would take on tasks such as hunting, the female members would specialize in food gathering, cooking, and child rearing (Kranzberg and Hannan, 2017).

During this time, there was little contact with other groups of humans in other places that may have had access to different kinds of foods, and to the extent that this was so, there was little trade to be made. Since the availability of food was fickle at best, there was little surplus to be bartered with. The organization of labor would become more advanced once pottery was developed. The quality of pottery was largely contingent on the quality of clay, which in itself was not universally and equally distributed across the lands. While pottery could largely be made to some extent almost anywhere, high-quality pottery products made in some places soon became merchandise worth trading elsewhere. Naturally, the quality of these products were further enhanced by the craftsmanship of the potter and the type of tools/equipment they used, which in turn encouraged further specialization.

Similar patterns of specialization followed in other areas as well, such as for textiles. Early on, at least some 70,000 years ago, but perhaps even as early as 500,000 years ago, animal skins were used to make various forms of protective garments (Bellis, 2018; Barber, 1991). However, once agriculture started becoming more developed, the available supply of skins was reduced. This prompted a substitute material for clothing, bringing the manufacture of textiles (initially yarn, and later other materials) into fruition (Kranzberg and Hannan, 2017).

Starting in the Bronze Age, humans would eventually develop and use copper tools and weapons, effectively initializing the formation of metallurgy, This, in turn, created a new organization of labor in which individuals would devote their full time to tasks such as mining, smelting and forging. These were tasks that were so physically demanding and required full mental concentration that they likely precluded the metallurgist from other chores such as farming or hunting. Moreover, copper ore was at this time generally not found in areas with a climate and topography that was favorable toward agricultural development (copper ore was generally located in mountainous regions). This further suggests that these individuals had made metallurgy their dedicated vocation. Likewise, other professional specializations developed in similar ways.

Eventually, along with various historical paradigm shifts, such as the various agricultural revolutions as well as the industrial revolution, would lead to substantial increases in productivity. At this point, however, such increases in productivity were more contingent on the rational organization of processes rather than on individual skill. Another important development occurring throughout the seventeenth to the nineteenth century in Europe was the massive urbanization process, which also acted as an added stimulus toward bringing a more rational organization of work to pass. This would eventually set the premise for the future mass production and mass consumption, further transforming the organization of labor.

What this historical development of labor tells us, is that it is the need (and subsequent exchange) of information that has always been the quintessential *primum movens* to building and forwarding the development of society, and the human race at large. How is it that mankind has been able to utilize information sharing and the technology that is spun from it?

3. The Japanese soldier and the use of information

There is a popular story that tells how Hiroo Onoda (1922–2014), an Imperial Japanese Army intelligence officer was found in 1974. He was found alone in a Japanese holdout in an inaccessible part of an island in the Philippines in the Asian jungle, several decades after the end of the World War II, where he had remained, fighting and refusing to acknowledge that the war had since long ended (Onoda, 1974). As a result of a combination of circumstances he had been left there alone. Perhaps he had been ordered to remain at his isolated post, and had been exercising his duties to the fatherland with exemplary loyalty for all those years, or perhaps he had simply been too frightened to venture into populated areas. But time had passed and no one had told him that peace had been declared. So the Second World War was still raging inside his head.

We have no reason to laugh at this confused soldier. He may have been wrong, but then so have we been, countless times. The soldier was not particularly well-informed, but then neither are we always. We all suffer to some extent from confused perceptions of what is going on outside the small part of our immediate world that we can get a direct impression of. This does not prevent us from forming, and being forced to form, opinions about one thing after the other, even in complicated matters where our knowledge is limited to say the least. Most of what we believe that we know is precisely that: what we believe ourselves to know. Other people's actions are comprehensible to us only insofar as we actually know what they in turn believe themselves to know – which is something we seldom know. The constant inadequacy of this information means that we have to swim through an ocean of misunderstanding on a daily basis, an activity which is both demanding and costly.

Like the Japanese soldier, we form our lives inside our heads. We have to, because the world is far too large and complicated for us to open ourselves to its every aspect without protecting ourselves with a multi-layered mental filter. For this reason we create fictions for ourselves, simplified models of how we believe the world works, or how we think it ought to work. These fictions have to fill the immense vacuums between our limited areas of knowledge. It is within this world of private fictions that we think and feel, but it is outside in the collective reality that our actions have their consequences. The more complicated a situation, the higher the degree of guesswork and the greater the contribution of fiction to our perception of reality.

This dependence upon fictions often has dramatic consequences, not just for us personally but for society as a whole. Like the Japanese soldier, we are fumbling blindly through dark forests. We react to signals that we can only partially understand, the consequences of which are only partially visible to us. Important political decisions are based upon shaky foundations and often have completely different results than were foreseen; great weight is placed on diffuse expressions of opinion, most often in the form of general elections, which are in turn the result of minimal knowledge, a problem which has been discussed, amongst others, by the author and journalist Walter Lippman in a couple of perceptive and intelligent books (Lippmann, 1922, 1925; Obar, 2015). This increasing lack of an overview explains for instance why today's voters find it easier to understand the credit card fiascos and alcohol consumption of individual politicians than serious political issues. Symbolism becomes attractive when real problems are perceived as being far too complicated. The business world is constantly forced to redefine its prognoses and adjust its decisions retrospectively in order to conceal the fact that they were based upon fictional rather than factual conceptions, as a result of the perpetual and chronic lack of information.

Becoming informed is an attempt to synchronize your own head with the reality outside. There are good reasons to make the effort: It is easier to interact with your surroundings when you have a relatively correct understanding of its mechanisms. Someone who has educated themselves in the psychology of the stock market has better prospects of succeeding in the markets; someone who has educated themselves in their own and other people's inner needs has better prospects of succeeding in relationships, and so on. Every failure reveals that we were not as well-informed as we thought or had hoped. The discrepancy between our own and other people's perception of reality, and between our own fictions and actual reality, was far too great. We learn from our mistakes; we take account of our earlier failures in the future and adjust our behavior accordingly. To put it another way, we make use of information.

Fictions can be more or less truthful, more or less applicable. They come in all possible forms, from private hallucinations to scientific theories. We are constantly testing them. Our culture consists of a perpetual evaluation and combination of both seemingly promising fictions and already proven fictions. The relationship between the fictions in our heads and unaccommodating realities is a recurrent theme in literature. Don Quixote, Othello, Raskolnikov and Emma Bovary are all victims of their own feverish ignorance. They are all relatives of the Japanese soldier. In attempting to study and gain an impression of the world around us we have to learn to differentiate between our prejudices – simplified models that we make use of not because they reflect empirical evidence but because they appeal to our own personal interests – and factual analyses and prognoses – necessary and intelligent simplified models of reality which make it comprehensible to us, even if the results do not appeal to us or fit in with our cherished fictions.

Our thoughts are directed by access to information. The story of the Japanese soldier is an illustration of this: Without access to news from the outside world he lived out an imaginary war for several decades. The same thing applies to whole societies and civilizations. Available information dictates which thoughts and actions are possible. It was not a lack of raw materials that prevented the Vikings from using water skis or the Romans from videotaping their orgies – it was a lack of relevant information. Civilization, in essence, is a matter of information. This means that any technological development which dramatically alters the preconditions for actions and the dissemination of information also implies a thorough re-evaluation of old and ingrained patterns of thought. The consequences of such a technological revolution are defined as a new historical paradigm. The advent of language was one such revolution.

4. Communication

The development of linguistic communication is one of the most important aspects that would come to separate humans from other animal species (Kranzberg and Hannan, 2017). The apes, our closest relatives, are intelligent animals with fantastic learning capabilities. But we cannot teach them to speak. From a physiological perspective we can say that their upper airways cannot function as vocal organs. But apes cannot use sign language in any real sense either. Chimpanzees can learn to combine signs in order to communicate on the level of a small child; they can indicate that they want something or that they want someone else to do something, but they never exchange experiences, never speculate about the great mysteries of life. They lack the capacity to communicate their thoughts and experiences with linguistic symbols, which seriously hampers the exchange of information. Man's path diverged from that of the apes about five million years ago, but language took longer to develop. To begin with we had elementary problems with our vocal organs, and evolution is a slow process. It is difficult to specify an exact time for the advent of spoken language, but current research suggests that it occurred as recently as 150,000–200,000 years ago. Only when the development of both the brain and our anatomy was sufficiently advanced was spoken language possible. Language differentiates man from other animals. The creation of technology requires abstract thought, which in turn arises from a linguistic system of symbols. Language made it possible for man to develop socially and to gather and maintain collectives, which opened up a new world of interwoven relationships between individuals. Social life developed entirely new and rich nuances as communication became more advanced. Language offered the possibility of innovative thought, with all its countless possibilities of expression, and stimulated creativity and intelligence. It also made possible the dissemination of information to everyone who was connected to a community. The basic facts of life for a hunter-gatherer society – which plants are edible, which poisonous plants are edible after various treatments, which animals leave which tracks, and so on – became possible to communicate throughout a large group, and between generations. Other people could gain knowledge of both successes and failures, and could go on to develop further the combined experience of the collective. Mankind developed memory. Knowledge could develop, but only to a certain point. Spoken language does not permit, at least not without a tape recorder, the reliable and comprehensive storage of information.

The mathematician Douglas S. Robertson (1998) has calculated the combined amount of information that a group or tribe of linguistically capable but illiterate people can access. He takes the poem the *Iliad* as his basis, a work comprising approximately five million bits (one bit indicates a choice between two alternatives: yes or no, black or white, one or zero), and which we know it is possible for one person to memorize. If the amount of information that a human brain can store is h, then h would appear to be somewhere between one and two *Iliads*, or, in other words, somewhere between five and ten million bits. If we multiply h by the size of a prehistoric tribe, a number between 50 and 1000, we get the maximum amount of information available within a society that was not capable of writing. We ought to bear in mind that there is a sizeable amount of redundant information here. Large amounts of the total store of information – how to hunt, how to fish, and so on – can reasonably be assumed to have been shared by most members of the community, which means that the total amount of information must be adjusted downwards accordingly. The numbers themselves must, of course, be taken with a pinch of salt, but Robertson's calculations provide an excellent illustration of the impact of written language when it was developed during the third millennium BC, and of the explosion in the amount of available information this represented.

Four of the so-called cradles of civilization – Egypt, Mesopotamia, the Indus Valley and China – developed at roughly the same time, and what united them, and simultaneously differentiated them from the surrounding societies in which trade and metallurgy were also practiced, was the invention of written language. To begin with, clay tablets were used to write on. The earliest "book" consisted of several of these tablets, stored in a leather bag or case. Certain texts, laws for instance, were inscribed on large surfaces so that everyone could see them. In this way, the fundamental ideas and norms of the society were transformed from something mystical and ancient which had been communicated orally by shamans into a visible and limited number of clauses and decrees that were available to everyone. Primitive, closed societies assumed a more open and more complex character. At the same time it became clear that knowledge gave power. Early forms of writing were initially an instrument of power. The Sumerian kings and priests used scribes to work out how many sheep different people ought to pay in tax. Another use of writing was propaganda: The ruler reminded his people of who was in charge and of the glittering victories he had won for them.

It was never intended that the written word would come into the hands of every Tom, Dick and Harry. The purpose of the first writings as a means of communication was, in the words of the French anthropologist Claude Lévi-Strauss (1961, pp. 291–292) "to facilitate the enslavement of other human beings". But revolutions have their own velocity, impossible to control for any length of time, and this is particularly true of information technology. Things that occurred either long ago or far away assumed a completely different accessibility and visibility when communicated via written text. The amount of available information exploded thanks to the ingenious invention of a visual code for communication. Intellectual life became far more vital. Thanks to the phonetic alphabet – where each sign represents a sound instead of a word or concept – the ancient Greeks were able to develop philosophy and sciences that had a far firmer structure, a grammar. The replacement of the ear by the eye as the main sense of linguistic reception brought with it a radical change in mankind's way of understanding the world.

Written language looked like magic: It was entirely logical that the Egyptian god Thoth, who gave the gift of writing to mankind, was also the god of magic. Reading and writing transformed both knowledge and the world. Empires could be established and held together only when written communication had developed; only then was it possible for detailed information such as orders to be communicated across large distances. This led to the dissolution of city states. The decline in papyrus production during the reign of the last emperors is held up by many historians as one important reason for the decline and ultimate collapse of the Roman Empire. Even hand-written information had its limits. Johann Gutenberg's invention of the printing press in the middle of the fifteenth century was the start of the next epoch-making revolution in information management. The printing press was also a basic precondition of what became modern science, and of the great discoveries and technical advances that led to industrialization. Printed books were the source material of the astronomer Nicholas Copernicus, and without the printing process his manuscript may well have gathered dust on the shelves of a monastery library. Instead his *De Revolutionibus orbium coelestium* (Copernicus, 1543), the thesis proposing for the first time that the Earth moved in orbit around the sun, spread quickly across the world of learning, where nothing was ever the same again.

Once the ball had started rolling, nothing could stop it. To put it bluntly, the printing press provided gifted and innovative people with the necessary information and inspiration to a previously undreamed of extent. Christopher Columbus read Marco Polo, large numbers of manuals and other technical literature circulated in Europe, and the whole of this tidal wave of new information prompted the development of new techniques and new thinking on the management of information, methods which paved the way for the gradual development of the sciences. Among the many innovations which followed in the wake of the printing press, after a certain incubation period, and which thoroughly and comprehensively altered mankind's way of looking at itself and the world, can be counted the clock, gunpowder, the compass and the telescope. One illustrative example of the power of developed information management, provided by the physiologist Jared Diamond, is the historically decisive meeting between literate Europe and essentially illiterate America in 1532 (Diamond, 1997). In the city of Cajamarca in the Peruvian highlands, Francisco Pizarro, with 168 men, captured the Inca leader Atahualpa, who had at his command more than 80,000 troops. The event only becomes comprehensible in light of the fact that the Inca leader knew nothing about his uninvited visitors whereas the Spaniards were well-informed about their opponent. Atahualpa was completely unaware that these visitors were in the process of conquering the whole of that part of the world, and that the great Indian civilizations of Central America had already fallen to them. He was entirely dependent upon defective oral information.

Atahualpa did not take the invaders seriously, and when his troops saw troops on horseback for the first time in their lives they panicked. Pizarro himself may not have been able to read, but he was a participant in a culture of writing and printing, and therefore had access to a wealth of detailed information about foreign civilizations. He was also aware of every phase of the Spanish conquest, and based his campaign upon the tactics of Hernando Cortés when he had defeated the Aztec leader Montezuma. Pizarro's success soon became known in Europe. In 1534, a book was published describing the events of Cajamarca, written by one of his company, which was translated into several other languages and became a bestseller (MacCormack, 1989). There was a great demand for information, and its benefits were self-evident.

5. The digital technology

Today's electronic and digital media comprise the most comprehensive information revolution of all. For a long time we believed that the central purpose of the computer was to think, to produce an artificial intelligence that would far exceed our own. Many people claimed that this goal was within sight when a computer named Big Blue beat the world master Garry Kasparov at chess (Newborn, 2003; Goodman and Keene, 1997). Today we can see that technology was heading in a different direction, toward communication via networks. Increasingly powerful and fast computers are making possible infinitely complicated and time-consuming calculations and simulations which were previously impossible to perform, which is of incalculable benefit to mathematicians and other researchers. Our collective knowledge is growing exponentially. But it is the global, digital network which is the most interesting aspect of this development. A new, dominant media technology means that a new world is evolving.

The internet is something completely new: a medium in which virtually anyone, after a relatively small investment in technical equipment, and with a few simple actions, can become both a producer and consumer of text, images and sound. In this sense it is hard to think of anything more democratic; on the net we are all authors, publishers and producers, our freedom of expression is as good as total, and our potential audience limitless. There are oceans of every conceivable sort of information available at the touch of a button. The growth of this new medium has been unparalleled.

The foundations of the internet were laid as early as the 1960s with the decision of the American defense organizations to use computerized networks to decentralize their resources via a series of distant but connected terminals. The purpose of this was to protect against and limit the effects of any nuclear war with the Soviet Union. Eventually American and foreign universities were connected to the system after it had proved stunningly effective in the organization of joint research projects. This development explains why the World Wide Web, the system which later became the standard for homepages on the internet, was developed not in the USA but by researchers at CERN, the European institute for research into particle physics in Switzerland. It was not until the end on the 1980s, as a direct result of the breakthrough of the personal computer and the launch of telecommunications modems, that the internet was transformed from the ARPANET, a tool for the United States Department of Defense and the scientific communities into public property. Even in the early 1990s there were relatively few people who had heard of the internet. It was only in December 1995 that Bill Gates woke up and announced in a memo that Microsoft would be changing direction and concentrating on net traffic, one month after a prior memo stating that Microsoft had no interest in the internet (Kearns, 2002). Since then the growth of the internet has been phenomenal. It is practically meaningless to give any figures regarding the number of computers linked to the net because its development is so dizzyingly fast. Figures that were accurate when this was written will be hopelessly out of date by the time it is read.

There are various responses to this development. Critics suggest that all this talk of IT-revolutions and new economies is preposterous, or at the very least seriously exaggerated. These skeptics often point to the fact that even if IT-related shares are soaring on trend-sensitive stock markets the world over, most of these companies are posting continual losses, and that this cannot continue in the long run. The only people who have become rich from computers and IT are the various consultants and the producers of the computers and the software that make the internet possible, while consumers have invested heavily for little or no gain. Any reflected exponential growth in the economy as a whole has not materialized.

6. New paradigms?

From the point of view of the skeptic, the world is essentially the same as it was. We still manufacture and sell hammers and nails, the banks continue to devote themselves to the lending and borrowing of money, a few office routines have changed, but the significance of all of this has been exaggerated. Most people now write their own business letters on a word processor instead of using a dictaphone or a secretary, but the question is whether the state of things has been dramatically improved by this. What is known as e-commerce is just business as usual, even if we are using flashy new machines.

According to this point of view, this is largely a case of following trends, that there is a certain cachet in being first with the latest innovations, no matter what concrete benefit these may actually bring. And it matters little what technology we use to communicate: It is still the content which is important. Old and tested truths will still be just that in the future.

The contrary point of view is ecstatic. Anyone who has seen the light on their screen claims that everything will automatically turn out for the best. The internet is the solution to all our problems: The economy will blossom for everyone forever, ethnic and cultural conflicts will fade away and be replaced by a global, digital brotherhood. All the information that becomes available will make our duties as citizens more meaningful than ever, and the whole of the democratic system will be revitalized as a result. In the digital networks we shall find the social cohesion that we often lack today, and harmony will spread throughout society. Entertainment will become, thanks to the inexhaustible possibilities of this new technology, more interactive and hence more entertaining than ever.

Both the skeptic and the enthusiast are mistaken. Neither radical skepticism nor blind faith is a fruitful strategy for orientation in the accelerated process of change in which we find ourselves. Both of these points of view indicate, in essence, an unwillingness to think critically, an inability to see. They are not analyses or prognoses, but prejudices. A new, revolutionary technology for communication and information will undoubtedly change the preconditions of everything: society, economy, culture. But it will not solve all our problems. It would be naïve to believe that it could. Development means that we can approach certain problems in a dramatic way, but to balance this we will have to confront a whole raft of new problems. We can live longer and more healthily, perceive ourselves to be freer, and realize more of our dreams. But the fundamental conflicts between classes and groups of people are not going to go away, just develop into more intricate and impenetrable patterns and structures.

Change of this type is not instantaneous. The skeptic who triumphantly points out that most of the global economy is still based upon the production of physical objects like fridges, airplanes and garden furniture rather than digital services on the net is partly a little impatient – we are still in many respects only in a preliminary phase – and partly incapable of grasping the extent of the change. There is no question of the fridge disappearing, but rather that the objects around us will take on new significance and new functions in an entirely new socio-ecological system. Marketing campaigns for fridges, for example, will no longer stress their capacity to keep milk cold, because we take that for granted, but rather their capacity to communicate intelligently in a network.

It is in the nature of things that it takes a certain amount of time for changes to be absorbed. Every revolutionary technology only reveals its true colors after an unavoidable period of incubation. As far as the printing press was concerned, it took more than three hundred years before it made its definitive breakthrough, the point at which it caused a dramatic shake up of social structures and created a new paradigm: capitalism. It took time, quite simply, before literacy was sufficiently widespread for print to affect large social groups beneficially. It was not until the Enlightenment of the 1700s that thinking became sufficiently modern, the exchange of information sufficiently lively, and technical advances sufficiently explosive for there to be signs of nascent industrialism in the offing.

Literacy spread rapidly through northern Europe during the 1600s, but its growth only accelerated more noticeably during the following century, primarily as a result of Protestantism and the dissemination of Bible translations into the various national languages. The preconditions were created for a completely new sort of critical public life, whose platform was primarily the first newspapers of recognizably modern form. New publications, such as the *Spectator* in England, were aimed at (and therefore also helped to shape) an educated and cosmopolitan middle class. The aim of the newspapers was to inform about and debate the latest ideas. In France the world of the salon arose, where the aristocracy and middle classes came into contact with one another and together examined the signs of the times. This form of gathering quickly became popular and spread throughout Europe.

But even if literacy and the development of information technologies lay the basis for the changes that occurred in society, they cannot explain them fully. A whole mass of factors have to coincide and co-operate if any epoch-changing process of change is to be set in train. The French sociologist Jacques Ellul, whose interest is primarily with the internal logic of technology and its radical effects upon our lives and environment, has pointed out a number of key phenomena (Ellul, 1964). The first and possibly most self-evident precondition is that the necessary apparatus must be in place already, which in turn presupposes a longer historical process. Every innovation has its roots in a previous era. Novelty consists of what can be termed a technical complex; in other words, a series of inventions of various sorts which together form a powerful combination which is stronger than their individual parts. Innumerable innovations saw the light of day between 1000 and 1750, many of them remarkable in themselves, but they played to different tunes, they did not communicate with one another. It was only after 1750 that innovations began to work together and thereby facilitate large-scale industrialization.

Another important precondition, according to Ellul, is population growth. An increase in population means increased demands which cannot be satisfied without growth. Necessity is the mother of invention. From another, even crasser, point of view, an increase in population means greater preconditions for research and technical and economic development partly in the form of an increase in the size of the market, and partly by providing a human basis for various experiments with different types of product. A third effect is that two specific and at least partially contradictory demands are placed upon the economic environment, which has to be both stable but also in some form of dissolution. On the one hand, a stable base is required for scientific experimentation which is necessary but unprofitable in the short term, but on the other there must be a capacity for widespread and fast change, a willingness to stimulate and absorb new thought processes. The fourth precondition concerns the social climate itself, and is, according to Ellul, probably the most important of them all. There has to be a loosening of various religious or ideological taboos, and liberation from any form of social determinism. For the development of industrialism, for instance, it was vitally important that a whole raft of traditional ideas about what was "natural" were thoroughly revised. No longer were either nature itself or hierarchical social orders perceived as sacred and inviolable.

Perceptions of man and his place in the world underwent radical change. The individual gained a new position, and human freedoms and rights were spoken about, which undermined preconceptions of natural groupings and classes. Suddenly unimagined opportunities opened up, offering social advancement and an improvement in living standards. The liberation of the individual and increases in technological efficiency co-operated. An historical resonance arose, where various factors dramatically strengthened one another in an accelerating spiral. The middle classes were rewarded for their willingness to adapt and made the most of this opportunity. Hence the middle class became the dominant class of the paradigm of capitalism.

The Industrial Revolution meant that that mankind's physical power was multiplied many times over through the use of machines. "The Digital Revolution" means that the human brain will be expanded to an incomprehensible degree through its integration with electronic networks. But we are not there yet, the necessary preconditions are not yet in place. Technology may be accelerating with breathtaking speed, but we humans are slow. Once again we are hampered by all kinds of religious and ideological taboos. Once again we are on the brink of a period of necessary creative destruction. This development cannot be controlled to any great extent. History shows that every new technology worth the name has, for better or worse, "done its own thing", completely independently of what its originators had imagined. In the words of the communications expert Neil Postman (1992, p. 7), technology "plays out its own hand".

Take the clock, for example, an apparently neutral and innocent artifact, but actually an infernal little machine that creates seconds and minutes, which has retrospectively given a whole new meaning to our perception of time. When the first prototypes were developed by Benedictine monks during the twelfth and thirteenth centuries their purpose was to establish a certain stability and regularity to the routines of the monastery, principally with regard to the prescribed seven hours of prayer each day. The mechanical clock brought precision to piety. But the clock was not satisfied with this. It soon spread beyond the walls of the monasteries. It may well have kept order over the monks' prayers, but above all else the clock became an instrument which synchronized and watched over the daily lives of ordinary people. It was thanks to the clock that it became possible to imagine something like regular production during a regulated working day. It became, in other words, one of the cornerstones of capitalism. This invention, dedicated to God, "did its own thing" and became one of Mammon's most faithful servants.

The same thing happened to the printing press. The devout Catholic Gutenberg could scarcely have imagined that his invention would be used to deliver a fatal blow to the authority of the Papacy and promote Protestant heresies by making the word of God accessible to everyone, which in turn made everyone his own interpreter of the Bible. When information became generally available, the natural but no less unforeseen consequence was that various accepted "truths" were put into question. From the 1700s, modern rationalism developed alongside the notion of the educated citizen, and it was the printed word that was to do the job. The goal was the extinction of every form of superstition, principal amongst them religion and the monarchy. According to the French Enlightenment thinker, Denis Diderot, "Men will never be free until the last king is strangled with the entrails of the last priest" (Burns, 1954, p. 478).

As long as information was an exclusive rarity, confined to the privileged few, it was unthinkable that ideas like that could be widely disseminated. Instead it became, after an incubation period of two hundred years, a mass movement. Technology played out its hand. And in the process, everything was changed. When the true agenda of the printing press began to appear, there was no longer any question of the old Europe plus a nice new invention, but of a completely new Europe which thought and acted in new ways. The progression had been uncovered, the historical process began to become clearer, and common sense and science would lift mankind out of the darkness of ignorance and progressively improve standards of living. A new world view, and a new view of man, had been born.

A new, dominant information technology changes everything, not least language. This is partly because of new terminology, new words for new toys, but the most interesting and, to an extent, most problematic aspect of this is that old words assume new meanings. As language changes, so does our thinking. New technology redefines basic concepts such as knowledge and truth; it reprograms society's perceptions of what is important and unimportant, what is possible and impossible, and, above all else, what is real. Reality assumes new expressions. This is what Neil Postman means when he talks of society going through an "ecological" change (Postman, 1992, 1995, p. 192). Technology shakes up the kaleidoscope of our intellectual environment and world of ideas and shows new, unforeseen patterns. We are entering a new social, cultural and economic paradigm.

The paradigm defines which thoughts can be thought, quite literally. The paradigm is simply the set of preconceptions and values which unite the members of a specific society. To take one example: when "everyone" at a certain point in time is convinced that the world is flat, it is pointless to try to work out a way of sailing round the world. When Copernicus claimed that the Earth actually moved around the sun many people thought him mad. This is no surprise. Ridiculing his critics with the benefit of hindsight merely proves that one does not understand how a paradigm works. It is not possible to say categorically that his critics were wrong, because what they meant by the term "Earth" was precisely a fixed point in space.

The terms still carried their former meanings, the paradigm shift had not yet taken place, people were still thinking along ingrained lines. The same thing occurred with the transition from Newton's physics to Einstein's. Many people dismissed Einstein's general theory of relativity for the simple reason that it presupposed that the concept "space" stood for something which could be "bent", when the old paradigm dictated that space was constant and homogenous. This was wholly necessary – if space had not possessed just these qualities, Newtonian physics could not have functioned. And since Newtonian physics had apparently functioned well for such a long time, they could not be abandoned easily. Hence a situation arose in which two paradigms competed with one another.

But two paradigms cannot exist for one person at the same time. It is either/or. The Earth cannot be both mobile and immobile at the same time; space cannot simultaneously be both flat and curved. For this reason individual transitions from one paradigm to another must be instantaneous and complete. It is like the Japanese soldier leaving the jungle and suddenly realizing that he has been living an illusion for years: peace, not war, is the status quo, and Japan has become the driving force of the Asian economic miracle. We are speaking here qualitatively rather than quantitatively. To move from an old paradigm to a new is not merely a question of becoming informed in the sense of adding new facts to old ones with which we are already familiar, but rather in the sense that new facts, and old facts in a new light, change our worldview entirely. And once we have perceived that our old worldview is exactly that, old, and is no longer capable of explaining difficult phenomena, which it is in turn no longer possible to ignore or deny, then it is necessary to abandon large amounts of irrelevant knowledge. This is one of the sacrifices demanded by a paradigm shift.

From a narrower perspective this is an acute situation for someone trying to orientate themselves in the world which is being formed around us within and by the electronic networks. The problem is no longer a lack of information, but an incalculable excess of it. What appears to be new information and new ideas might actually be yesterday's news, or in the worst cases abject nonsense, which will direct us into time- and resource-wasting cul-de-sacs. Old recipes for success become outdated fast. It is only human to become more attached to old strategies if they have proved successful in the past, and it is therefore all the more difficult to abandon them. Someone who has built up a successful business, or who has merely managed to make his life tolerably comfortable, seldom recognizes the necessity of dropping everything and starting again from scratch.

It is here that we find the true novelty in what is happening now. Previously the point of a paradigm was that it provided us with firm ground beneath our feet after a longer or shorter period of tremors. We need to get accustomed to losing that luxury and recognize that change itself is the only thing that is permanent. Everything is fluid. The social and economic stability that has been the ideal and the norm is becoming more and more the exception and a sign of stagnation. It is not enough to think, or to think in new ways; it is now necessary to rethink constantly, and to think away old thoughts. Creative destruction never rests.

Within the world of scientific theories, where the concept of paradigms was first established, there is talk of anomalies and crises. Anomalies are phenomena which are in part unforeseen, and in part difficult to adapt to fit the current paradigm. We can see them all around us these days: in society, within our cultural life and media, and in the economy. The preconditions which underlie politics are altering at a dizzying pace. Yesterday's ideological maps have nothing to do with the reality of today. Whole branches and great empires within the media are collapsing before our eyes. Working life is undergoing a dramatic revolutionary process which is effectively destroying all our old preconceptions of secure employment, automatic promotion and hierarchical organization. Youngsters still wet behind the ears and wearing strange clothes are becoming multi-millionaires in a few short months, in businesses which few of their shareholders have any real grasp of.

When a large number of anomalies appear there are two possibilities. The first is to try to squeeze the new phenomena into the old system of explanations. This is what people have always done within science: patched up and repaired old theories, like for example the old Ptolemaic system of astronomy with the Earth in the center and all the other heavenly bodies circling around it. It holds for a while, bearably, but with time it becomes gradually more apparent that the conditions produced by the old theory are no longer of any use. And then we are confronted unavoidably with option number two: to admit that the old system has had its day, even if there is no new system ready to take its place. This precipitates a crisis. The importance of this crisis is that it signals a need for new thinking. And this is where we are at the moment, in the middle of the crisis which has arisen from the old capitalist paradigm showing that it is incapable, but before any new system has won over enough adherents to be able to function as a generally accepted explanatory model. A lot of people are still patching up and repairing the old system, and there is a noticeable lack of new thinking. Sullen skepticism as to whether the new is actually anything genuinely new, and blind faith in the new which maintains that everything is now on its way to ordering itself automatically for the best, do not count as new thinking.

7. Conclusion

Writing about the future is obviously incredibly problematic because it does not yet exist. The best we can do is to produce more or less qualified guesswork. Someone who understands how dominant information technologies have played out their hands throughout history, and who understands how the dynamism within and between digital networks functions, has the best possible preconceptions for grasping the essential points of the current revolution. This chapter set itself out to explore the factor(s) that drive the organization of labor and how technology is used as a driving force, even in those instances where it may cause society to surrender its extant norms and routines. The discovery was that information exchange has been and remains a quintessential factor in driving this development. In answering the two postulated research questions, we claim two things. The first is that a new social, cultural and economic paradigm is taking shape. The main reason is the ongoing revolution within the management of information: digitalization, and the astonishingly fast development of electronic networks. One immediate consequence of this is that our mental ecology is drastically changing, which in turn forces a whole sequence of necessary adjustments. And secondly, we suggest that the form that the new paradigm is in the process of assuming will not be concrete, but fluid. It is not merely that we are developing new social norms; it is a matter of a completely new sort of norm.

The Japanese soldier in the jungle was ill-informed, and was fighting his own private world war within his own head, but then his circumstances were hardly optimal. We, on the other hand, cannot blame anything other than laziness or stupidity if we do not manage to garner a relatively clear picture of what is going on around us and if we cannot draw the relevant conclusions from this picture. Because one thing we can say without any doubt is that it will not be the meek who inherit the earth.

Note

1 This chapter is a reworked and expanded version of a text originally published as "Technology as the Driving Force of History", chapter 1 (pp. 13–34) in the book *The Netocrats – The Futurica Trilogy, Part 1* (Stockholm, Sweden: Stockholm Text), by Bard and Söderqvist (2002). Permission for reprint has been granted by the copyright holder.

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3 The substitution of labor

From technological feasibility to other factors influencing the potential of job automation[1]

Jochem van der Zande, Karoline Teigland, Shahryar Siri and Robin Teigland

1. Introduction

This chapter, which illustrates the potential of a number of technologies to replace labor, begins with a brief overview of digitalization and automation and the three primary technologies enabling job automation – artificial intelligence (AI); machine learning (ML) – a subcategory of AI; and robotics – in order to create a solid understanding of the concepts. We then proceed to discuss the distinct human capabilities that are required in the workplace and to what degree the three primary technologies can substitute these capabilities based on their current state of development. We then turn to a categorization of job tasks based on a commonly-used framework of routine vs. non-routine and cognitive vs. manual tasks and map the human capabilities in the workplace from the previous section onto this matrix. In the next section, we discuss the resulting automation potential of tasks, jobs and industries. We then turn to discuss a set of factors beyond technological feasibility that influence the pace and scope of job automation. The chapter concludes with a brief summary of the findings that support our prospects for the future of labor.

2. Brief overview of digitalization and automation

Before one can make a proper judgment on the substitution potential of specific tasks, or even complete jobs, it is essential to first develop a solid understanding of the processes and technologies that underlie this substitution. This section aims to create the first part of this understanding by exploring the definition and history of each of the involved technologies and processes.

First, it will touch upon the process of digitalization as it is technology-led and it arguably has had, and will continue to have, a significant influence on labor. We then turn to automation, which is the overarching concept describing the substitution of human labor by machines. Subsequently, artificial intelligence and its subfield of machine learning along with robotics will be discussed as these have been identified as the three most prevalent technological areas within automation.

2.1. Digitalization

2.1.1. Definition of digitalization

Of all the topics in this chapter, digitalization is arguably the broadest concept with the most dispersed definition. Concepts such as Internet of Things (IoT), big data, mobile applications, augmented reality, social media and many others all fall within the scope of digitalization.

In business, digitalization is generally used to describe the process of improving or changing business models and processes by leveraging digital technologies and digitized resources in order to create new sources of value creation.

At the core of this process lies the rise of data-driven, networked business models (Mäenpää and Korhonen, 2015), also known as digital businesses. Digitalization is also used to describe the wider global trend of adopting digital technologies and the effects of this adoption throughout all parts of society (I-Scoop, 2017).

The term digitalization is frequently used interchangeably with digitization and digital transformation. However, it is helpful to make a clear distinction between the three. In this study, digitization will refer solely to the process of transferring analogue data (like pictures, sounds, etc.) into a digital format, i.e., binary code (Khan, 2016; Oxford Dictionaries, 2018b; I-Scoop, 2017).

With digitalization, we will refer to the business process previously described. Lastly, digital transformation is both used to describe a company's journey to become a digital company as well as the larger effects of digitalization on society at large.

Digitalization is also occasionally confused with concepts like mechanization, automation, industrialization and robotization. However, these terms usually refer to improving existing processes, such as workflows, whereas digitalization refers to the development of new sources of value creation (Moore, 2015).

2.1.2. A brief history of digitalization

The history of digitalization began with the development of the modern binary system by Gottfried Wilhelm Leibniz in 1703. However, digitalization, as we refer to it today, started with the introduction of the first digital computers in the 1940s and accelerated with the widespread adoption of the personal computer in the second half of the century (Press, 2015; Vogelsang, 2010).

Digitalization surged with the establishment and development of the World Wide Web in the 1990s, which revolutionized the access to and diffusion of information around the world. Today, with the rapid development of digital technologies like Internet of Things, big data, and AI, this transformation is happening at an unprecedented pace. Though digitalization has caught the attention of both the public and private sector, most organizations are still insufficiently prepared for a digital future, according to IBM (Berman, Marshall and Leonelli, 2013).

2.2. Automation

2.2.1. Definition of automation

The term automation refers to the process of introducing technologies to automatically execute a task previously performed by a human or impossible to perform by a human (Grosz et al., 2016). The field is closely related to mechanization, which refers to the replacement of human labor by machines (Groover, 2018). This is different from systems operating *autonomously*, which relates to the achievement of a goal without predefined execution rules provided by humans. The term automation therefore suggests that the system follows a fixed set of rules to complete its goal (Sklar, 2015). Automated systems are typically made up of three building blocks (Groover, 2018):

1 Power sources. Power sources, such as electricity, are necessary to execute the required action. In general, power sources are used to execute two types of actions: processing, which relates to the mutation/transformation of an entity, and transfer and positioning, which relates to the movement of an entity.
2 Feedback control systems. Feedback control systems monitor whether the required action is performed correctly or not. An example is a thermostat, which monitors the temperature in a room to match a target temperature, and adjusts the heating element's output if this is not the case.
3 Machine programming. This comprises the programs and commands that determine the system's aspired output and the required execution steps. Typical methods for machine programming are using paper/steel cards, tapes, and computer software. Automation by computer-controlled-equipment is also known as computerization (Frey and Osborne, 2013).

One of the most prevalent use cases for automation is within manufacturing. Automation in this field is also known as industrial automation (PHC, 2016). There are three types of industrial automation (Groover, 2018):

1 Fixed automation. The equipment configuration is fixed and cannot be adapted to perform another process. Hence, the sequence of processing operations is permanent.
2 Programmable automation. The equipment can be reprogrammed to perform another process, but the reconfiguration takes time and requires human interference.
3 Flexible automation. The system is controlled by a central computer and can be reprogrammed automatically and instantly. Therefore, the system can perform different processes simultaneously.

Modern, complex automated systems comprise several technologies (Robinson, 2014). Consequently, developments in the field of automation are closely related to advances in these technological sub-fields. Examples are artificial intelligence, neural networks, and robotics (Chui, Manyika and Miremadi, 2016). These will be discussed later in the chapter.

2.2.2. A brief history of automation

The term automation was coined in 1946, but its history stretches back to the dawn of humanity. As mentioned previously, automated systems usually comprise three building blocks. The history of automation can be explained by the development of these three blocks (Groover, 2018):

The first large development in automation came with the invention of tools that utilized a power source other than human muscle. This development started in the early stages of humanity with the creation of tools that magnified human muscle power, like the cart wheel and the lever.

Subsequently, devices were invented that could operate in complete absence of human power by harnessing the energy of wind, water and steam.

In the nineteenth and twentieth centuries, stronger power sources, like electricity, were incorporated into the machines, which significantly increased their power.

The growing machine power gave rise to the need for control mechanisms to regulate the output. At first, human operators were needed to control the energy input to the machine. However, the invention of the first negative feedback system removed human involvement from the process. These systems monitor whether the output of the machine corresponds to the desired level and enable a machine to self-correct its input if the output is off. Developments in this field from the seventeenth century onwards gave rise to modern feedback control systems.

The third large development in the history of automation was the introduction of programmable machines. The first was developed by Joseph-Marie Jacquard in 1801, who used steel cards with different hole patterns to determine the output of his automatic loom. Nowadays, machines are programmed by using paper cards with whole patterns and computers.

The combination of these three developments ultimately led to the rise of automation. The introduction of electrical power enabled a surge in automation at the turn of the nineteenth century. During the second half of the twentieth century and the start of the twenty-first century, the capabilities of automated systems increased significantly following several technological advancements. Firstly, automated systems became much more sophisticated and faster after the introduction and incorporation of the digital computer. This increase in power accelerated following advances in computer science, programming language and storage technology. Meanwhile, the prices of these technologies decreased exponentially. Secondly, developments in mathematical control theory and sensor technologies amplified the capabilities and power of feedback control systems, increasing the systems' versatility and ability to operate autonomously in unstructured environments.

2.3. Artificial intelligence

2.3.1. Definition of artificial intelligence

Artificial intelligence (AI) is a technological field that arguably holds considerable potential for the future. It is such a broad field that it is hard to define precisely what it really is. A famous and useful definition made by Nils J. Nilsson (2010) reads, "*Artificial intelligence is that activity devoted to making machines intelligent, and intelligence is that quality that enables an entity to function appropriately and with foresight in its environment*." In other words, AI is computers performing tasks that normally require human intelligence (Oxford Dictionaries, 2018a). However, "intelligence" is a complex phenomenon that has been studied in several different academic fields, including psychology, economics, biology, engineering, statistics and neuroscience. Over the years, advancements within each of these fields have benefitted AI significantly. For example, artificial neural networks were inspired by discoveries within biology and neuroscience (Grosz et al., 2016).

The field of AI research has grown significantly over the past few decades and it has been used for a variety of applications, from beating professionals in board games such as chess and Go to the navigation of self-driving cars (Marr, 2016a). Terms such as big data, machine learning, robotics and deep learning all fall within the scope of AI, alluding to the breadth of the technology.

There are several ways to divide and categorize the different methods, subsets, and applications within AI. One way is to distinguish between general and applied AI. Applied AI, also known as weak or narrow AI, is more common and refers to algorithms solving specific problems and programs completing specified tasks (Aeppel, 2017). For example, a computer may excel in one specific board game that is bounded by specific rules, but outside this task it is useless (MathWorks, 2018c). General AI, or strong AI, aims to build machines that can think and perform almost any task without being specifically programmed for it (Copeland, 2018). This means that the machine has a mind of its own and can make decisions, whereas under weak AI, the machine can only simulate human behavior and appear to be intelligent (Difference Wiki, 2017).

Another way of dividing AI is into research areas that are currently "hot". This is an appropriate division as AI arguably suffers from the "AI effect", or "odd paradox", which means that once people get accustomed to an AI technology, it is no longer perceived as AI. Today, "hot" research areas include large-scale machine learning, deep learning, reinforcement learning, neural networks, robotics, computer vision, natural language processing (NLP), collaborative systems, crowdsourcing and human computation, algorithmic game theory and computational social choice, Internet of things (IoT) and neuromorphic computing (Grosz et al., 2016).

Robotics, deep learning and machine learning are all discussed further on in this chapter; however, NLP is also a subset that has made substantial progress in the last few years. NLP applications attempt to understand natural human communication, written or spoken, and to reply with natural language (Marr, 2016b). The research in this field is shifting from reactiveness and stylized requests toward developing systems that can interact with people through dialogue (Grosz et al., 2016). The other subfields will not be discussed individually.

2.3.2. A brief history of artificial intelligence

The term artificial intelligence was first used by John McCarthy in 1956 at the Dartmouth Conference, the first conference in history on artificial intelligence (Childs, 2011). The goal of the conference was to discover ways in which machines could be made to simulate aspects of intelligence. Although this was the first conference on AI, the technical ideas that characterize AI existed long before. During the eighteenth century, the study on *probability* of events was born; in the nineteenth century, *logical reasoning* could be performed systematically, which is much the same as solving a system of equations; and by the twentieth century, the field of *statistics* had emerged, enabling inferences to be drawn rigorously from data (Grosz et al., 2016).

Despite its long history, AI has only recently begun to pick up speed in research advancements. Between the 1950s and 1970s, many focal areas within AI emerged, including natural language processing, machine learning, computer vision, mobile robotics and expert systems.

However, by the 1980s, no significant practical success had been achieved and the "AI winter" had arrived; interest in AI dropped and funding dried up.

A decade later, collection and storage of large amounts of data were enabled by the internet and advances in storing devices. Moreover, cheap and more reliable hardware had stimulated the adoption of industrial robotics and advances in software allowed for systems to operate on real-world data. As a confluence of these events, AI was reborn and became a "hot" research field once again (Grosz et al., 2016).

2.4. Machine learning

2.4.1. Definition of machine learning

A plethora of papers discuss machine learning (ML), but none truly succeed in explaining what it is or what subdivisions there are. As a result, the term machine learning is often misused and confused with artificial intelligence.

According to the Oxford Dictionary, ML is a subset of artificial intelligence and is defined as "*the capacity of a computer to learn from experience, i.e., to modify its processing on the basis of newly acquired information*" (Copeland, 2018). This definition describes what machine learning is, but it does not explicitly explain what the field encompasses. The following paragraphs attempt to explain what machine learning comprises.

Machine learning has grown into a fundamental research topic with several different approaches and algorithms to be used depending on the problem. One way of dividing the field is into supervised and unsupervised learning. In supervised learning, the answer is known (found in past or completed data), whereas in unsupervised learning it is not (Libesa, 2016). Supervised learning uses a known dataset (a training dataset that is a set of labeled objects) to make predictions for datasets in the future. Unsupervised learning, on the other hand, draws inferences from datasets where input data have no labelled response (MathWorks, 2018b).

Unsupervised learning allows computers to reason and plan ahead in the future, even for situations they have not yet encountered or for which they have been trained (Bengio, 2017).

For example, both types of ML can be used for image recognition, a common machine-learning problem in which the system has to classify objects based on their shape and color. If supervised learning is used, the computer has already been taught how to identify and cluster the objects. It will know that an octagon has eight sides and will hence cluster all eight-sided objects as octagons. Under unsupervised learning, the system does not follow a predefined set of clusters or object characteristics. The system must create these clusters itself by identifying logical patterns between the objects; it will notice that several objects have eight sides and cluster them if the characteristics are deemed prevalent (MathWorks, 2018a).

Supervised learning itself has two distinct categories of algorithms: (1) classification – used to separate data into different classes, and (2) regression – used for continuous response values (MathWorks, 2018d).

Unsupervised learning can also be divided into two different categories: (1) cluster analysis – used to find hidden patterns or groupings in data based on similarities or distances between them (MathWorks, 2018b), and (2) dimensionality reduction – where smaller subsets of original data are produced by removing duplicates or unnecessary variables (Ghahramani, 2004).

Supervised learning is the less complicated of the two since the output is known, and it is therefore more universally used. Nonetheless, unsupervised learning is currently one of the key focus areas for AI (Bengio, 2017).

One of the machine-learning techniques that has been widely covered the last few years is deep learning (Deng and Yu, 2014). Deep learning is used within both supervised and unsupervised learning and teaches computers to learn by example, something that comes naturally to humans. Deep learning uses deep neural networks, a network consisting of several layers of neurons loosely shaped after the brain, to recognize very complex patterns by first detecting and combining smaller, simpler patterns.

The technology can be used to recognize patterns in sound, images and other data. Deep learning, is, among others, used to predict the outcome of legal proceedings, for precision medicine (medicine genetically tailored to an individual's genome), and to transcribe words into English text with as little as a seven percent error rate (Marr, 2016b).

2.4.2. A brief history of machine learning

Arthur Samuel coined the term machine learning in 1959, three years after AI (Puget, 2016), but, just as for AI, the technical ideas around ML were developed long before. The two major events that enabled the breakthrough of machine learning were the realization that computers could possibly teach themselves, made by Arthur Samuel in 1959, and the rise of the internet, which increased the amount of digital information being generated, stored and made available for analysis.

The focus point within machine learning has changed over time. During the 1980s, the predominant theory was knowledge engineering with basic decision logic. Between the 1990s and 2000s, research focused on probability theory and classification, while in the early to mid-2010s, focus switched to neuroscience and probability. More precise image and voice-recognition technologies had been developed which made it easier. Memory neural networks, large-scale integration and reasoning over knowledge are currently the predominant research areas. The recent discoveries within these fields are what has brought services such as Amazon Echo and Google Home into scores of households, particularly within the US market (Marr, 2016a).

2.5. Robotics

2.5.1. Definition of robotics

The field of robotics comprises the science and technology of robots and aims to develop, operate and maintain robots by researching the connection between sensing and acting (Siciliano and Khatib, 2016; Grosz et al., 2016).

Robotics is a mix between several academic fields, including computer science, mechanical engineering and electrical engineering, and is one of the primary technologies used for automation (Groover, 2018). The field is strongly related to AI (Encyclopaedia Britannica, 2018) and particularly to the fields of machine learning, computer vision and natural language processing (Grosz et al., 2016).

Developing an overall definition for robots is difficult as robots differ widely in terms of purpose, level of intelligence and form (Wilson, 2015). The Oxford Dictionary defines a robot as "*a machine capable of carrying out a complex series of actions automatically, especially one programmable by a computer*" (Oxford Dictionaries, 2018c). The International Federation of Robotics (IFR) makes a distinction between two types of robots: industrial robots and service robots.

The IFR has aligned its definition for industrial robots with the definition of the International Organization for Standardization (ISO) and refers to them as "*automatically controlled, reprogrammable, multipurpose manipulators programmable in three or more axes, which may be either fixed in place or mobile for use in industrial automation applications*" (International Federation of Robotics, 2017, p. 2).

An example of an industrial robot is a robot arm used in a car manufacturer's production process. Service robots are defined as robots "*that perform useful tasks for humans or equipment excluding industrial automation applications*". The IFR further distinguishes between personal service robots and professional service robots. The first are service robots that are not used for commercial purposes, for instance a domestic vacuum-cleaning robot, while the latter include all service robots that are used for commercial purposes, such as delivery robots in hospitals and offices (International Federation of Robotics, 2017, p. 2).

Combining the previous definitions, Wilson (2015) defines robots as "*artificially created systems designed, built, and implemented to perform tasks or services for people*". Moreover, he expands the definition of robots to include cognitive computing, which refers to automated computer programs. In other words, physicality is not a requirement and many robots solely consist of software (Horton, 2015). Examples of this are Twitterbots and IPSoft's virtual assistant, Amelia.

For the purpose of this study, the term robot will refer to all artificially created systems that perform tasks and services for people, whether they have a physical state or not. We will also adhere to the split between industrial robots and service robots. In addition, while some authors distinguish between robots and automated vehicles, for the purpose of this study they will both fall under the umbrella of robotics.

2.5.2. A brief history of robotics

From Greek mythology to da Vinci's machine designs, humans have always fantasized about creating skilled and intelligent machines, but the word robot was only introduced in 1920 by Karel Čapek, a Czech playwright (Siciliano and Khatib, 2016). The first electronic autonomous robots were created in the 1950s and the first industrial robot was developed in 1959. Nevertheless, it took two more years until the first industrial robot was acquired and installed in a manufacturing process (International Federation of Robotics, 2017). From that moment, robotics became widespread in industrial, warehousing and military applications (Boston Consulting Group, 2014; Siciliano and Khatib, 2016).

The first generations of robots consisted of large, immobile machines with a narrow skillset and limited power to adapt to their surroundings (Latxague, 2013).

Over the past decade, the field of robotics has made a gigantic leap as advances in programming, sensors, AI and robotic systems have significantly increased the intelligence, senses and dexterity of robots (Decker, Fischer and Ott, 2017; Sander and Wolfgang, 2014; Manyika et al., 2013). This has resulted in robots that are more versatile (Decker, Fischer and Ott, 2017), smaller and better connected to each other. Consequently, it is much safer for robots and humans to work closely together and the range of applications for robots has increased significantly. For example, the technological advances have enabled robots to enter the realm of services, which was previously deemed impossible (Manyika et al., 2013). In the future, technological advances are expected to further increase the capabilities of robots and prices are expected to drop. As a result, the field of robotics is expected to surge (Sander and Wolfgang, 2014).

3. The current state of the three technologies

The second step in assessing the technical feasibility of technologies posed to take over work activities is to analyze the technologies' current capabilities. In other words, what are the technologies currently able to do? To do this, we follow a framework from Manyika et al. (2017) that identifies five broader areas of capabilities: sensory perception, cognitive capabilities, natural language processing, social and emotional capabilities and physical capabilities, which enable humans to perform 18 activities in the workplace. These categories were developed based on an analysis of 2000 distinct work activities across 800 occupations. The framework is displayed in Figure 3.1.

This section discusses the current state of the technologies for each of these five broader areas of capabilities. The three technologies will be discussed simultaneously because they are closely related and are often used in combination to perform a single activity. It is important to note that many of these capabilities are still only proven in laboratories and are not yet available on the market.

3.1. Sensory perception

The area of sensory perception, or machine perception, covers the sensing and processing of external information from sensors and includes the three subfields of visual, tactile and auditory (Anderson et al., 2017). Sensory perception covers the capabilities of the sensors as well as the underlying software that processes and integrates the information. Sensory perception is essential for a variety of applications, including feedback control systems of automated systems and physical capabilities of robots (Grosz et al., 2016). Over the years, sensors and the underlying machine-learning algorithms have become increasingly sophisticated (Hardesty, 2017), and in some fields machines have even reached a capability level that is at par with the human level, according to McKinsey (Anderson et al., 2017).

Computer vision has developed significantly over the past decade, enabled by advances in sensors, deep learning and the abundance of data due to the internet. In some narrow-classification tasks, computer vision systems can outperform their human counterparts. Meanwhile, developments in sensors and algorithms for 3D object recognition, for example LIDAR (Laser-Imaging Detection and Ranging), allow for more precise distance measuring than ever before. Nonetheless, complex tasks, such as dealing with cluttered vision and fields, still present a challenge for the current technology (Manyika et al., 2013; Frey and Osborne, 2013; Robinson, 2014).

Computer vision is essential for machines to perceive and adapt to their environments and is one of the major enablers of autonomous vehicles. Advances in vision technology also enable progress in other applications, e.g., industrial and software robots.

For example, it enables robots to manage patients at the front desk of a pharmacy and to assemble customized orders in pharmaceutical settings (Qureshi and Sajjad, 2017; Manyika et al., 2013).

"Machine touch" refers to the processing of tactile/haptic information and is indispensable for a robot's ability to grasp and manipulate objects (Izatt et al., 2017; Hardesty, 2017). Though progress is being made to develop sophisticated

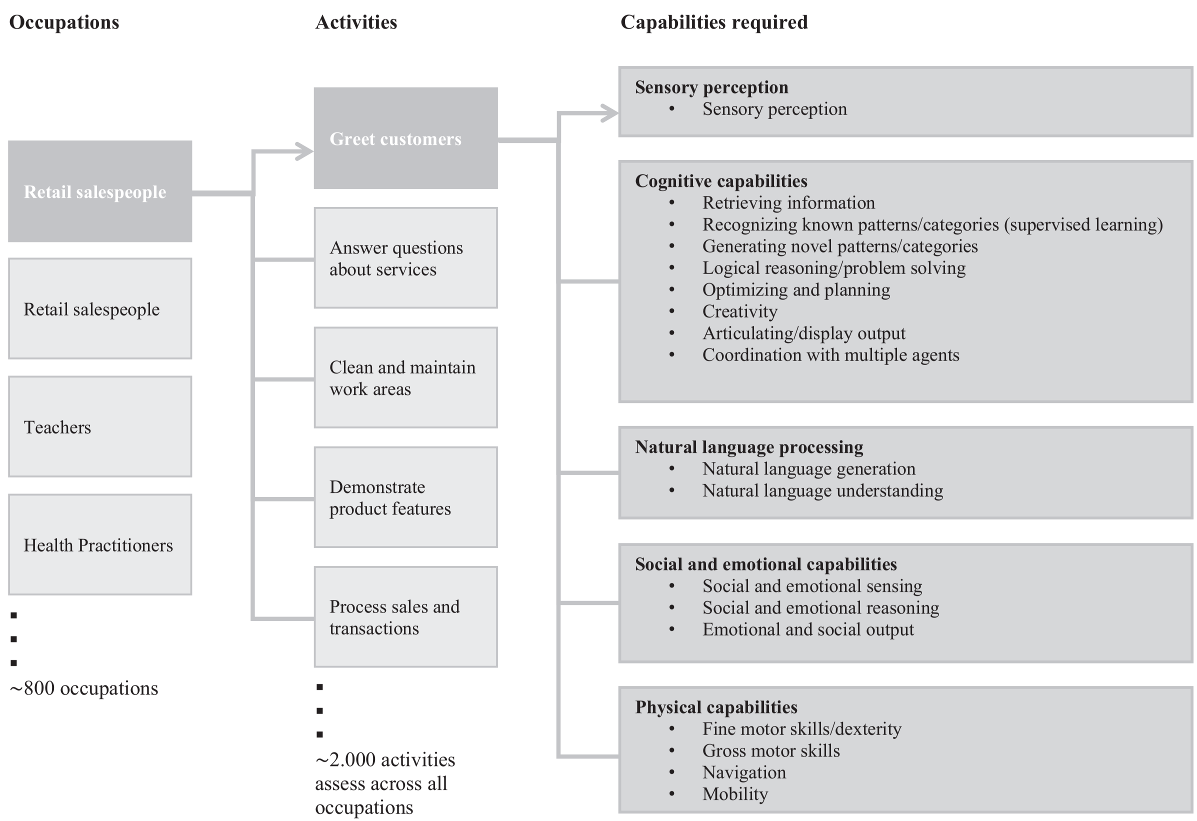

Figure 3.1 Capabilities required in the workplace (Manyika et al., 2017).

haptic sensors that mimic human capabilities, robots still struggle to obtain accurate local information. For example, it is hard to estimate how much force to apply when grabbing an object or to accurately estimate an object's position once it is in the robot's gripper and out of its camera's sight. One recent development is robot skin, a development by Georgia Tech, which gives robots the ability to feel textures (Manyika et al., 2017).

"Machine Hearing" refers to the processing of sound by computers. It is vital for natural language processing and auditory scene analyses, which is the ability to separate and group acoustic data streams (Hahn, 2017). The goal of machine hearing is for machines to be able to distinguish between different sounds, to organize and understand what they hear, and to react in real time (Lyon, 2017, pp. 131–139). For example, a serving robot in a restaurant should be able to distinguish and group the voices of the different customers at a table and accurately take their orders. Today, machine hearing is still in its infancy stage compared to machine vision. For machine-hearing models to be designed, analyzed and understood, math, engineering, physics and signal-processing are essential.

Although some subfields of sensory perception have advanced rapidly, it remains a large challenge to integrate multiple sensor streams into a single system (Hahn, 2017), and it will take several years for the technology to completely surpass the human level (Manyika et al., 2017).

3.2. Cognitive capabilities

This area covers a wide range of capabilities, including making tacit judgments, retrieving information, logical thinking, optimizing and planning, creativity, coordination with multiple agents and recognizing and generating known and novel patterns/categories. Significant developments have been made within the area, but it is also where the most technical challenges lie (Hodson, 2016; Manyika et al., 2017). As of today, there are cognitive systems that beat humans in several activities.

For example, IBM's Watson computer has a 90% success rate in diagnosing lung cancer compared to a human's 50% (Steadman, 2013). Watson also beat the reigning chess champion in 1997 and the champions in gameshow Jeopardy! in 2011 (Knight, 2016). Each individual capability will be discussed briefly.

Optimizing and planning for objective outcomes across various constraints can currently be done by a computer with the same precision as the most skilled humans in this field (Manyika et al., 2017). It includes optimizing operations and logistics in real time, for example, optimizing power plants based on energy prices, weather and other real-time data, or automating machinery to reduce errors and improve efficiency (Henke et al., 2016).

Retrieving information includes being able to search and retrieve information from a wide variety of sources. Based on this information, a computer should also be capable of writing research reports. As of today, technologies are far more skilled at retrieving information than humans (Manyika et al., 2017) because computers are much faster than humans and can go through millions of sources in the blink of an eye. For example, IBM's Watson searched through 20 million cancer research papers and diagnosed a patient with a rare form of leukemia in only ten minutes, while the doctors had missed this for months at the University of Tokyo (Ng, 2016).

Recognizing known patterns/categories is identical to the concept of supervised learning. As explained earlier, supervised learning uses known patterns to categorize and predict for datasets in the future (MathWorks, 2018d). The use and power of supervised learning has increased considerably with the growing availability of large data sets following the internet and advances in sensors. The capability of recognizing patterns is one where computers already outperform humans. For example, a deep-learning based lip-reading system, created by Google's DeepMind and the University of Oxford, trained by watching over 5000 hours of BBC programs, easily outperformed a professional human lip-reader (Frey and Osborne, 2013; Manyika et al., 2017).

Technology has not come as far in generating novel patterns/categories as it has with recognizing them; the field of unsupervised learning, which deals with this problem, is still in an early stage and the capability level of computers is below median human performance (Manyika et al., 2017). One of the difficulties is that the creation of something new requires creative intelligence, which is highly difficult to codify, as will be discussed next. For example, mathematicians perform tasks involving "*developing new principles and new relationships between existing mathematical principles to advance mathematical science*" (Frey and Osborne, 2013, p. 267). This task requires a lot of creativity and is therefore very hard to automate.

Creativity is currently one of the most difficult capabilities to automate. To be creative one must be able to make new combinations of familiar concepts, which requires a rich body of knowledge. The challenge for computers is to make combinations that "make sense" as they lack common knowledge. For this to happen, we must be able to specify our creative values precisely so that they can be codified. Another obstacle is the fact that these creative values vary between cultures and change over time. Despite the challenges, AI has already been used for some creative tasks, like creating music and staging performances (Grosz et al., 2016; Frey and Osborne, 2013).

Logical reasoning and problem-solving can be done on different levels of complexity; from limited knowledge domains with simple combinations of output to many contextual domains with multifaceted, potentially conflicting, inputs. An example of such a task is the ability to recognize the individual parts of an argument and their relationships as well as drawing well-supported conclusions (LSAC, 2018). This capability is also one of the toughest for machines to perform, and performance is still at a low level compared to humans. However, the technologies are improving. Some activities requiring judgment might even be better off being computerized because AI algorithms make unbiased decisions while humans often may not. For example, it has been shown that experienced judges are considerably more generous in their rulings after a lunch break (Manyika et al., 2017; Frey and Osborne, 2013). An algorithm would deliver the same output regardless of the time of day.

Coordination with multiple agents reflects a machine's ability to work together with other machines as well as with humans. This capability, especially human-machine collaboration, is still underdeveloped (Manyika et al., 2017). Early stages of robot collaboration have been proven, but these are largely based on laboratory research (Perry, 2014; Kolling et al., 2016). For example, researchers at Carnegie Mellon University made two different types of robots collaborate by letting a mobile robot bring work to a static robot arm that was controlled by the latter robot (Sklar, 2015).

As pointed out earlier, the general focus has shifted from substitution toward human-machine collaboration. However, the ability of machines to collaborate with humans is currently at a low level (Manyika et al., 2017), limited, for example, by the inability of AI systems to explain their decisions and actions to humans (Turek, 2017) and to understand and produce natural language.

One early example is the humanoid robot Asimo, which has a limited ability to respond to voice commands and human gestures (Boston Dynamics, 2018).

3.3. Natural language processing

Natural language processing comprises both the understanding and generation of natural language. Research within this field has shifted from reacting to clearly specified requests with a limited range of answers to developing refined and sophisticated systems that are able to have actual conversations with people. The generation of natural language is described as "*the ability to deliver spoken messages, with nuanced gestures and human interaction*" (Manyika et al., 2017). Natural language understanding is described as "*the comprehension of language and nuanced linguistic communication in all its rich complexity*" (Manyika et al., 2017). While computers' current level of generation of natural language is comparable to humans, the understanding of natural language remains at a lower level. The development within this area is one of the key factors influencing the pace and extent of automation (Manyika et al., 2017; Henke et al., 2016).

Natural language processing requires lexical, grammatical, semantic and pragmatic knowledge. Despite the fact that computers currently possess some of this knowledge, they are still less capable than humans.

Computers face difficulties in understanding multi-sentence language as well as fragments of language, while incomplete and erroneous language tends to be the norm in society (Bates, Bobrow and Weischedel, 1993). In addition, teaching computer systems and robots to detect sarcasm (Maynard, 2016), both in written and verbal conversations as well as the difference between polite and offensive speech (Steadman, 2013), currently proves to be very difficult.

In order to generate natural language, a machine must know *what to say* and *how to say it*. In order to know *what to say*, the machine must have data and should be able to determine what information from this data to include. The latter process, *how to say it*, requires a machine to know the language rules so that it can make a text (verbal or written) that makes sense. Currently, it is still very difficult for the software to produce grammatically correct and well-formed texts that have natural flows and that fit into an individual's context and needs (Coupel, 2014).

There have been some recent developments within the field, and companies such as Google, Amazon, and Apple use NLP in their products. Every time you ask Alexa, Siri or Google Home what the weather is like at your location or where to find a Japanese restaurant, NLP allows the program to understand your speech and answer in verbal language (Hunckler, 2017).

3.4. Social and emotional capabilities

This area deals with human social intelligence, which includes a machine's capability to sense and reason about social and emotional states as well as the ability to generate emotionally suitable output. These are essential capabilities for daily (human) interaction and for tasks like negotiation, persuasion, and caring. Among the five broader capability areas, social and emotional capabilities is currently the least advanced and will probably not surpass human level for at least two more decades (Manyika et al., 2017; Frey and Osborne, 2013).

Advances in machine learning and sensing have given machines a limited ability to recognize human emotions.

However, the current capabilities of these software programs are still far below human levels and face significant challenges with regards to instantaneous and accurate recognition of emotions. It is even more difficult for machines to comprehend and reason about the social and emotional states of humans.

Existing techniques analyze facial expressions, physiological factors (e.g., heart rate or blood pressure), text and spoken dialogues to detect human emotions. These techniques hold great future potential for several applications like automated call centers (Picard, 2007) and targeted advertisements based on emotional states (Doerrfeld, 2015).

Several emotion recognition software programs are already in use. Affectiva, for example, applies facial expressions analysis to adapt mobile applications to adjust to the emotional state of the user (Turcot, 2015).

To date, even the most advanced algorithms are not capable of communicating in a way that is indistinguishable from humans, and no machine has ever passed the Turing test.[2] The generation of emotionally suitable output is complicated by the existence of "common sense", which is tacit or implicit knowledge possessed by humans and ingrained in human interaction and emotions.

This knowledge is hard to define and articulate and therefore almost impossible to incorporate in algorithms (Hager et al., 2015; Frey and Osborne, 2013; Manyika et al., 2017). Communicating, in the absence of common sense, results in awkwardness or feelings of unnaturalness. There are some robots on the market that have a limited ability to mimic human emotions, like the humanoid Pepper, which can express joy, surprise, anger, doubt and sadness, but the actual creation of emotions is far away (Murphy, 2015).

3.5. Physical capabilities

This area includes fine and gross motor skills, navigation and mobility. It is closely related to the area of sensory perception, which provides the information input for physical activities (Manyika et al., 2013). Machines have already surpassed humans in terms of gross motor skills and the use of robots is widespread in industrial and warehousing settings, for example for picking and placing, welding, packaging and palletizing. Amazon has even completely automated some of its warehouses using robots.

However, on the frontier of fine motor skills and dexterity, technology is lagging behind significantly (Ritter and Haschke, 2015; Manyika et al., 2017). Manual skills are deeply integrated into the human cognitive system. Therefore, grasping and manipulation of smaller and deformable objects are still large sensorimotor challenges for the current technology. Robot dexterity is constrained by the strength of miniaturized actuators as well as visual and tactile sensors, which currently perform far below human levels (Hardesty, 2017; Ritter and Haschke, 2015; Frey and Osborne, 2013). Moreover, robots do not yet have the same degrees-of-freedom as human hands and current control systems are not yet capable of dealing with the multifaceted and unstructured nature of manual tasks. Nevertheless, there are several anthropomorphic robot hands with human-like capabilities on the market. The most advanced of these is the Shadow Dexterous Hand (Ritter and Haschke, 2015), which can perform delicate tasks such as opening a bottle cap and grabbing strawberries without crushing them.

Empowered by advances in machine vision and machine learning, navigation has already surpassed human capabilities. Advanced GPS systems, supported by vast amounts of spatial data, enable the pinpointing of exact locations and navigation toward almost every destination imaginable.

These capabilities are already widely used for example in (partly) autonomous cars and navigation apps, like Google Maps.

Despite advances in computer vision, robot mobility is still at a low level, especially autonomous mobility. Autonomous movement through static environments, e.g., specially designed warehouses, has largely been solved (Grosz et al., 2016; Manyika et al., 2017), but adapting motion to new and dynamic environments remains a substantial challenge (Heess et al., 2017).

Some of the reasons for this are technical challenges, including balance and control (Electronics Teacher, 2017), as well as insufficiently developed algorithms (Heess et al., 2017). Moreover, a lack of research on robot mobility in indoor settings has hampered progress in the area of indoor mobile robots (Grosz et al., 2016).

However, progress is being made on algorithms, as is shown by the DeepMind computer which recently taught itself to move through new, complex environments in a computer simulation (Heess et al., 2017). Real-life examples of advanced mobile robots are Boston Dynamics' Atlas, a humanoid robot which can move to various unknown terrains on two legs (Boston Dynamics, 2018), and Asimo, a humanoid robot capable of running, walking, kicking a ball and reacting to human instructions (Honda, 2018).

3.6. The overall state of current technologies

Though substantial progress is being made in all five capability areas, several capabilities currently remain out of reach for the available technologies. Most notably, technology is underdeveloped for processing and generating natural language and social/emotional output, autonomous mobility, fine motor skills and a range of cognitive capabilities. On the other hand, technology is excelling in fields such as recognizing known patterns, gross motor skills and navigation, and is largely at par with humans in the field of sensory perception. Moreover, further advances are expected in all areas, and machines will likely be at or above human levels for most capabilities within one to two decades (Chui, Manyika and Miremadi, 2015).

However, current technological progress is mainly focused on narrow, individual capabilities.

The integration of several capabilities into well-functioning holistic solutions is another significant challenge that needs to be overcome and will probably take much longer than for the individual capabilities (Frey and Osborne, 2013).

On the other hand, environmental control can mitigate the current limitations of machines. This concept refers to the alteration of the environment or the task to make it simpler and more structured, for example by breaking it down into smaller tasks or by transforming an unstructured environment into a structured one. Environmental control can obviate the need for advanced flexibility, mobility, manual dexterity and cognitive capabilities. For example, Amazon placed bar-code stickers on the floor of its warehouses to assist the robots in their warehouse navigation. They adapted the environment so it would become structured.

However, though environmental control is applied in warehouses and other local environments, countries and cities are still lagging behind in adapting their infrastructures to accommodate the new technologies (Frey and Osborne, 2013; Grosz et al., 2016).

4. The substitution of job tasks

Having discussed the current technological capabilities in the previous section, the ensuing section aims to relate these capabilities to their potential of substituting labor, focusing on the individual tasks that constitute jobs, rather than jobs in their entirety. The reason for this is that jobs include several different types of tasks, which all have a different relation to the current capabilities of technologies. Consequently, some types of tasks can already by automated while others cannot. Hence, it is essential to first understand which individual tasks can be substituted before one analyzes the effect on jobs and labor in general.

The different types of tasks are introduced in the next section, following the task model by Autor, Levy and Murnane (2003), and the substitution potential of each task category will be discussed in relation to the previously mentioned capabilities. In the next section, *The Impact on Labor*, we utilize our findings to make a judgment on the overall effect of automation on a selection of jobs and industries.

4.1. Four types of job tasks

To determine the job substitution potential of computers, Autor, Levy and Murnane (2003) conceptualized work as a series of tasks rather than complete jobs. Specifically, the paper distinguishes routine tasks from non-routine tasks and manual from cognitive tasks. This classification results in a 2 × 2 matrix, which is displayed in Figure 3.2. Routine tasks are defined as tasks that follow explicit rules, which can be exhaustively specified and, hence, translated into code. For non-routine tasks, these rules are not understood sufficiently well, which makes them much harder to codify. As a corollary of this definition, routine tasks are automatically classified as tasks that are easily substituted by technology while non-routine tasks are not.

Manual tasks are physical activities that require motor skills and mobility whereas cognitive task relate to mental processes.

In addition to the matrix in Figure 3.2, there are several other task classifications. For example, Manyika et al. (2017) have developed seven broader activity categories:

1 Predictable physical
2 Processing data
3 Collecting data
4 Unpredictable physical
5 Interfacing with stakeholders
6 Expertise
7 Managing and developing others

These seven categories fit largely within the 2 × 2 matrix of Autor, Levy and Murnane (2003). Predictable and unpredictable physical activities are aligned with the routine manual and non-routine manual task classification of Autor, Levy and Murnane (2003). Data collecting and processing largely fall under

	Cognitive	*Manual*
Routine	Explicit rules Mental processes	Explicit rules Motor skills
Non-routine	Rules difficult to codify Mental processes	Rules difficult to codify Motor skills

Figure 3.2 Four categories of job tasks (Autor, Levy and Murnane, 2003).

routine cognitive tasks, whereas interfacing with stakeholders, applying expertise and managing and developing others can be placed under non-routine cognitive tasks.

Each of the four categories is discussed in more detail in the next section.

4.1.1. Routine manual tasks

The routine manual task category includes physical activities that require systematic repetition of a consistent procedure, i.e., structured physical tasks that take place in predictable environments. The primary capabilities required to perform these types of activities are gross and fine motor skills, sensory perception and, to some extent, mobility.

Examples of activities include assembling, picking and sorting, welding and cooking. These tasks are easily translatable into computer programs and the technology to perform them is at an advanced level, especially for gross motor skills, where machines have been outperforming humans for a long time.

Consequently, this task category has the highest technological potential for substitution by machines (Manyika et al., 2017; Frey and Osborne, 2013; Autor, Levy and Murnane, 2003). Manyika et al. (2017) even predict that in the United States as much as 81% of the tasks in this category can be substituted.

The substitution of routine manual tasks has a long history and goes back to the introduction of the first machines that were capable of functioning automatically. Since then, machines have continuously pushed out humans, and a vast number of manual activities have been automated in the twentieth century (Finnigan, 2016). For example, many processes in the agriculture and car manufacturing industries are currently performed by machines. As a corollary, Autor, Levy and Murnane (2003) found that the percentage of people active in jobs with large proportions of routine manual activities declined between 1960 and 1998.

More recently, advances in sensory perception and manual dexterity have made it possible for robots to be assigned to tasks that require higher precision, e.g., slicing meat, assembling customized orders, manufacturing electronic components (Sander and Wolfgang, 2014; Sirkin, Zinser and Rose, 2015). Robots have also become safer and much more flexible to use, which allows them to quickly switch between different tasks and to safely work next to humans. Furthermore, the advances in mobility and navigation allow robots to move autonomously in static environments like warehouses.

In addition, robots are increasing their presence in the service industry. Simple service tasks, like cleaning, have been performed by robots for over a decade, the most notable example being the robot vacuum cleaner. However, with their increased dexterity and mobility, robots are increasingly able to take on complex routine manual tasks in the service industry. A prime example is the food sector where robots can be deployed to prepare and serve food and beverages (Frey and Osborne, 2013; Manyika et al., 2017).

For instance, the pizza delivery company Zume Pizza has automated its production process almost completely using sophisticated robots (TechCrunch, 2016).

Nonetheless, robot deployment is still in an early stage in this industry and the substitution potential remains limited.

Many routine manual tasks can and most likely will be performed by robots in the future and the share of repetitive, rule-based activities in jobs will decrease. With advances in sensors and increasing robot dexterity, more high-precision tasks will become candidates for substitution, such as manufacturing tasks in the electronics sector. As robots become safer, they will likely take up more positions next to their human coworkers. Further engineering advances are necessary to increase the flexibility of robotic systems by decreasing the reconfiguration time (Robotics Technology Consortium, 2013).

4.1.2. Non-routine manual tasks

Non-routine manual tasks are non-structured physical tasks that take place in unpredictable environments, often involving situational adaptability and in-person interaction. They require capabilities like sensory perception, fine and gross motor skills, social and emotional capabilities, natural language processing, navigation and mobility. The majority of these capabilities have not yet reached human-level performance and the incorporation of flexibility remains a considerable challenge (Autor, 2015; IPsoft, 2018). Consequently, the automation potential of this category is low, only 26% according to Manyika et al. (2017). Examples of tasks include operating a crane, assisting with surgery, janitorial work and making hotel beds.

Recent advances in sensory perception and physical capabilities as well as machine learning have enabled machines to take over an increasing number of manual non-routine tasks. Improvements in sensor technology and manual dexterity allow robots to perform high precision, non-standardized tasks, such as the manipulation of delicate products like fruit and vegetables. By incorporating advanced sensors, computer programs can also take over condition-monitoring tasks, such as checking the state of an aircraft engine or examining the moisture level in a field of crops. When alerted by the program, human operators can perform the required maintenance. Even some maintenance tasks are being substituted.

For example, General Electric has developed robots to climb and maintain wind turbines (Frey and Osborne, 2013).

Another well-known new application of machines for non-routine manual tasks is the autonomous vehicle. Autonomous driving was deemed impossible not so long ago as it requires activities such as parking, switching lanes and adapting to traffic lights, other vehicles and pedestrians (Autor, Levy and Murnane, 2003; Manyika et al., 2017).

However, today, facilitated by machine learning and advanced sensors, Google's autonomous car is driving the streets completely by itself and is even seen by some as safer than human-controlled cars (Frey and Osborne, 2013; Grosz et al., 2016). Autonomous mobility has also entered the warehousing industry (Autor, 2015). Here, enabled by environmental control, many warehouses, such as Amazon's warehouses, have become largely automatic.

Nonetheless, most non-routine manual tasks remain out of reach for machines for now and the near future. Despite the advances in the field of autonomous cars, autonomous mobility in general remains a significant challenge. Likewise, significant progress in perception and dexterity technologies is required before autonomous manipulation is viable in unstructured and delicate settings (Robotics Technology Consortium, 2013). Moreover, tasks that require human interaction demand further advances in language recognition, social and emotional capabilities and user interfaces. One example is walking a patient down a hospital (or nursery) hallway (Grosz et al., 2016). This requires a robot to help a patient get out of bed, which requires that the robot communicate with the person based on their emotional state, possess fine motor skills and sensory perception, to know where to hold/touch the patient and how much force to apply and to navigate through an unstructured environment. The activity is therefore not likely to be automated in a near future.

4.1.3. Routine cognitive tasks

Routine cognitive tasks include all mental (non-physical) tasks that repeat a certain procedure in a predictable environment. To a large extent, this relates to the different aspects of processing structured information, such as data collection, organization and storage (Autor, Levy and Murnane, 2003).

The required capabilities for these tasks are retrieving information, recognizing known patterns, optimizing and planning, logical reasoning/problem solving and natural language processing.

Examples of tasks are data-processing tasks such as calculating and bookkeeping but also routine customer-service activities performed by people such as cashiers, telephone operators and bank tellers. Because of their routine nature, these tasks have a high potential for machine substitution, ranging from 64% for tasks relating to data collection to 69% for tasks relating to data processing in the US, according to Manyika et al. (2017).

The automation of cognitive tasks started with the introduction of the computer (Autor, Levy and Murnane, 2003), which enabled the digitization and automatic processing of information. Subsequently, many processes, including administrative tasks, bookkeeping, invoicing, optimizing resource needs, and numerous others, have already been automated (Acemoglu and Autor, 2011).

Today, technological advances and the current focus on digitalization have brought the automation of routine cognitive tasks to an unprecedented scope and pace. Many companies have embarked on so-called “digital transformations”, which refer to the simplification, standardization, and digitalization of an entire organization (Ketterer, Himmelreich and Schmid, 2016).

At the front-end, this means that large parts of customer interaction interfaces can be automated. Examples range from the automation of customer data collection for mortgage brokers to the employment of full-fledged, AI-based, virtual employees who can take over all aspects of customer interaction (IPsoft, 2018). At the back-end, the restructuring of the organization's IT landscape obviates many processes and activities (Ketterer, Himmelreich and Schmid, 2016).

In addition, for some structured processes that remain in existence, robotic process automation can be employed, which uses software robots to automate well-defined transactions/user actions normally performed by humans (Bughin et al., 2017; Ketterer, Himmelreich and Schmid, 2016). These software robots can be seen as virtual employees who work with existing applications in a similar fashion to humans (Forrester Research Inc., 2014).

The further proliferation of automated data collection and processing activities depends on the pace of digitalization. As companies progress on their digital transformations, more data and processes will be digitized and therefore likely automated. Moreover, further automation of customer service activities will depend on the machines' capability to interact with customers and thus depends on advances in natural language processing and emotional capabilities.

4.1.4. Non-routine cognitive tasks

Non-routine cognitive tasks are mental (non-physical/abstract) tasks that do not follow a structured procedure and/or take place in unpredictable environments (Autor, Levy and Murnane, 2003). These types of tasks require several cognitive capabilities, including creativity, logical reasoning, generating novel patterns and coordination with multiple agents. In addition, natural language processing and social and emotional capabilities are often of high importance (Acemoglu and Autor, 2011). These types of tasks include activities that relate to interfacing with stakeholders, applying expertise and managing and developing others. Examples of activities include legal writing, negotiations, teaching and diagnosing diseases.

Historically, these types of tasks have been the most difficult to automate (Frey and Osborne, 2013; Autor, Levy and Murnane, 2003). However, the availability of big data and recent advances in machine learning (pattern recognition in particular) have enabled machines to enter the realm of unstructured tasks. By applying unsupervised learning, a computer can create its own structure in an unstructured setting. Moreover, developments in the field of user interfaces, like language recognition, enable computers to respond directly to voice and gesture instructions (Manyika et al., 2013).

One of the tasks that can now be automated is fraud detection, a task that requires the ability to detect trends in data as well as to make decisions (Frey and Osborne, 2013). By using machine learning to build models based on historical transactions, social network information, and other external sources, the system can use pattern recognition to detect anomalies, exceptions, and outliers. This means fraudulent behavior can be spotted and fraudulent transactions can be prevented (Wellers, Elliot and Noga, 2017).

The legal domain is another area that machines are entering; nowadays, computers can analyze and order thousands of legal documents swiftly and present their findings graphically to the attorneys and paralegals (Frey and Osborne, 2013).

Yet, most of the involved capabilities remain far under human level for now. Especially tasks that require creativity, problem-solving and complex communication (a confluence of natural language processing and social and emotional capabilities) have a very low substitution potential (Manyika et al., 2017; Autor, Levy and Murnane, 2003).

Even in fields in which machines can outperform people on narrow tasks, like route planning, humans are often still required to set the target, interpret the outcomes and perform common-sense checks. Arguably there, major advances are required before machine learning and artificial intelligence become mature technologies. For instance, there are several examples of failing AI systems, like Microsoft's Tay Chatbot, who had to be shut down only 16 hours after launch because of the highly controversial messages it tweeted. Correspondingly, the three categories identified by Manyika et al. (2017), interfacing with stakeholders, applying expertise, and managing others, all have a substitution potential of below 20%.

Besides other required advances in cognitive, social and emotional capabilities, the availability of a sufficient amount of task-specific information is essential for the automation of cognitive non-routine tasks. In absence of this information, pattern recognition cannot be applied. In addition, as with the other types of tasks, environmental control, or task simplification, can be applied to mitigate engineering bottlenecks. For example, self-checkout stations in supermarkets obviate the need for advanced customer interaction (Frey and Osborne, 2013; Autor, Levy and Murnane, 2003).

4.2. The overall substitution of job tasks

As is evident from the previous discussion, technologies can take over an increasing number of activities. Routine, both manual and cognitive, tasks have been in the automation process for some time, whereas machines have only just acquired the ability to substitute for human labor in some non-routine tasks. The substitution potential for routine tasks is high and will only increase with technological advances. The substitution of non-routine tasks, on the other hand, remains largely limited to narrow applications for which human involvement is still required. A summary of the discussion for each of the job task categories is provided in Figure 3.3. To bring the automation of non-routine tasks to the next level, significant advances in all five capability areas are necessary, with natural language processing capabilities being the most important according to Manyika et al. (2017).

5. The impact on labor

Though several books and papers argue that technology will take over many jobs resulting in mass unemployment (Berg, Buffie and Zanna, 2016; OECD, 2016), as

	Cognitive	*Manual*
Routine	***Primary Required Capabilities*** Retrieving information Recognizing known patterns Optimizing and planning Logical reasoning/problem solving Natural language processing ***Sample Tasks*** Data processing tasks, e.g., calculating and bookkeeping Customer service tasks by e.g., cashiers, telephone operators, bank tellers **Predicted Substitution Rate: 64–69%***	***Primary Required Capabilities*** Gross and fine motor skills Sensory perception Mobility to some extent ***Sample Tasks*** Assembling Picking and sorting Welding Cooking **Predicted Substitution Rate: 81%***
Non-routine	***Primary Required Capabilities*** Creativity Logical reasoning/problem solving Generating novel patterns Coordinating with multiple agents Natural language processing Social and emotional capabilities ***Sample Tasks*** Legal writing Negotiating Teaching Diagnosing diseases **Predicted Substitution Rate: <20%***	***Primary Required Capabilities*** Fine and gross motor skills Sensory perception Social and emotional capabilities Natural language processing Navigation Mobility ***Sample Tasks*** Operating a crane Assisting with surgery Janitorial work Making hotel beds **Predicted Substitution Rate: 26%***

Figure 3.3 Summary of required capabilities, sample tasks and predicted substitution rate (in the USA) for each job task category.

of yet, this scenario seems unlikely to happen (Arntz, Gregory and Zierahn, 2016; Frey and Osborne, 2013; Manyika et al., 2017). Many activities can currently not be substituted by machines, and machines are not capable of performing several types of activities in an integrated way (Manyika et al., 2017; Autor, 2015). Hence, they are generally not capable of substituting labor for entire jobs, which usually include many bundled activities. Rather, to determine the substitution potential of a particular job, it is better to focus on the substitution of the individual activities within that job. A large body of research aligns with this approach and suggests that technology will take over significant parts of every job across all industries and levels of society (Manyika et al., 2017; Arntz, Gregory and Zierahn, 2016; OECD, 2016).

The following section will first analyze the automation potential of individual occupations and broader occupation categories and subsequently the nature of work and the impact of technology on industries.

5.1. The potential of job automation

Estimations of the potential of job automation differ significantly across studies. Frey and Osborne (2013) estimate that as much as 46 percent of all occupations in the United States consist of more than 70% activities that can be automated and are therefore highly automatable. By using the same methodology, but with a task approach rather than an occupation approach, Arntz, Gregory and Zierahn (2016) find that only nine percent of jobs in the US have an automation potential of more than 70%.

While Manyika et al. (2017) does not use 70% as a threshold for high automation potential, one can deduct from their study that around 25% of all jobs are more than 70% automatable in the United States.

Clearly, making an accurate estimation of automation potential is difficult and largely depends on subjective judgment of the capability of technologies and the task structure of occupations. Despite this variance, however, several high-level observations can be made.

Firstly, jobs that can be automated completely are likely to consist entirely of routine manual and routine cognitive tasks that require no human interaction or manual dexterity. Examples of these types of occupations are sewing-machine operators and order clerks.

Secondly, jobs with a high risk of automation also largely consist of routine manual and routine cognitive tasks, but will most likely include some degree of human interaction or unpredictable/high-precision physical activities. Occupation categories that include many highly automatable jobs are, for example, manufacturing and production because of their high degree of manual routine tasks, as well as sales, office and administrative support jobs because of their high dependence on information collecting and processing (World Economic Forum, 2016). Other occupation categories with large elements of routine manual activities are transportation (Frey and Osborne, 2016) and material-moving as well as food and accommodation services. According to Manyika et al. (2017), the latter even has the highest automation potential of all categories.

Lastly, the higher the proportion of non-routine tasks, the lower the automation potential of the job. This effect is enhanced if capabilities such as human interaction (requiring natural language processing and emotional and social capabilities), creativity, logical reasoning/problem solving, high-level dexterity or mobility are required. Jobs that consist entirely, or to a large extent, of these kinds of capabilities are not at all susceptible to automation (Arntz, Gregory and Zierahn, 2016; Manyika et al., 2017).

For example, the job of a choreographer primarily consists of the creative task to develop choreography and of human interaction to deal with stakeholders and train the dancers to bring the choreography to life.

A dentist, on the other hand, requires high-level dexterity and sensory perception as well as emotional and social capabilities to interact with their clients. Hence, both occupations have almost no activities that can be automated.

Still, the majority of occupation categories fall somewhere in between. This includes both routine and non-routine tasks. Therefore, they can be partly automated. For example, cognitive tasks are the core value drivers for investment bankers, yet a large proportion of their job consists of gathering and analyzing information and could thus be automated. The same holds for many legal professions. It is likely that these types of jobs will not disappear, rather, they will harness technology to improve efficiency of humans and the quality of output (Frey and Osborne, 2013).

It is important to note that this is a generalized view. The aforementioned occupation categories also include substantial proportions of jobs with low levels of automation potential, and the substitution potential of a job varies significantly across industries. For example, while supermarket cashiers and specialized software sales agents both fall under the sales occupation category, the substitution potential of the first is high while that of the latter is low because of the required technical expertise and emotional intelligence (World Economic Forum, 2016).

Furthermore, the substitution potential of similar jobs varies across different countries due to alterations in the structure of the jobs, industries and education, and previous investments in technology (Arntz, Gregory and Zierahn, 2016). For example, the automation potential in Sweden might be lower than average because Sweden sits at the forefront of technology investment. Consequently, technology will already have been included in many processes, making it difficult to automate large parts of the remaining activities. In addition, Sweden has a strong focus on high-skilled employees, who typically perform fewer tasks that are automatable. Correspondingly, Arntz, Gregory and Zierahn (2016) estimate that only seven percent of jobs in Sweden are at high risk of being substituted, compared to nine percent for all OECD countries. A discussion of other considerations such as these is provided in the next section.

5.2. The future nature of work

The large-scale substitution of individual tasks will likely change the nature of work and of all jobs (Frey and Osborne, 2013). As machines start to take over routine manual and routine cognitive tasks, human employees will be able to spend more time on complementary tasks where they hold a comparative advantage, such as activities involving creativity and human interaction (Autor, 2015; Finnigan, 2016; Arntz, Gregory and Zierahn, 2016).

Moreover, for many of these tasks, humans will be augmented by machines, and a closer collaboration between technology and humans is expected (International Federation of Robotics, 2017). For example, while a doctor is likely to remain responsible for the final diagnosis of a patient in the next decades, they will be able to base a decision partly on the automated diagnosis advice provided through AI.

As a result, jobs will require more training and a higher understanding of technology. In addition, as the incorporation of technology increases productivity, human employees might spend less of their time on work, resulting in shorter workweeks.

5.3. The effect on the labor market

The automation of activities has caused a well-documented shift in the labor market over the past decades. As part of this shift, scholars observed a polarization of the labor market in both the United States and Europe (Autor and Dorn, 2013; Autor, 2015). This polarization included a sharp decline in the share of middle-skilled jobs accompanied by increases in the share of low-skilled service jobs and high-skilled jobs (Frey and Osborne, 2013; Autor and Dorn, 2013). These middle-skilled jobs could be automated because they consisted primarily of routine manual and routine cognitive tasks, such as collecting and processing data. Tasks that could not be automated included non-routine manual and cognitive tasks. The first are usually found on the low-skill side of the spectrum while the latter are usually found on the high-skill side.

Consequently, the increase in general demand for labor following the productivity growth from automation mostly affected low-skilled jobs, e.g., hairdressers, janitors and high-skilled jobs, e.g., computer scientists, causing an overall polarization effect (Autor, 2015).

However, because of recent and future technological developments, this polarization is expected to taper off. The reason for this is threefold. Firstly, many remaining mid-level jobs require a combination of non-routine tasks and capabilities, including emotional skills, problem-solving, and flexibility, that cannot yet be performed by machines. Secondly, the rise of new technologies has created several new types of middle-skilled jobs, such as healthcare technicians and has stimulated demand for others, such as managers of eating establishments. Lastly, as discussed in this chapter, machines are increasingly able to take over low-skilled service jobs and high-skilled cognitive jobs (Holzer, 2015; Autor, 2015; World Economic Forum, 2016).

There has also been a global debate on the effect of technology on offshoring and reshoring initiatives, especially within the US manufacturing industry. Because the implementation of robotics obviates the need for cheap labor (Robotics Technology Consortium, 2013; International Federation of Robotics, 2017), many argue that it would give rise to a trend of reshoring manufacturing activities to the Western world while the offshoring trend would slow (Van den Bossche et al., 2015). However, more recently, opposing views have arisen, arguing that technology is also enabling the offshoring of many services and simplifying the management of complex global supply chains, leading to an increase in offshoring of manufacturing activities. The latter effects seem to be stronger and the reshoring trend, for example, advocated by the consultancy BCG, seems to have already ended (Boston Consulting Group, 2015). Meanwhile, offshoring is only found to increase (Van den Bossche et al., 2015).

Accurately estimating the overall effect of the previously discussed change drivers on the labor market is nigh on impossible and estimates range from mass unemployment to increases in labor demand. As large parts of jobs can be automated, fewer people will be needed to deliver the same output (Finnigan, 2016).

Consequently, automation could lead to unemployment in the short term (OECD, 2016) before gains in overall productivity raise the demand for labor again. Historically, technological progress has not significantly increased unemployment in the long run, but it remains to be seen whether this time will be the same (Autor, 2015). What is certain is that technology will cause large labor displacements, especially in high-routine occupation categories. Organizations and employees will need to increase their focus on education and training in order to be able to keep up with the increasing pace of change.

5.4. The automation potential of industries

The automation potential of work varies across industries because different industries have different job constellations and similar jobs in different industries might comprise different sets of tasks. In addition, there are also significant differences among countries regarding the job constellation of their industries. For example, an attorney in Sweden might perform very different tasks on a daily basis than an attorney in the United States.

As mentioned before, according to Manyika et al. (2017), the accommodation and food industry has the highest proportion of automatable tasks globally. These findings are supported by a study made in the US on the relation between innovation and employment (Frey and Osborne, 2015). The sector has such a high automation potential because food preparation consists of highly predictable manual tasks. For instance, tasks such as order taking and order serving do not require high levels of emotional intelligence, making them both susceptible to automation. The fast-food chain McDonald's, for example, has automated its ordering and payment processes using digital screens, and many casual-dining operators are implementing tabletop tablet systems in their restaurants.

Other industries with large proportions of automatable tasks identified by both studies are transportation and warehousing, retail trade, wholesale trade and manufacturing. For example, Amazon has already shown that robots can run entire warehouses and the technology for autonomous vehicles is largely ready, creating the opportunity to automate truck transportation.

On the low-end of the automation spectrum are industries such as educational services and the management of companies and enterprises. For many jobs in these sectors, emotional intelligence and complex communications are large and essential parts of daily activities, which substantially decreases automation potential.

The studies also disagree on the automation potential of several industries. For example, for some of the mining, real-estate rental, administrative and support services and construction industries, automation potential is estimated as average by Manyika et al. (2017) and high by Frey and Osborne (2015) while for other industries it is exactly the other way around. For example, the agriculture and information sectors are hardly automatable according to Osborne and Frey while they are averagely automatable according to Manyika et al. (2017).

Manyika et al. (2017) has also performed a study on the Swedish economy. According to the study, three industries have the highest proportions of automatable tasks. These are manufacturing, mining and transportation and warehousing. The industries with the lowest automation potential are educational services, the information sector, and the arts, entertainment and recreational sector.

In terms of the absolute number of employees who could be substituted, the manufacturing sector has by far the largest share. The study estimates that the work of as many as 420,000 people could potentially be automated. Other industries representing large numbers of people are healthcare and social assistance, administrative support and government and retail trade. Overall, Manyika et al. (2017) estimates that 46% of activities could be automated in Sweden, representing a potential redundancy of 2.1 million employees.

6. Other considerations for automation

Though it is technically feasible to substitute human labor with machines in many jobs and job tasks, there are several other factors affecting the pace and extent of automation. Five of these factors are discussed in the following sections: commercial availability, cost of implementation, economic benefits, labor-market dynamics and social, legal and ethical acceptance. We have based these factors on the five factors affecting the pace and extent of automation identified by Manyika et al. (2017). However, we renamed their first factor of technical feasibility as commercial availability in order to remove any confusion with our use of the term technological feasibility in this chapter.

6.1. Commercial availability

Although the previously discussed technologies have been proven in laboratories, the majority of them are yet to be commercialized. Many technologies are still in the early or middle stages of their development; they have not yet reached full maturity and require more scientific research. An example of this is artificial general intelligence (AGI). Despite the vast amount of research in this technology and the demonstration of some applications, much more scientific research is needed and academics estimate it might be 2050 before we can expect widespread adoption of robust AGI platforms (Vorhies, 2016).

Moreover, there is a distinct difference between technological feasibility and commercial adoption. Whereas basic (scientific) research focuses on broad generalizable cases, applied research focusses on developing engineering solutions for specific use cases. Developing viable products out of new technological concepts takes time and effort.

For example, predictive engineering for aircraft engines and predictive health care could be seen as similar scientific problems since both predict the failure of a system. However, both applications would need entirely different software, models and hardware to work and each would take years to be developed (Manyika et al., 2017).

Moreover, the ability to diagnose diseases can already be performed to some extent by computers, but computers diagnosing all types of diseases in the near future is unlikely due to technical difficulty (Bughin et al., 2017).

6.2. Cost of implementation

Besides the availability of commercially ready applications, there must be a solid business case for a company to implement automation and digitalization technologies. Hence, the development and implementation costs of new technologies are an important determinant of their adoption speed and scope. When analyzing these costs, there is a profound difference between the cost size and structure of hardware and software solutions.

6.2.1. Hardware

Hardware includes all physical components involved in a technological solution and often requires sensory perception, fine motor skills, gross motor skills and/or mobility. The capital expenditures for these components are often high and require significant upfront investments. This makes the business case more challenging and raises the need for available capital. Large companies in advanced countries, such as Sweden, are expected to have the fastest adoption rates of these solutions because they face high labor costs and are in the possession of readily available capital. Furthermore, the adoption cycles for industries facing high capital intensity are likely to be longer (Chui, Manyika and Miremadi, 2017).

The primary example of a hardware solution is an industrial robot. The cost of sophisticated robots has been declining over the past decades (Manyika et al., 2013; Frey and Osborne, 2013) and is expected to continue to decline in the future (Sirkin, Zinser and Rose, 2015).

This price drop has been enabled by significant cost decreases of advanced sensors and actuators. In addition, due to increases in production volumes of robots, economies of scale might lead to further cost reductions (Manyika et al., 2013; Grosz et al., 2016).

Despite the price drops, the cost of reliable mechanical devices remains high, and most industrial robots are still relatively expensive, ranging from several tens of thousands to hundreds of thousands of dollars. Moreover, besides the costs of the robot itself, large investments are required for engineering the robot's work cell (Robotics Technology Consortium, 2013). For example, to be able to work safely, an industrial robot often needs advanced safety equipment, and if a robot arm is to work with different tools, a tool-changing system needs to be in place. This kind of equipment is very expensive and can more than double the price of the robot's implementation (Slepov, 2016).

However, with the introduction of simpler general-purpose robots, the automation costs for simple tasks might drop significantly. Besides being cheaper themselves, these robots are more flexible and do not require extensive work cells. Likewise, they are safer for humans to work with, obviating the need for expensive safety equipment. The proliferation of this type of robots could significantly impact the adoption rate of robots. Service robots are, in general, cheaper than their industrial brothers and do not require surrounding equipment (Frey and Osborne, 2013; Manyika et al., 2013).

6.2.2. Software

For software solutions, the capital requirements are much lower, especially for solutions that are cloud-based. These low costs are enabled by increasing performance and decreasing costs of computing power, data storage and cloud computing. Often, the marginal cost of an additional software unit is negligible (Manyika et al., 2013; Autor, 2015).

However, the deployment of software can also incur highly taxing implementation costs, especially if legacy software systems are in place.

These implementation processes comprise activities such as software customization, staff training and new process architecture, and they can be more expensive than the software itself (Forrester Research Inc., 2014). Moreover, the talent required to develop, customize and implement advanced solutions is scarce and therefore extremely expensive.

For example, a study by Paysa, a career-consultancy firm, estimated that, in the United States alone, there were 10,000 open positions for AI talent in 2016, and that companies such as Alphabet and Microsoft are paying millions to acquire talented employees (Ketterer, Himmelreich and Schmid, 2016).

Robotic process automation forms a cheaper and quicker solution than the implementation of expensive new software solutions. This technology can automate workflows and substitute human labor without major investments. However, the overall benefits are limited compared to a complete system redesign (Horton, 2015).

6.3. Economic benefits

Another component in making a solid business case for the adoption of new technologies are the derived economic benefits from implementation. Companies will only be inclined to incorporate new technologies into their organizations if the benefits exceed the costs.

The first and most obvious economic benefit from the implementation of automation technologies is the reduction of labor costs, resulting from the substitution of human labor. As previously discussed, it is unlikely that many jobs will be substituted completely, but it is likely that fewer employees will be necessary to achieve the same output due to increased productivity.

The economic benefits of automation do, however, not only show in forms of saved labor costs but also in the form of new value creation. Examples include benefits such as increased throughput and productivity, improved safety, reduced waste and higher quality, all of which can increase profit in one way or another. These additional benefits can sometimes even exceed the benefits of labor substitution.

For example, implementing autonomous trucks would not only reduce labor costs but would also improve safety, fuel efficiency and productivity as there is no driver that requires stops. In turn, these improvements lead to increased profit. Google DeepMind is another example; the implementation of AI from DeepMind machine learning in Google's data centers has reduced energy consumption by 40%, resulting in increased profit (Grosz et al., 2016; Manyika et al., 2017).

Furthermore, due to the advancements in robotics, robots have become more economically viable options for tasks that were once seen as too expensive or delicate to automate, such as robotic surgery assistance.

As mentioned in the section *Definition of Digitalization*, digitalization is a means to create and capture new value within an organization. For example, it allows companies to open new digital customer channels and to develop new customer insights and products and services, leading to the creation of new value for the customer and the company. Moreover, the automation of routine processes enables employees to spend a larger amount of their time on high-value tasks. For example, within the finance sector, by letting a computer monitor existing processes and learn to recognize different situations (e.g., matching a payment with an order number), finance staff is freed from this activity and can instead focus on more valuable strategic tasks (Wellers, Elliot and Noga, 2017). Consequently, companies and industries that have digitalized to a larger extent, such as media, financial services, and technology, often show higher productivity and wage growth than industries that have digitalized to a lesser extent, such as education, retail and healthcare.

Besides increased profits for companies, society as a whole can gain substantial benefits from the implementation of technologies. Transportation is a prime example. As mentioned before, the automation of truck transportation will lead to higher productivity, higher safety and lower fuel consumption. Higher productivity means that fewer trucks will be necessary, leading to higher fuel reductions and less congested roads. As a result, the public will benefit from lower pollution, fewer traffic jams, fewer accidents and lower spending on road maintenance.

The benefits previously mentioned drive the pace of automation. However, it is important to note that most industries are still in very early stages of the adoption cycle of technologies such as AI, ML and robotics. Because of the small number of existing implementations, it is difficult to estimate what the overall benefits of these technologies will be. Moreover, it often takes years before the indirect economic benefits become visible. This time-lag between investment and benefits is especially large in capital-intensive industries where investments in hardware are required. Consequently, it is difficult for companies and regulators to understand the cost-benefit trade-offs of implementing new technologies (Grosz et al., 2016).

An example is an AI-based system. According to a survey by Bughin et al. (2017), most business leaders do not know what AI can do for them, where to use it, how to integrate it and what the benefits and costs will be.

6.4. Labor market dynamics

Since labor costs form an integral part of the business case for companies, the dynamics of the labor market are an important factor influencing the adoption rate of these technologies. These dynamics include the supply, demand and cost of human labor and are closely related to the demographics of a country and the skill-level of its citizens.

The supply and demand of labor have a large influence on the cost of labor and therefore on the economic benefits derived from the substitution of labor (Frey and Osborne, 2013). A high supply of labor in combination with low demand leads to a decrease in wages. Subsequently, low wages will decrease the economic benefits from labor substitution and thus decrease the incentive for companies to automate. For example, the food industry was identified as one of the industries in the United States with the highest automation potential based on current technologies. However, wages have historically been low in comparison to most other industries due to an oversupply of labor. Consequently, this industry has had little incentive to automate and the current level of automation is low. The opposite holds true when supply of labor is low and demand is high.

The supply of labor is a function of a country's demographics and the skill level of the working population (Manyika et al., 2017). The first influences the number of people on the labor market. In countries with a large working population, there will be an over-supply of labor in many industries and the incentive to automate will be low. On the contrary, for countries with shrinking working populations, such as Sweden and many other Western countries, the incentive to automate is larger (Manyika et al., 2013).

The skill level of the working population determines in which industries there are labor surpluses and deficits. For example, if a significant number of people have followed an education to become an English teacher, the market for English teachers will be saturated and wages will drop. Meanwhile, the market for French teachers could face a deficit of supply, increasing the wages. If activities are substituted by technology, it enables a higher level of human productivity, which would increase the labor supply. These workers can be redeployed if there is demand for activities within their skill range.

However, there often is a mismatch between the skills in demand and the skills that are in oversupply. In such a situation, people are required to reskill themselves through education and training before they can be redeployed. This takes time, money and effort. Consequently, the adoption of labor-substituting technology often leads to short-term unemployment and subsequently a period in which people need to re-educate themselves. However, as the pace of technological change and adoption is increasing, the question is whether the educational and training systems can keep pace. This is particularly difficult for people at the low-end of the skill spectrum.

A labor market polarization emerges when low-skill workers and high-skill workers represent the majority of the working population. In Sweden, technology has changed the labor market over the past 10–20 years as it has in other similar countries. Some argue that the Swedish labor market is undergoing a substitution of labor and that the Swedish regulatory and social security system is not ready for these changes. This will lead to an increased polarization and Sweden will face a difficult time redeploying employees if timely investments in training plans are not made (Breman, 2015).

Lastly, one can never really predict the future of the labor market. One year it can be steady with low unemployment and the next year it can be instable with high unemployment and a large degree of polarization. Unfortunately, the labor market is unlikely to benefit everyone equally when automation technologies are adopted. Some people will be negatively affected by either losing their job or facing wage pressure while others might see wage increases and new job openings. However, government policies, the way organizations choose to work and how individuals seek to learn new skills and jobs can all reduce the disparity in provided benefits across the labor spectrum (Grosz et al., 2016).

6.5. Social, legal and ethical acceptance

In order for the substitution of human labor to truly occur, applications of new technologies must be socially and legally accepted. This factor is one of the most central influencing the pace of automation, perhaps second only to technological feasibility. Social acceptance and legal acceptance are closely connected, and both largely depend on the related concept of ethical acceptance. Therefore, these three concepts will be discussed in combination.

Legal as well as social acceptance of new technologies are processes that take a lengthy amount of time. For example, a patient accepting a robot as a nurse or for a government to implement self-driving buses is not something that will happen overnight. It is therefore inevitable that it will take years for new technology to be completely adopted and adapted into society. Some of the requirements that must be fulfilled are decision makers realizing the potentials and benefits of AI as well as employees and workers adapting to the technologies once they are installed.

One of the major barriers for the automation process is privacy concerns. In order for new technologies and solutions to develop in the best interest of society, a large amount of data is needed. However, due to privacy concerns and regulations, data is difficult to access or anonymize. In addition, people are afraid of giving out their personal information because they do not know who will have access to it, who will use it and for what purpose (Bughin et al., 2017). It also becomes an ethical question when, for example, an employer has access to one's medical records. If someone is ill for some reason, or because they are overweight, an employer may not be interested in hiring this person.

The ethical issue also comes into consideration when technologies are, for example, used for predictive policies. It is a technical challenge to not feed the systems with biased information – e.g., racial, sexist or religious discrimination – to avoid innocent people being unjustifiably monitored and discriminated, when the real world is in fact biased (Grosz et al., 2016). However, when predictive hiring processes are performed with caution, and through careful design, testing and deployment, there is a chance that AI algorithms will make less-biased decisions than humans.

As mentioned, the extent and pace of automation rely on the social acceptance and trust for technology and AI. For example, many of the activities a nurse performs can theoretically be automated, but both coworkers and patients will likely have a difficult time to accept it initially. Arguably a majority of patients expect to be greeted by humans and have human contact when they have their meal delivered to them. In order for the activity to actually be substituted, patients and co-workers have to accept and trust the machines. This can only be accomplished if hospitals exhaustively integrate the automation technologies and make sure that the interaction between intelligent computers and humans feels natural (Manyika et al., 2017; Grosz et al., 2016).

This trust and acceptance is also important for security systems to be able to use the innovative technologies. Today, cities in North America have already deployed AI technologies in border administration and law enforcement and will heavily rely on these techniques in the future. For example, autonomous cars, drones and cameras will be used for surveillance as well as algorithms to detect financial fraud and create predictive policies. However, this is only possible if there is broad social acceptance. Furthermore, regulatory acceptance is also necessary for full-scale adoption. For example, while autonomous vehicles are fully usable they will first be adopted when regulators accept them (Manyika et al., 2017).

Furthermore, questions are raised about accountability when implementing the technologies. Issues such as who is responsible for the actions and conclusions made by robots and AI have never been dealt with before, making them difficult to tackle (Bughin et al., 2017). For example, who is responsible for a traffic accident where an autonomous vehicle is involved and maybe caused it? Is it the owner of the car, the automaker, the city, one of the many software or hardware providers or one of the many programmers who wrote some of the lines of software code?

Once the technologies are adopted, there may be consequences. For example, there is no way to know if AI would optimize the labor market without regard for nuanced social preferences or sell treasured documents about people's skills to private companies or political parties. However, it is unlikely that AI would autonomously *choose* to inflict harm on people, but there nonetheless remains a real risk that it can be *used* by people for a harmful purpose.

To summarize, the social, legal and ethical acceptance are important factors that impact the adoption of automation technologies. It is understandable that social acceptance of new technologies is difficult due to the fear that a lot of people will lose their jobs. However, as discussed earlier in this chapter, it is activities within jobs that will be substituted rather than entire jobs. Regulators must clearly state this fact and that only certain people will have access to personal information, in order for the social acceptance to increase.

7. Conclusion

This chapter aimed at investigating the substitution potential of labor by a selection of technologies. We first discussed the technological feasibility of artificial intelligence, machine learning and robotics to substitute for labor. We found that technology can perform an increasingly wider variety of job activities and that automation is no longer confined to routine tasks. Nevertheless, the automation potential for non-routine tasks remains limited, especially for tasks involving autonomous mobility, creativity, problem-solving and complex communication.

For jobs themselves, we concluded that the majority of jobs will be affected by the automation of individual activities, but that only a few have the potential to be completely substituted. The jobs most at risk are those that consist largely of routine tasks and do not rely on mobility or human interaction. Though few jobs can be substituted completely, automation could still lead to short-term unemployment, often leading to re-training and further education. In addition, we concluded that the nature of jobs will change as mundane tasks will be substituted and people will work more closely together with machines. The industries that have a large potential for activity substitution are food and accommodation services, transportation and warehousing, retail trade, wholesale trade and manufacturing.

In the last section of the chapter, we discussed five major factors that come into play before automation potential turns into actual automation: commercial availability, cost of implementation, economic benefits, labor market dynamics and social and legal acceptance. All five of these factors have a significant influence on the speed and scope of technology adoption. In particular, a lack of applied research, low wages, high costs and legal and ethical boundaries hamper the adoption of technology.

Overall, technology is advancing rapidly and the pace of change is increasing. Consequently, an increasing number of activities will have the potential to be performed by machines rather than by humans. Though the extent and speed of adoption are reduced by several factors, it is inevitable that technology will have a stronger presence in the workplace. It is unlikely that this will cause long-term unemployment, but in the short-term reskilling will be required to enable the reemployment of displaced labor. To cope with the pace of automation, an increased focus on education and training will be required – for individuals, organizations, regions and countries.

Notes

1 This chapter is a reprint of an identical report that was originally released under the same title by the same authors as “Report #5” for The Internet Foundation in Sweden (IIS), as part of the “Innovative Internet” project. The report was originally published by Stockholm School of Economics: Center for Strategy and Competitiveness, Stockholm: Sweden, in 2018 (ISBN: 978–91–86797–32–4). Permission for reprint has been granted by the copyright holder.

2 The Turing test is a computer intelligence test, requiring that a human being should be unable to distinguish the machine from another human being by using the replies to questions posed to both.

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4 Minimum wages for online labor platforms?

Regulating the global gig economy

Alex J. Wood, Mark Graham and Mohammad Amir Anwar

1. Background

In 2018, over half of the world's population was connected to the internet. The rise of the so-called "gig economy" has enabled internet users to find work that they might not otherwise have been able to obtain. Over the last four years' researchers based at the Oxford Internet Institute have been at the forefront of wide-ranging research into conditions on the "online labor platforms" which constitute a global remote gig economy. Online labor platforms enable clients to access labor power potentially from anywhere in the world. According to one estimate, this has created a USD5 billion market for online work that is served by 48 million workers (Kuek et al., 2015). These platforms have been the focus of much of our research. Such platforms are global in nature, and involve the remote buying and selling of digital labor which is by its nature highly mobile and "non-geographically sticky" (also known as "crowdwork" this is work that can, in theory, be done from anywhere).

Collectively we have interviewed 250 remote gig economy workers across ten countries and four continents. We have interviewed workers in Kenya, Uganda, Ghana, Malaysia, Nigeria, the Philippines, South Africa, the United Kingdom, the United States and Vietnam as well as other stakeholders such as platform CEOs and government and trade union officials. We have also conducted a survey of 679 Asian and African workers; analyzed six months of transaction data from one of the world's largest platforms and undertaken observation at dozens of gig worker community events. It is this wealth of research which informs our following discussion (Anwar and Graham, 2017, 2018; Graham, Hjorth and Lehdonvirta, 2017; Graham et al., 2017; Graham and Anwar, 2018a, 2018b; Wood et al., 2019a, 2019b; Wood, Lehdonvirta and Graham, 2018). The platforms that we looked at were global in nature, and in this response we focus on "non-geographically sticky work" (i.e., "crowdwork" or work that can, in theory, be done from anywhere).

2. Introduction

Any discussion of platform minimum wages is worth foregrounding with a few key points. First, it is clear that pay rates are not the most important issue relating to the quality of platform work. In fact, pay rates were often significantly higher than what was available locally and were often considered to constitute decent pay. More important issues to emerge from our qualitative interviews and supported by our survey research were the limited social contact which workers experienced, that they often worked long or irregular unsocial hours at intense speeds, that many felt they had little security and some had low incomes. Nevertheless, the downward pressure on pay rates created by the individualized and competitive design of online labor platforms contributed to these outcomes. However, they were also due to an oversupply of workers relative to clients, meaning that there were inadequate earning opportunities to meet the needs of all workers and this in turn generally weakened the bargaining position of workers. Therefore, while implementing minimum wages on online labor platforms might alleviate some of these problems by increasing pay rates at the bottom, doing so might also exacerbate these problems by reducing the supply of clients (by making the platforms less attractive) while increasing the supply of workers (by making the work more attractive). Thus, any intervention to increase a platform's pay rates would require increases in the quality of the services provided in order not to reduce demand and exacerbate the weak position of labor. However, in the long run the elimination of low-productivity jobs which are unable to sustain a living wage is not necessarily bad thing. As minimum wages can force employers to invest in automation and new working methods which increase productivity and thus create new jobs which have the potential to provide decent wages (Kaufman, 2010).

Second, our empirical research highlights how the competition on many online labor platforms is international. What is more, we find that many workers perceive themselves as threatened with replacement by workers in other countries who are able to work for less due to the lower cost of living in that country. This international aspect is a key consideration in thinking about minimum wages, as any intervention is likely to unevenly affect workers living in diverse contexts. For example, a minimum wage set at North American or Western European levels would erode the comparative advantage of workers in lower income countries. This is not to suggest a race to the bottom in wages, but rather a need to make sure that minimum wages do not become an overly protectionist measure at the cost of workers in the Global South.

Third, our research has detailed that some platforms have implemented global minimum wages – mainly as an attempt to ensure quality by pricing out low-quality workers. However, a major issue with these minimum wages is that they relate only to hourly paid work when much of the work is paid on the basis of a fixed price per project. This means that the effective wage can be below the minimum hourly rate.

3. Discussion: labor market principles for online labor platforms

There is currently insufficient empirical data to fully evaluate the likely labor market consequences of online labor platform minimum wages. Instead we suggest some general labor market principles which we believe should be applied to online labor platforms.

First, all work that is done happens somewhere. Therefore, paid work undertaken through online labor platforms should fall under at least one set of national jurisdictions. There are few countries on the planet that do not have some form of regulated labor standards and minimum wage regulations. Therefore, online labor platforms must not exist as mechanisms for the avoidance of labor regulations. Just because a digital platform is used to connect a client with a worker, does not mean that the underlying economic and regulatory geography of that work should be ignored (Graham and Anwar, 2018a; Wood et al., 2019a).

We should, as a starting point, adopt the principle that we do not need to reinvent the wheel. Online labor platforms should ensure that the relevant labor laws – including the classification of workers – are being followed. This is not an unusual expectation and it is widely accepted that conventional labor market intermediaries, such as employment agencies and labor brokers, have this responsibility.

When considering this issue it is useful to draw upon the discourse surrounding what is known as "tax dodging". Both tax evasion and tax avoidance are forms of tax dodging. While only tax evasion is illegal, as only these activities break the letter of the law, both evasion and avoidance are generally seen as harmful and immoral. We argue, therefore, that what matters, when thinking about labor regulation avoidance is the spirit of the law, not the letter of law.

Online labor platforms not only have a responsibility to ensure that the letter of the law is being followed but also the spirit of those laws. This is especially important regarding employment classification as minimum wages often only apply to those classified as "workers" or "employees". In the spirit of the law, "self-employed contractors" are widely understood as being equal parties to those with whom they are entering into contracts with and thus do not require minimum wages. Conversely, "employees" are regarded as being the more vulnerable party in the relationship and in need of special protections such as minimum wages. However, in the contemporary labor market, many independent contractors are best understood as "self-employed workers" as they are in a vulnerable position due to dependence on their clients and therefore in need of protections. Therefore, the spirit of these laws dictates that self-employed workers i.e., the vulnerable self-employed should be entitled to minimum wages as well as other protections outlined in relevant labor laws.

Importantly online labor platforms tend to be based upon a business model which is premised upon creating dependency. For example, there is evidence from the local gig economy that it is impossible for Uber to make sustainable profits in a competitive marketplace (Horan, 2017). Platforms usually earn income from each transaction which takes place between workers and clients. Therefore, the success of the platform rests upon keeping the worker and client using the platform, however, workers and clients tend to develop trust and confidence which can enable repeat business to bypass the platform. In order to curb this behavior, platforms utilize a number of mechanisms, which actively seek to create worker dependency. This is not to say workers do not take their work outside the platforms but to be successful the platforms must seek to limit their ability to do so. Most platforms include exclusivity clauses in their terms of services which can hinder workers and clients doing business outside of the platforms. The control and ownership of data also acts to lock users into a platform in an attempt to prevent them from taking their platform profiles and reputations with them to another platform (see Rosenblat and Stark (2016) and Shapiro (2017) for similar findings regarding the local gig economy). Finally, platforms have monopolistic tendencies due the benefits of "network effects". A network effect is a phenomenon whereby each additional user increases the value of the platform for all users. The network effect can make it difficult for new platforms to compete with established ones, as a new platform is of little value unless everyone switches platform at the same time. However, the online gig economy seems to be oblivious to, or ignore, the problems of platform dependency and the fact that as a result labor regulations should apply to workers. An employer based in Germany who sources work from a worker based in Kenya (via a platform based in the US) rarely has any knowledge of Kenyan labor law and nor do the platforms suggest that they should.

4. Concluding analysis and future recommendations

It is also important to note that many countries' minimum wage regulations include piece work. Under these laws employers are usually required to calculate a minimum piece rate which is not less than the hourly minimum. In some countries, such as the United Kingdom, the law also ensures that a "fair" minimum piece rate is one which is achievable by workers who are less skilled or more fatigued than the average worker (Gov.uk, 2018). Platforms should use the wealth of data they collect on work tasks to calculate piece rates. These rates should be cross-checked, verified and regulated by state bodies. However, there will be some situations where the time taken to complete an average task undertaken by an average worker will be too variable for the platform to accurately or meaningfully calculate. For example, the time taken to complete some programming tasks may vary significantly due to the specific problem and whether the worker has encountered something similar before. Therefore, where average productivity cannot be adequately measured or meaningfully calculated a piece rate payment method must be recognized as unsuitable and platform workers should instead be paid on an hourly basis.

In addition, EU labor law includes a posted worker directive which stipulates that "posted workers" (someone sent by their employer to carry out a service in another EU member state on a temporary basis) should be remunerated in accordance with host countries' laws and practices. Online labor platforms enable labor to be sent digitally to the client's country and therefore the posted worker directive should apply to EU remote gig workers. This is an approach which could be adopted more widely and updated to recognize the fact that while the work is being undertaken in the client's location via the internet the costs of reproducing labor will be dependent on the worker's physical location. Therefore, minimum wages should be adjusted by purchasing power parity, perhaps with platforms adjusting their minimum rates every year (this could be perhaps verified by an independent body like the Fairwork Foundation). A benefit of doing so would be that it avoids unfairly disadvantaging workers in countries with lower labor costs.

Second, (and perhaps somewhat paradoxically), platforms should get rid of their global minimum wages. Global minimums send a message to clients that if they pay above the minimum then they are in compliance with relevant local regulations. However, it is entirely possible for workers to earn above platform minimum wages, but below their client's national/local minimum wages

Third, we acknowledge that there might be claims that any attempts to enforce minimum wages could be unenforceable given the global and dispersed geographies and networks of online work. However, our research shows that the vast majority of demand for digital work comes from just five countries. Furthermore, a small handful of platforms mediate the vast majority of that work. These two facts demonstrate that initial barriers to regulation are not due to a dispersed geography or dispersed network of work. These topological and geographical bottlenecks in the global trade of digital work offer potential sites in which regulation can be enforced (we realize that many of the other submission to this call deal with some of the specifics of "how to do regulation" and we therefore leave the details of that discussion to others).

We hope that some of these suggestions can help to bring about a fairer set of relationships between the employing class, the governing class and the working class. Online gig work has brought income and jobs to many, but that does not mean that we should expect it to function as an unregulated labor market.

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5 The digital disruption of science

Governments and scientists toward an "Open Science"

Antoine Maire

1. Introduction: Open Science, a new era for science?

The digitalization is a key element in the evolution of public policies and governments' activities. It is an important tool to foster efficiency and a better consideration for users' needs. It is an opportunity to foster the creation of "digital governments" (OECD, 2016), characterized by a greater implication of citizens and businesses in the agenda-setting, the elaboration but also in the making of public welfare policies. It is an opportunity to foster the creation of "digital governments" (OECD, 2016), characterized by a greater implication of citizens and businesses in the agenda-setting, the elaboration but also in the making of public welfare policies. Science is at the forefront of this evolution, being recognized as a strategic issue in new knowledge-based economies.

In science, digitalization comes from the availability of new technologies and tools that enable the emergence of innovative research practices. It does not only concern the use of digital technologies in the daily work of scientists: It also provokes an important evolution in the very activity of research from agenda-setting to the publication of results. The disruption provoked by digitalization in science is often summed up with the buzzwords "science 2.0", "science in transition", "digital science", "e-Science" or more generally with the concept of "Open Science" (Millerand, 2015). If nuances exist between those concepts, they all stress the idea of a transition from one type of research to another, based on collaborative work, transparency and efficiency allowed by the digitalization of scientific activities. The concept of "Open Science" will be used in this chapter, as it is the one used by governments and European institutions when they refer to this evolution (European Commission, 2015).

1.1. Digitalization and science: what is at stake?

The digitalization refers to the use of tools coming from the web 2.0 in research activities (Teif, 2013). It is sometimes referred as the basis of a second revolution in science (Bartling and Friesike, 2014). The first revolution was based on the professionalization of research activities, and on the continuous build-up of new knowledge based on the work of other scientists. The second revolution would be based on digital technologies. It would lead to a more collaborative science, a new mode of creation of scientific knowledge; complex, non-linear, heterogeneous and transdisciplinary (Szkuta and Osimo, 2016). Thus, digitalization is commonly seen as a way to go toward a "better science" (Millerand, 2015), a potential solution to the challenges that modern science is facing, that is an increasing number of authors, of publications and of data available (Burgelman, Osimo and Bogdanowicz, 2010). They are creating new opportunities to develop more complex and more collaborative approaches, where interdisciplinary is crucial, to solve wicked problems (Bly and Ginanni, 2012).

The evolution generated by digitalization can be summed up with five main characteristics (Fecher and Friesike, 2014):

- The democratization of science: It stresses the ability of digitalization to facilitate the diffusion of the scientific results across all spheres of society, from governments to NGOs, from big businesses to small and medium enterprises. This expectation is closely associated with the "Open Access movement";
- An improvement of scientific processes: the way research is done and on how digitalization will strengthen its efficiency. It emphasizes the increasing collaboration between scientists that this movement will promote;
- The development of innovative infrastructure: The new tools available in this digital age will enable scientists to deal with an increasing amount of data and to develop a data-based culture;
- The diversification of the actors involved in the making of science: Citizens and civil society's organizations can now be involved from the funding of research, through crowdfunding for example, to the processing and analysis of data. It is sometimes summed up with the nickname "citizen science";
- The emergence of new measurement tools, new type of impact measures, sometimes called "alt-metrics". It will allow to better understand the influence and impact of science over the rest of the society.

To sum up, the disruptive effect of digitalization in science is seen as a major opportunity to foster the emergence of a new mode of production of scientific knowledge, called "Open Science". It is a tool to promote a better science and to increase its efficiency and impact.

1.2. Digitalization of science from a governmental perspective

For government, the move toward Open Science is an opportunity to foster the efficiency of public investments in science and to further increase the competitiveness of their economy (OECD, 2016). Three stakes explain governments' interest in Open Science and why they are framing new policies to foster this movement. For government, the move toward Open Science is an opportunity to foster the efficiency of public investments in science and to further increase the competitiveness of their economy (OECD, 2016). Three stakes explain governments' interest in Open Science and why they are framing new policies to foster this movement.

First, digitalization is a tool to limit the differences between heavily-funded research centers and small research centers and the polarization of the scientific field (Breivik, Hovland and From, 2010). It should allow small research centers to be more competitive, with fewer investments required, in particular if such centers do not have to devote an increasing amount of money to pay for subscriptions to research journals.

Next, digitalization is also a tool to strengthen the efficiency of national scientific communities, and to take more benefits of a huge public investment (Buhr, 2014). It asks the question of the competitiveness of a scientific community in an increasingly competitive scientific world. Moving toward Open Science is a solution to this challenge as it should increase the efficiency of the research process.

The final stake for governments is that digitalization is seen as a tool to close the gap between science, businesses and other actors, strengthening the impact of science on society (Hetland, 2011). Behind this preoccupation lies the question of how to improve the efficiency of an economy. Digitalization of science is a tool to use, as it allows scientific results to be more quickly and easily spread among businesses and among the rest of the society.

1.3. Barriers in moving toward digitalization of science

If this portrait emphasizes the advantages and hopes that digitalization is creating in science, some difficulties remain on the way. One of the characteristics of the Open Science movement is the fact that it implies the evolution of how scientists are doing research. Such evolution is already noticed with the increasing number of publications being open access or with the growing importance of research social networks (Millerand, 2015). The ability of researchers to use those new tools and the evolution of their practices are one way to move toward Open Science. It could be described as a bottom-up phenomenon, researchers experimenting directly new tools, new technic and new collaboration strategies in their daily activity (Vignoli, Kraker and Sevault, 2015). However, there are also barriers in moving toward an Open Science.

Surveys on this question show that researchers have, for an overall majority, a positive image of Open Science. When asked (Schöpfel et al., 2016), researchers mentioned several potential changes that digitalization should foster: a broader diffusion of results and publications, more collaboration, the breaking-down of discipline barriers, the ability to involve non-usual actors in the research process, but also an opportunity to better meet societal needs and public demands. Nevertheless, this positive opinion does not necessarily translate into practices. In 2015, the European Commission has commissioned a survey to better understand researchers' perceptions about what was called at the time "Science 2.0" (European Commission, 2015). When asked about the barriers in moving toward Open Science, researchers mention a limited awareness about the benefits of such a move, a lack of incentives given to Open Science in their career, a lack of infrastructure and of financial supports. All those elements, combined with a cultural resistance to change, show that a bottom-up approach is not sufficient to move toward Open Science. It shows that this evolution also needs to be encompassed and furthered by a top-down approach, in other words, by public policies (Vignoli, Kraker and Sevault, 2015; European Commission, 2015; Schöpfel et al., 2016).

The debate about the digitalization of science usually takes place within the broader debate of the digitalization of government activities and public policies, creating a discussion between researchers, experts, policymakers and citizens. However, most scientific work done on the subject is devoted to Open Science as a concept and not as a new object of public policies. Due to that, this chapter will study the evolution of emerging public policies that must foster digitalization in science and a move toward Open Science.

2. Methods

2.1. Theoretical framework

From a theoretical perspective, the problem studied is specific because the inclusion of Open Science in public policies does not come from the need to solve a specific problem. It rather comes from the perception that an opportunity should be taken. Thus, the question here is not how to solve a problem but rather how to promote a specific approach on a relatively new and unknown subject. Within this perspective, this chapter will be based on the "advocacy coalition framework" (ACF) (Sabatier and Weible, 2007). This theoretical approach assumes that policy making is so complex nowadays that public policies are elaborated in subsystems made up of experts, legislators, bureaucrats, lobbyists, researchers, experts, journalists and activists. Within such subsystems, it is argued that actors are joining and progressively establishing a "coalition of causes" to influence policy making according to their own objectives and beliefs. To understand a given policy, the ACF framework argues that it is necessary to identify a "coalition of causes" within the subsystem of public policy making. Compared to other approaches, the ACF framework has the advantage of not having to focus on whether or not to make a particular decision, but rather on issues requiring long-term policies.

2.2. Survey methodology

To apply this approach on the making of public policies toward Open Science, a comparative approach will be used with two case studies: the European policy and the French policy toward Open Science. Those two cases should lead to a better understanding of the disruptive effect of digitalization on research activities. In both cases, the ACF framework will be applied. It will lead to the identification of action subsystems of the public policy toward Open Science. It will also identify core beliefs of involved actors, to better understand why they are pushing in favor of such policies and what causes they are supporting. Finally, it will identify coordination mechanisms established within those coalitions to progressively go toward a kind of institutionalization of such gatherings.

2.3. Materials and data

The case studies will be analyzed through primary sources, such as reports, decisions and presentations made by the actors involved in this process. The documents allow for a proposal that seeks to outline various policies aimed toward promoting Open Science. However, they do not say much about the debates that such policies have faced. To know more about them, a third step in this research has used semi-directive interviews with key actors involved in the implementation of such policies.

3. Open Science in Europe and in France, assessment of two case studies

3.1. The European impetus for "Open Science"

3.1.1. The elaboration of a European policy toward Open Science

The European Union (EU) has been among the first institutions to push for Open Science. Its ambition was to strengthen the competitiveness of European research and more broadly the competitiveness of the European economy. This emphasis is relatively recent and the timeline of European actions shows an increasing globalization of European institutions' policies. A sequential approach allows the identification of four main kinds of actions. They are related, in a chronological order, to Open Access, Open Data, the development of new infrastructure and next to Open Science, an encompassing concept recently adopted by EU institutions.

As for Open Access, the EU has played a key role in fostering Open Access, seen as a strategic stake in the establishment of a European Research Area (ERA). The EU has followed a gradual approach. In 2006, the European Research Council (ERC) published a statement about the importance of Open Access for all publications receiving public funds (European Research Council – Scientific Council, 2016). This first move led to the creation of a Pilot project for Open Access in the frame of the implementation of the seventh framework program for science (European Commission, 2007). This pilot project has defined two ways to develop Open Access publishing. The "golden way" provides a reimbursement of the publications costs by European funds. The "green way" allows a publication in open archives for 6 or 12 months (for social sciences) after the first publication. This policy echoes the two strategies already mentioned for Open Access in the Budapest declaration of 2002 (Chan et al., 2002). This orientation was later confirmed by the European Commission in July 2012 with a recommendation on access and preservation of scientific information (European Commission, 2012b), updated in April 2018 to give more concrete orientations to Member States (European Commission, 2018f), and a communication entitled, "Towards better access to scientific information: boosting the benefits of public investment in research" (European Commission, 2012a). This commitment in favor of Open Access has been confirmed and strengthened in the FP8 – H2020 program (European Commission, 2014a). Since 2014, all scientific publications receiving European funding should be made available through Open Access, following either the "golden" or the "green way". Ultimately, the objective is to achieve 100% of Open Access publications in Europe from 2020.

Regarding data, following the adoption of the Reda report by the European Parliament in 2015 (European Parliament, 2015), a revision of the directives related to copyrights is under review. Its objectives are to ease the move toward Open Access and to allow the development of innovative research methods such as text and data mining. The process followed is similar to the one used for Open Access. The recommendation published by the European Commission in 2012 has encouraged Member States to adopt Open Data policies (European Commission, 2012b). The debate and policies cover both the access to research data, as well as access to public data. Thus, the FP8 – H2020 has done research data open by default for all project implemented within the program. It has also imposed the adoption of a data management plan. In the data management, the European Commission is pushing for a "FAIR" approach, meaning that data should be Findable, Accessible, Interoperable and Reusable (European Commission, 2016b).

The Open Access and Open Data objectives have led the European Commission to develop innovative infrastructure needed to support both moves. The main project is the European Open Science Cloud (EOSC). Its ambition is to build an infrastructure that would enable European researchers to stock and to exploit their data in a common infrastructure (EOSC Summit, 2017). It will also connect existing scientific data infrastructure built by Member States. A pilot has been launched in 2018 (European Commission, 2018b) and the objective is to implement the project from 2020. The other infrastructure project developed by the European Commission, called OpenAIRE for Open Access Infrastructure for Research in Europe (European Commission, 2018e), is dedicated to Open Access and to foster interactions between researchers.

The question of Open Access, Open Data and the need of affiliated infrastructure has led to the birth of a debate about the consequences of digitalization for scientific activities. It is based on the assessment that digital technologies are not only making access to research and data easier but rather that they radically change the way scientific knowledge is produced. Confronted with this challenge and based on initial reflections about the influence of digitalization in science (European Commission, 2013), the European Commission has led a public consultation on the impact of digitalization on science between July and September 2014 (European Commission, 2014b). The results have been published in February 2015 (European Commission, 2015). They show the preference of researchers for the term "Open Science" rather than "Science 2.0" previously used by European institutions, and a consensus about the benefits of Open Science as a means to foster the impact of science and to promote more collaborative and multidisciplinary projects. It has also identified a lack of awareness of the

European research community about the meaning and implications of this digital evolution.

Based on the results of this consultation, the new European commissioner, Carlos Moedas has made of Open Science one of its three strategic priorities with Open Innovation and Openness to the World (Moedas, 2015). From this new impetus, the European Commission has drafted a European Open Science agenda published in February 2016 by the Directorate General for Research and Innovation (European Commission, 2016a). Five main policy actions are identified: (1) fostering Open Science; (2) removing the barriers to Open Science; (3) developing research infrastructure for Open Science; (4) mainstreaming Open Access to research results; (5) embedding Open Science in society. Those policy actions must be translated into concrete measures to be taken by European institutions and Member States.

One of the main measures is the creation in 2014 of an advisory body in charge of co-designing and co-developing policies implemented to foster Open Science (European Commission, 2018c). Named the Open Science Policy Platform (OSPP), it is placed under the authority of the Directorate General for Research and Innovation. Apart from this assignment, the OSPP is also in charge of the education and training of the European research community to Open Science. The European Commission has thus financed a project under the nickname FOSTER, which stands for "Facilitate Open Science Training for European Researcher" (European Commission, 2018c) in February 2014. It includes a website offering free training courses, toolkits, and an Open Science training book. The ambition of this project is to tackle one of the main difficulties in the evolution toward Open Science, the need of a change in researchers' behavior.

The creation of the OSPP represents an important evolution because it should play a key role in the elaboration of a new European policy toward Open Science. It gives the EU the ability to encompass all the aspects of Open Science. The work already done by the platform is proof. Working groups have been established and have produced reports (European Commission, 2018c) on alt-metrics, citizen science, on how to provide researchers with the skills they need for Open Science, on the evaluation of research careers fully acknowledging Open Science practices or on the awards, incentives and recognition for researchers practicing Open Science. This work comes in parallel with the ignition of the process leading to the elaboration of the next Framework Program, FP9, which will follow H2020. The advance report already published under the leadership of Pascal Lamy strongly emphasized the need to go further on Open Science. It argues that Europe now needs to "*embrace the transformative power of Open Science*" (Lamy, 2017, p. 8).

If actions were taken by the Commission, it was also the case at the intergovernmental level. In particular, Open Science has been promoted under the Dutch presidency of the European Union Council in the first half of 2016. The Dutch government, jointly with the European Commission, organized an important international conference on Open Science in Amsterdam in April 2016 entitled "Open Science, from vision to action." It was based on the assessment that the transition toward an Open Science needs to be accompanied by governmental actions. It has led to the adoption of the Amsterdam Call for Action on Open Science (Ministry of Education, Culture and Science, 2016) that identified five main areas of actions: (1) removing the barriers to Open Science; (2) developing research infrastructure; (3) fostering and creating incentives for Open Science; (4) mainstreaming and further promoting Open Science policies; and (5) stimulating and embedding Open Science in science and society. This call was later used to push for the adoption of a common position between the Member States regarding Open Science during the competitiveness council of May 2016 (European Union Council, 2016). Its adoption has not faced any opposition from Members States, all being aware of the importance of the topic. This common position has validated the orientation of the Commission on Open Science. It is also a testimony of the desire of all Member States to work for the emergence of an Open Science.

3.1.2. Analysis of the elaboration of the European policy

The analysis of the emergence of a European policy according to the ACF framework allows for a better understanding of the dynamics and logic behind the increasing role played by European institutions in the field of Open Science. The subsystem is the one in which the science policy of the European Union is framed. The central actor within this move is the European Commission. Compared to other subjects, the Commission has been a frontrunner on the topic of Open Access and Open Data, but also regarding the financing of the infrastructure needed to support the move. The action of the Commission precedes the ones implemented by Member States, even the most advanced ones such as the Netherlands and Germany. The Commission can be considered a frontrunner in this evolution because its commitment was a deliberate one. It comes first from the attention given to Open Access and Open Data and later to the formalization of a more comprehensive policy toward Open Science, which followed the survey commissioned in 2014. It was implemented under the orientation of the commissioner and the responsibility of this policy is divided between two directorates: A and B. The first directorate is in charge of the policy development and coordination and the second one of Open Innovation and Open Science.

The European Commission is convinced of the necessity to deal with digitalization as it changes the whole life cycle of the research project. This conviction is supported by the results of the 2014 public consultation that have shown a strong appetence of the research community for Open Science. Thus, one of the ambitions of the European Commission is to give a voice to the research community and to progressively translate its aspiration into policy actions. This should lead Member States to take into account this perspective and this new orientation. Besides this aspiration, the core beliefs of the initiators of such policies, in particular of European commissioners, is to strengthen the efficiency of the European investment in public research. Therefore, the Commission considers that moving toward Open Science is critical to maintain a dominant position for Europe in the field of Science. Moreover, the scientific policy of the European Union is often criticized due to its lack of ambition, in part because it is difficult for the EU to bypass the specificity and isolation of each Member State's scientific policies, many of them being reluctant to give up parts of their sovereignty in this strategic field. The adoption of a European policy for Open Science allows the Commission to go beyond this compartmentalization. It can promote an encompassing concept that could foster the efficiency of scientific research and that offer the occasion to promote the connectivity and the interoperability of Member States' scientific policies. The mutual learning exercise organized by the Commission in 2017 in an example of this ambition (Miedema et al., 2018).

This ambition is also related to one of the most important objectives of the European Commission: the creation of a common European Research Area (ERA), a key objective of the former Lisbon Strategy (European Council, 2000). The objective is for the ERA to do for scientific research what the Common Market did for economic exchanges. In this perspective, Open Science is a tool to further the integration of national research initiatives. This objective clearly appears in the directorate general's organizational chart as the unit in charge of Open Science is also in charge of the ERA (European Commission, 2018a). The European Open Science Cloud is another symbol of how Open Science is used by the Commission to promote a unified European Research Area.

Within this perspective, the European Commission appears to be at the center of the advocacy coalition pushing toward a more active policy for Open Science. The creation of a European Open Science Platform strengthens the coordination within the coalition and is a tool to gather and exchange for supportive actors. The European Open Science Platform actually recommends the creation of similar administrative structures in each Member States to enable them to develop a comprehensive policy on the subject (Open Science Policy Platform, 2018d). The key element for this coalition is to convince the Member States to support this orientation and more importantly to translate it at a national level. The common position adopted by the Member States regarding Open Science during the competitiveness council of May 2016 is thus an important milestone. It has given legitimacy to the European Commission to go further on this topic. It has also marked the commitment of Member States to engage in this endeavor.

3.2. Open Science in the French context

3.2.1. The elaboration of a French policy toward Open Science

The study of the French case shows several differences with the European case studied before. The appropriation of Open Science, as a concept, is relatively recent. Because of that, key documents regarding the orientation of French science policy forgot to mention the concept as an objective or a reference. For example, the French national strategy for research, published in 2015, never mentioned Open Science (Ministry of National Education Teaching and Research, 2015). More recently, the French white paper for research and higher education mentions the concept of Open Science but only on a vague perspective (Ministry of National Education Teaching and Research, 2017), in a sidebar saying that some debates exist at the European and national level about Open Science. It also mentions that the French ministry for higher education and research is working on new International Strategy for Research, Innovation and Higher Education. Its purpose is to provide strategic guidance for French stakeholders, ensuring that France establishes relevant and efficient partnerships and endowing France with a strong decision-making capacity in international bodies (Ministry of National Education Teaching and Research, 2017). This new strategy is supposed to take into account the European dimension of research and in particular the European impetus regarding Open Science. This approach tends to resume Open Science to an EU initiative, an element that the French international science policy should take into account, and not to a bottom-up phenomenon associated with the disruption of scientific activities created by the digitalization. Nonetheless, if Open Science is not directly mentioned, the question of the digitalization of scientific and teaching activities is a major concern in all those texts. The white paper insists on the disruptive effect of digitalization and on the need for research to better understand the consequences of such evolution on scientific activities. The concept of Open Science is also supposed to appear more clearly in the next French national strategy for research.

Apart from this assessment, the formalization of the debate has followed in France approximately the same process as at the European level. It has started with Open Access, moving to Open Data before leading to the progressive elaboration of an encompassing policy toward Open Science. The necessity of Open Access has been pushed in France by activists since the beginning of the 2000s. They have built upon the global movement for Open Science with the three declarations of Budapest in 2002 (Chan et al., 2002) and Bethesda (Brown et al., 2003) and Berlin in 2003 (Chan et al., 2003). Local initiatives have been implemented through COUPERIN, Open Edition or through the establishment of an archive which allows researchers to safely store their works, *Hyper Articles en Ligne* [Eng: Hyper Article Online] (HAL). Those initiatives show the progressive emergence and structuration of a coalition of actors pushing in favor of Open Access. For them, science is a global common to which everyone should have access (Chartron, 2016).

As for Open Data, the French initiative has also to be understood within a broader context, international and European. The Sebastopol meeting held in California in 2007 has affirmed the principles related to Open Data (Malamud et al., 2007). In France, the implementation of an open data policy has followed an initiative pushed by the new French President, François Hollande, for the opening of administrative data. It has led to the reform of "Etalab". Initially designed to build a public portal of administrative data (Government Bill, 2011), it is now described as an "administrative start-up" in charge of supervising the opening of public data. Besides this mission, Etatab is also in charge of fostering scientific practices based on a culture of data. It has also pushed for the French adhesion to the Open Government Partnership in 2014, later used to elaborate a first French policy toward Open Science.

The different aspects of Open Science have been highly debated in France on the occasion of the adoption of the new law, "Towards a Digital Republic", in 2015–2016 (Government Bill, 2016). On Open Access, the law allows researchers to make their articles freely accessible 6 months after the publication and 12 months for humanities and social sciences, following the European recommendations. On Open Data, the law is also making public data open by default. It is opening the way for text and data mining, even though the application decree still needs to be adopted. The debate surrounding this application decree is symptomatic of the controversy that opposed the research sphere and the publishing sphere. Publishers are usual opponents of Open Access, arguing that it threatens their economic model and the viability of their industry. In the French context, this debate is important because it indirectly touches the "cultural exception" that France is claiming. Transposed to the European debate surrounding copyright, it explains the difficulties faced by the Commission to change the directives related to copyright to allow the development of text- and data-mining practices.

Moreover, the innovative and collaborative method used to shape the law has allowed many actors, individual and institutional to publish recommendations in the frame of the elaboration of the law. For example, the French National Council for Scientific Research (CNRS) has published a white paper (CNRS, 2016) and strategic guide (CNRS, 2017) arguing in favor of moving toward Open Science in the broader context of the construction of the so-called new "digital republic". This debate is structuring because it has allowed the progressive acceptance and recognition of Open Science as a concept in France.[1]

This growing interest for Open Science has later led to the definition of a French embryonic strategy for Open Science. Practical decisions have been made, such as the creation of a special position within the Ministry of Higher Education, Research and Innovation dedicated to Open Science. It has also led to the adoption of a full engagement on Open Science in the frame of the Open Government Partnership (State Secretariat in charge of Digital Affairs, 2018). This international initiative was supposed to focus on the opening and the transparency of governmental activities. However, France has pushed to include an engagement bearing the objective of building an "Open Science ecosystem" in France. This engagement, "number 18", can be considered the first French embryonic strategy toward Open Science. It has been translated into a national plan for Open Science in July 2018 (Ministry of Higher Education, Research and Innovation, 2018b).

Apart from further investments in existing infrastructure such as the archive HAL, the ScanR search engine, or the Isidore platform, the main evolution proposed by this strategy is the creation of a special committee dedicated to Open Science (Ministry of Higher Education, Research and Innovation, 2018a). Under the leadership of the Directorate General to research and innovation of the Ministry of Higher Education, Research and Innovation, it will gather experts who will recommend policy orientations and concrete actions to foster Open Science. Its main mission will be to define a French policy for Open Science and to oversee its implementation. It will also play a role in the diffusion of knowledge related to Open Science in the scientific communities and in the gathering of potential remarks and ideas in a bottom-up approach.

3.2.2. Analysis of the French policy toward Open Science

The application of the ACF framework allows for better understanding of the progressive elaboration of a French policy toward Open Science. The sequential approach that led to the formulation of a French policy toward Open Science is similar to the phenomenon observed at the European level. It started with Open Access and Open Data, with a support to needed infrastructure and it has later ended up with the formalization of a comprehensive policy toward Open Science.

Compared to the European case, the French subsystem of action appears to be mainly dominated by actors involved in the technical aspects of digitalization. Two of the milestones in the elaboration of a French policy toward Open Science have been promoted directly and indirectly by the Secretariat of State in charge of Digital Affairs: the adoption of the law, "Towards a Digital Republic", and the French commitment to the Open Government Partnership. It is also true for the National Center for Scientific Research, since the white paper on Open Science published in 2016 was produced by the directorate for scientific and technical information (CNRS, 2016). On the contrary, the Ministry of Higher Education, Research and Innovation plays a secondary role in this evolution as the absence of Open Science in strategic documents is a testimony. The creation of an advisory position in charge of Open Science within the ministry is, however, changing the dynamic and should allow the ministry to better take into consideration Open Science in the future.

As for the advocacy coalition framework, the French case shows an interesting convergence of two different advocacy coalitions. The first one structured itself around the promotion of Open Access to scientific publications. It is mainly composed of activists who believed that science is a common good for which no one should have to pay. Their core beliefs were a bit different than the one previously mentioned for the European case. Access to science results is seen as a principle when it was mainly seen by European institutions as a tool to reinforce the efficiency of the money invested in research. The main challenge this coalition has to face is an advocacy coalition organized around publishers. The recommendations published in 2012 by the European Commission have thus played a key role in strengthening the position of the Open Access advocacy coalition within the French system. It has demonstrated that Open Access is not only a utopian concept but also a matter of economic efficiency and scientific competitiveness.

The second advocacy coalition which merged in this trend toward Open Science is related to the opening of data. It was mainly structured around entrepreneurs. They have pushed in favor of the opening of public data arguing that the private sector has now access to enough calculus power to offer innovative services to the public. Its theoretical basis is "Government as a platform" described by O'Reilly (O'Reilly, 2011) and translated in the French context by Colin and Verdier (Colin and Verdier, 2015). In this perspective, opening public data should allow citizens and businesses to do more with those data and to develop innovative services, science not being an exception. The coalition has strongly pushed in favor of the opening of public data and has succeeded in making the "Government as a platform" a new objective for the French government (State Secretariat in charge of the Modernization of Public Action, 2018).

The collaboration between those two advocacy coalitions has played a crucial role in the elaboration of a new French policy toward Open Science. It was the symbol, in a way, of the alliance between a scientific and technological perspective. The modernization of government has offered an occasion to those two coalitions to meet and collaborate through inter-ministerial consultations to frame those new policies. The law, "Towards a Digital Republic", and the commitment in the Open Government Partnership are good examples of such consultations. The success of these advocacy coalitions is linked to the ability of some of their members to access public positions, enabling them to act directly within the administrative structure. For the Open Data coalition, Henri Verdier has been appointed in 2013 director of Etalab and later inter-ministerial director in charge of digital, information and communication systems as well as administrator general in charge of data. For the Open Access, Marin Dacos has been appointed in 2017 as an advisor in charge of Open Science in the French Ministry of Higher Education, Research and Innovation.

However, despite the convergence between those two advocacy coalitions, the emergence of a comprehensive coalition arguing in favor of Open Science is still in the making. The call of Jussieu signed by many actors of the sector in October 2017 is a good illustration, both of the composition of this advocacy coalition and of the central role it played within the French debate. Entitled "Jussieu Call for Open Science and Bibliodiversity" (Bauin et al., 2017), it illustrates the central role played by the Open Access movement in the elaboration and structuration of a new advocacy coalition in favor of Open Science. The creation of the future Committee for Open Science should also play a key role in the coordination of this coalition of actors to push for Open Science. It presents a lot of similarities with the European Open Science Platform previously mentioned.

4. Discussion of the results

This study shows that the digitalization of science is still in an emerging phase. The process that led to the formulation of new policies toward Open Science is reflecting a convergence between different dynamics, Open Access and Open Data being the most prominent ones. Both the European and the French cases are confirming this tendency, even if it appears that they come from different origins. However, both cases also confirmed that Open Science policies are still fragmented and that a comprehensive policy in charge of fostering the development of an Open Science is still in the making. The adoption of the "Open Science" concept is thus playing a key role that should allow the elaboration of a more comprehensive policy. The creation of governing bodies is also a key element in this process. Those new structures, specifically dedicated to Open Science, have the ability to deal with all the aspects created by the digitalization in science. The transition toward an Open Science has such a great impact that it is difficult for a traditional administration to deal with all those elements and to develop a comprehensive policy on this subject. At the EU level, those new structures ease the cooperation between European institutions and Members States with the emergence of a single administration.

The study of both cases, however, confirms the difficulties of going toward a real digitalization in scientific activities and not only toward a simple digitization, that is to say a digitization of a paper-based system. This evolution is complex because, to be fully achieved, it needs to come not only from the top-down but to adopt a bottom-up approach. A more comprehensive approach would be necessary to better understand the challenges and difficulties that such a bottom-up approach must face.

The analysis of the elaboration of the public policies to favor the digitalization of scientific activities also shows that it paradoxically comes across two movements. Frontrunners have already created and implemented a lot of local initiatives that directly improve their daily scientific activities and enable them to develop innovative research approaches. The case of the elaboration of HAL, the French scientific archive platform, is an example of a local initiative, later taken over by the government to develop a more global policy. The elaboration of public policies toward those initiatives comes late and tries to encompass them in a more general and coherent framework. This step, a governmental intervention in this transitory period, appears to be a necessity in the development of a coherent scientific community organized around the Open Science concept.

At the same time, it also appears that in the broader scientific community, digital technologies lead to digitization rather than to digitalization. Due to that public intervention regarding the digitalization of science is facing a strong inertia within the scientific communities. The most important challenge regarding a true evolution toward the digitalization of scientific activities is related to the lack of knowledge of scientists about the movement itself, its implication and to the lack of incentives for a change in habits that could be seen positively in a career perspective. Studies about the subject are currently underway and should later play a key role in the revision of the career logic of scientists to foster the development of Open Science habits. The role of government in this movement will also be fundamental.

The assessment that digitalization is just emerging, through a transition from innovative practices implemented by frontrunners toward a much more general diffusion, means that the role of government is still central in its evolution. The digitalization of science cannot come only from a bottom-up approach, i.e., from an inherent and progressive change of researcher behaviors. The transition process is just beginning, but it is characterized by a tendency of governments to transform local initiatives in general behaviors. The Open Science and the Open Data movements are examples of such ambitions. Going further is also requesting a strong implication of governments to ease and soften the conditions of the transition. This accompanying role comes out with the creation of the needed infrastructure (archive, data center, innovative tool) but also from the progressive creation of the conditions needed for the emergence of new research practices. The movement is here just in the making. It will go through an evolution in the career system of researchers, in the evaluation of their works, of the methods used to analyze the impact of their work and through a lot of pedagogy toward this movement. The role of government is central because it has created the legal conditions to foster such evolution. It is also because it can use funding requirements to promote certain habits and behavior, as it was done by the EU regarding Open Data and Open Access for example. It is, however, too early to really identify the consequences of this evolution on the relation between governments and science when this transition process is over. Even though some tendencies can be mentioned such as the horizontalization of the research process, the diversification of research funding possibilities or the increasing importance of multidisciplinary and multi-stakeholder's research, they remain tendencies that will need to be confirmed in the long term.

This study of the elaboration of public policies toward Open Science is also opening new research perspectives. Among them, several could be mentioned:

- Research about the structures of local initiatives implemented by so-called frontrunners to favor the full digitalization of science. Such an approach could start with the cartography of these initiatives. It should also lead to a better understanding of how these initiatives are later taken over by governments;
- The other research perspective that could be pursued should be related to the implementation of the policies previously described: the creation of innovative governing structures, the way they are working and interacting with the research community but also with the policy-making process is a theme of research per se;
- The other aspect that deserves more attention is the connection between the so-called Open Science and Open Innovation. Open Science is seen as a major tool to close the gap between academics, businesses and government spheres. This connection clearly appears within the administrative structure of the European Commission because Directorate B is in charge both of Open Innovation and Open Science;
- More broadly, digitalization of science questions how knowledge is produced and used in a given society, finally asking the question of collective intelligence.

5. Conclusion

The study of the European and French policy toward Open Science has demonstrated that the way Open Science has been put on the agenda was the result of a progressive evolution that encompassed the debate around Open Access, then about Open Data and later the question of the infrastructure. Open Science later appeared as a convenient concept to encompass all the dynamics, changes and opportunities generated by the digitalization of science, thus all the policies implemented regarding this change.

Nonetheless, much remains to be done regarding the emergence of this potential new scientific revolution. The movement toward Open Science comes mainly from local and individual initiatives that have pushed in favor of Open Access, Open Data but also for the development of innovative research habits. The proliferation of such initiatives in the French context is the best example of the vitality and the expectation that this digitalization movement is creating. However, the spread of this bottom-up evolution is also facing barriers. Because of them and because of the importance of the stakes involved, governments have started to implement top-down approaches. Their objective is to encompass existing initiatives and to encourage a broader implication of the whole scientific community.

Regarding the evolution of the relation of government toward science, the transition toward the digitalization of research activities is ongoing. Thus, the role of governments is still central, as they must accompany this transition and create the progressive conditions needed for a generalization of innovative practices so far implemented by frontrunners.

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Note

1 This evolution can be traced back to some various symbolic decisions. Two of which are the following: (1) the 2018 amendment of the title of the annual conference organized by COUPERIN from the "Open Access Days" to the "Open Science Days". (2) The transformation of the Digital Scientific Library into a new Committee for Open Science. This evolving transformation reflects the broader French interest in regards to the issue of Open Science.

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6 Black boxes of cognitive computers and the impact on labor markets

Victor Erik Bernhardtz

1. Introduction

This chapter discusses the impact of digitalization on labor and labor markets. More specifically, it deliberates on the introduction of Internet of Things (IoT) and cognitive computing in labor and how it changes, to some extent, all types of labor. At the heart of this discussion is a duality: Digitalization of labor markets has the potential of bringing significant advances in productivity, work quality and work safety. On the other hand, the early stages of digitalization of labor markets has produced concerning outcomes, such as precarious work, ethical concerns and low pay, to mention a few. In other words, we *can* harness the potentials of digitalization of labor, but we are currently not always doing so.

The connecting of work tools (analog and digital) to the internet opens up new potentials for productivity. More types of work can be organized without concern to physical space, enabling remote control over devices as large as mining trucks or as delicate as surgery equipment. Connected tools have the added potential of generating data on how they are used. This means that not only products, but also how work is carried out, can be extensively evaluated without taxing human resources. Moreover, a connected work tool can also function as a location device, provided the worker is mobile.

The potential of connected tools can be unleashed with help of cognitive computing. Cognitive computing is the introduction of computer systems[1] designed to mimic the human brain, with the power of modern computers. This allows for analysis of masses of unorganized data much greater than a human brain could grasp. One application is evaluations of productivity, based on data generated by work tools. What cognitive systems *could* do is in theory all but limitless.

Even though recent research suggests that the number of jobs that will be lost to automation are significantly fewer than predictions from just a few years ago, the jobs lost still count in the many millions (Nedelkoska and Quintini, 2018). Equally important is the alteration of jobs that will remain, but in new forms. In order for workers to retain such jobs, massive retraining efforts needs to be implemented, lest employers lose human capital that cannot be replaced by software.

Cognitive computer systems will be able to replace humans in carrying out work tasks previously thought to be impossible to automate. One such task, equally alluring as a cause for caution, is management. Today, management executed by computer programs is most visible, albeit often in a rudimentary form, in so-called platform work. In platform work, tasks are distributed from the buyer of the task to workers via computer systems. Proponents of platform work emphasize the increased opportunities for correctly matching task and worker, minimizing transaction costs and friction. Critics cite risks in one-sided flexibility for platform firms, while workers' flexibility will be all but lip service.

The automated management in platform work is worth special attention, as the experience from such organization of work is likely to influence a wider implementation of cognitive computer management in traditional employment. It raises key questions, of which the most important center on the transparency of the computer systems. Computer programs designed to mimic the human brain are intimidating. In order to implement them in the daily work life they need to be demystified and less opaque, if workers are to accept them as tools for management, as well as other tasks.

Employer's organizations and unions play a crucial role in this. If they in cooperation and through negotiations can find solutions both parties can accept, the long-term success of digitalization of labor is more likely.

1.1. Method

This text is a literature study of, and a theoretical discussion on, the impact of digitalization on the labor market. In the discussion, the Nordic Social Partner Approach will be applied as a suggested model in addressing the labor market challenges posed by digitalization.

2. Evolution of digitalization of labor and labor markets

The Roman *cursus publicus* used carriages pulled by horses and oxen as well as attaching messages to pigeons. In time, mail would be sent over open sea in ships and eventually the electric telegraph made its appearance. The telautograph, the fax machine, telex and other electronic devices for sending messages, followed. Today we use email and various applications for instant messaging. In all likelihood, we will invent even more methods for sending mail.

What is here very briefly described is the evolution of sending mail. The same exercise can be carried out with other phenomena, changed by digitalization, which we in casual conversation might characterize as "revolutionary", while we should probably refer to them a "evolutionary". Understanding digitalization as an evolution paves way for the insight that we are able to adapt to and harness digitalization within existing societal structures.

2.1. Industrie 4.0

Computer programs are today processing and analyzing data of larger scales and with deeper complexity than ever before (Brynjolfsson and McAfee, 2014). This is a truism, but it should be read in the context that things will never be as *slow* again as they are today.

The work of Intel's co-founder Gordon E. Moore has given name to *Moore's law*, the observation that the number of transistors in a dense integrated circuit doubles every two years (Moore, 1965). Moore's law has proven to hold relatively true, despite being challenged academically as well as practically, for some odd 50 years (Khan, Hounshell and Fuchs, 2018). This is essential to our discussion as the integrated circuit is a prime example of a general-purpose technology, which has made possible a wide array of inventions that together have brought us to our current state of digitalization. The integrated circuit is a technology that has changed the conditions for human life.

Currently, almost two decades into the twenty-first century, the labor market is at the dawn of the so-called *Industrie 4.0*. Industrie 4.0 (or "Industry 4.0" for the purpose of this chapter) was first launched as a concept by the German government in 2013. "4.0" connotes a fourth industrial revolution (European Commission, 2017).[2] In this shift in production the "smart factory" comes to realization. The robots and digital tools in the smart factory are augmented by computer systems that largely automate the management of (increasingly complex) production processes, in collaboration with humans, throughout the value chain. In the smart factory, robots and digital tools are also connected to the *Internet of Things (IoT)* (Kramp, van Kranenburg and Lange, 2013).

2.2. Internet of Things (IoT)

The Internet of Things (IoT) encompasses the expansion of the internet beyond the computer screen to devices that traditionally have been analogue, such as (but not limited to) manufacturing robots, trucks or soccer balls. A driving force for IoT is the ambition to increase work productivity. Tech giant Cisco projects that by 2030 IoT will consist of some 500 million devices.

Whether Industry 4.0 constitute a "revolution" as such, or should perhaps be characterized as evolution, will be for historians to decide. Regardless, two component of Industry 4.0 stands out as both new and at the same time highly relevant for the labor market in a scope far beyond manufacturing: connectivity with the world outside the workplace and cognitive computing.

The potentials in connecting work devices to IoT will bring an increasing proportion of devices used wherever work takes place online. Connecting work tools to the internet allows both for the smart factory previously described to operate, but also allows for worker and tool to exist in different physical spaces. Robots controlled from a computer screen can operate in places and under conditions that are impractical or outright dangerous for humans. Equipment used in delicate surgery can be operated by a doctor hundreds of miles away. The space for innovation is vast. Public administration stands out as one sphere where the potential is particularly high, as increased productivity could benefit citizens both in their everyday lives as well as in tax money being spent more efficiently.

2.3. The advent of cognitive computing

The other key characteristic of Industry 4.0 that will have impact well beyond the smart factory is *cognitive computing*. While the term has no widely agreed upon definition, it refers to a computer system that – more or less – has the function of mimicking the human brain (Kelly III, 2016). Such systems have the ability to reason, interact with humans and adapt and learn from such interactions as well as to reflect on the work they carry out. They are not programmed in the traditional sense. Kelly III (2016, para.5) formulates the difference between cognitive systems and their predecessors in terms of output:

> Those [previous] systems were deterministic; cognitive systems are probabilistic. They generate not just answers to numerical problems, but hypotheses, reasoned arguments and recommendations about more complex – and meaningful – bodies of data.

The most common public understanding of cognitive computing is artificial intelligence (AI), which in itself has a public image quite far from reality. AI as a term was coined in 1955 (Kelly III, 2016). It has since inspired cultural works such as William Gibson's pioneering cyberpunk novel *Neuromancer* (Gibson, 1984) and the iconic action-science fiction movie *The Terminator* (The Terminator, 1984), directed by James Cameron. Both works were incidentally released in 1984 and both paint a dark future of AI in society. However, the reality of cognitive computing is quite different from those of Gibson's hacker Case and Cameron's waitress Sarah Connor.

Cognitive computer systems can make sense of data of greater volume and complexity compared to previous generations of computer systems. The value in such applications is, similar to the gains of IoT, that we are able to make machines do things that humans cannot do. Cognitive computing is not about imitating humans, the purpose is to augment what humans are able to do. The OECD (2016) provides the example of diagnosing rare diseases with the help of cognitive software extracting conclusion from data shared between thousands of health professionals, data far too vast for humans to comprehend. Kelly III (2016), a vice president of IBM, points out that cognitive computing has nothing to do with sentience or autonomy on the part of robots or digital tools and that human qualities, such as common sense and ethics, are needed to maximize the potentials of cognitive computing.

The potential of cognitive computing is, according to some, gigantic. Google CEO Sundar Pichai stated that the invention of AI is perhaps more profound than the invention of electricity or the discovery of how to make fire (Goode, 2018). Kelly III (2016) describes cognitive computing as a "new era of technology, business and society". Andrus Ansip, vice-president of the European Commission, compared the impact of AI to that of the steam engine and electricity, while calling for investments of at least €20 billion by the end of 2020 (European Commission, 2018). To provide a counter argument in order to avoid hyperbole, we would do well to remember that cognitive systems can be vastly superior to humans in carrying out specific tasks but at the same time rarely can perform the simple task of drawing a circle.

Nonetheless, the strong vocal support from both government and business leaders suggest that significant political and financial capital will be invested in cognitive computing. IBM has invested USD15 billion alone in Watson, a cognitive computing system sometimes attributed with bringing the AI industry out of a longer stretch of relatively low attention (Thomas, 2017). Moreover the market value for systems applying AI systems in office settings is projected to reach USD 48.5 billion by 2022 (Waters, 2018).

3. Impact of digitalization on labor and labor markets

The devices we use in our work will be increasingly connected to the internet and cognitive computing will gradually become part of labor and labor markets. While the introduction of new technology is something that has always been present in the life of a manufacturing worker, workers in other sectors will be acting within a, at least partly, new context.

3.1. Will robots make the worker obsolete?

Office workers may have seen the introduction of more efficient ways of sending mail (although the email inbox constitutes a serious mental health concern for some) or more sophisticated ways of writing said letter (digitization such as the evolution from typewriter to word-processing computer software). But a shift to higher penetration of IoT and cognitive computing constitutes a more profound change.

In an oft-cited study by Frey and Osborne (2017) initiated 2013, they suggest that 47% of total US employment is at risk of being computerized. The figure of 47% has since been put in headlines of newspaper articles worldwide and the data in the working paper has been extrapolated over data for other countries, with the result of slightly alarmist messages. Furthermore, in the Frey and Osborne (2017) study, there are some estimates that spark skepticism, such as models (the job, not the scientific activity) being at a 98% risk of being replaced by computers – the category of employment at highest risk.

While one can be tempted to smirk at such a prediction half a decade later, there is something to be said on modeling that has bearing on digitalization and labor. Instagram, a freeware photo- and video-sharing social-networking service owned by Facebook, has grown from 150 million active users in September 2013, when Frey and Osborne initiated their study, to over one billion monthly users in June 2018 (Kuchler, 2018; Hernandez, 2013; Chaffey, 2018). Models and so-called influencers have a very high presence on Instagram and other social media. Instagram posts that are more likely to generate engagement typically show faces (Bakhshi, Shamma and Gilbert, 2014). Hence, Instagram is an ideal work tool for a model.

Models are yet to see themselves computerized, but their work has changed to a large degree. The model's own camera is part of IoT and computer software is used in retouching their persona both by professional art directors and – with easy-to-use applications such as Instagram – models themselves. Models in the twenty-first century are hence potentially less dependent on gatekeepers. This transformation of the job "model" requires a different skill set from people who work as models, compared to what a model active in the twentieth century needed. In that sense, modelling is a good example of how impacts of digitalization on labor and labor markets can manifest. The job remains but a significant portion of the job has changed radically, as has the product.

3.2. Risks related to automation vary between countries

Since 2013, several studies have arrived at more conservative estimates than Frey and Osborne (2017). Bakhshi et al. (2017) predict that one-fifth of the workforce in the United Kingdom and the US are in jobs that are likely to be less in demand in the future as an effect of automation (Bakhshi et al., 2017). Conversely, one-tenth of the workforce are in jobs that are likely to increase in demand. Bakhshi et al. (2017) also stress the levels of uncertainty associated with such predictions. The OECD, in a working paper studying all its member states, found that about one in two jobs are likely to be significantly affected by automation (Nedelkoska and Quintini, 2018). The amount of jobs that are highly automatable to a degree that humans are no longer needed is estimated to 14%, across OECD member states. The OECD points out that this lower estimate compared to Frey and Osborne still translates into 66 million workers at a high risk of losing their jobs.

The risks are not evenly distributed. Workers in Anglo-Saxon countries, the Nordic countries and the Netherlands are at a considerably lower risk, compared to workers in Eastern European countries, Japan, Chile, Germany and South European countries. This is mainly due to two reasons. Firstly, countries differ a lot in economic structure and secondly, the way work is organized within the same industry in different countries can be quite different. According to the OECD, the latter seems to represent the bulk of jobs at risk of automation. This can be explained partly by the fact that some countries are lagging behind in automation processes that other countries have already transitioned through (Nedelkoska and Quintini, 2018).

The OECD further finds, in contrast to some previous studies, that cognitive computing will not have a higher impact on jobs requiring a higher skill set. On the contrary, the OECD concludes that the jobs with the highest risk of automation are among jobs with lower education requirements and skill levels. However, as mentioned previously, a hefty proportion of the jobs that will continue to exist are predicted to change to a large degree, as a result of automation (Nedelkoska and Quintini, 2018).

Another important finding of the OECD is that when controlling for industry and occupation, women are at a higher risk of being affected by automation. It seems that while women are over-represented in sectors where jobs are at a comparably lower risk, women have more automatable tasks than their male colleagues within these sectors (Nedelkoska and Quintini, 2018).

To summarize, while the number of workers made obsolete by smart robots in labor markets influenced by Industry 4.0 are lower than what has earlier been estimated, the number is still high, particularly in certain countries and sectors. Higher still is the number of workers that will need substantial retraining, as the jobs they hold remain, but change. Ensuring workers are equipped, in terms of education, to meet the growing demands for high-skilled workers in some sectors, is also essential (Nedelkoska and Quintini, 2018).

3.3. New methods for evaluating labor

In what way the characteristics of any specific job are altered by what is previously described is a task too daunting for this chapter and its author to stipulate. However, there are some characteristics that could be expected to be fairly similar. One area relates to labor management.

If the tools used to carry out work are connected to the internet, it means that working with the tools in and of itself can be a data-generating activity, regardless of what a worker or a robot is creating with said tool. The data generated can then be shared both with other similar tools, but more broadly, with the entirety of the internet (subject to restrictions set up by company policy and the licensor of the software). Depending on the quality of programming of the software, the evaluation of what a worker/robot produces can be measured not only by looking at a *product* (be it a car component, a salad or a quarterly budget) and the time and resources the worker/robot used in creating said product, but also how the *tools* were used.

The upside of this is that computer systems can replace humans in gathering and organizing data about how work is carried out. If the computer system analyzing the data generated in turn is cognitive as previously described, larger and more complex sets of data can be examined and compared with other analysis. In the end, humans in managerial positions could potentially have access to deeper analysis about a broader scope of production, while using far fewer human resources and not having to take the limitations and risks for measurement errors that come with humans, into account.

On the other hand, the risks of leaning on cognitive computing for evaluating labor are several. Firstly, any computer system that aims at measuring something will yield less useful outcomes if the programming quality is not sophisticated enough. Secondly, software engineers will be dependent on receiving all the needed input data from the ordering part – data that might not always be possible to provide. Thirdly, the ordering part and the software engineer must be on the same level of understanding of what outcomes are expected as well as understanding of their respective limitations.

As a consequence of the previously mentioned challenges, workers risk ending up in a situation where poorly designed computer systems evaluate their work performance. In addition, there is a risk of management providing feedback based on information generated by poorly designed systems. The effects could be even less favorable for workers if outcomes from poorly designed systems influence decisions on wage increases and promotion opportunities. We will elaborate this discussion in the following section.

4. Ethical and social dimensions of digitalization of labor

Aside from significantly altering how we work, cognitive computing has the potential of affecting the ways in which work is structured. Cognitive computing opens up for management that is informed, guided or even organized by machines. While this opens up for a number of potential productivity gains, there are also major challenges. How implementation of cognitive computing in labor markets is organized will determine its success. This is particularly true for computer-system management.

4.1. Management by app

In a world of digitalized labor, a probable scenario is that the data generated by humans carrying out work tasks will be copied, disseminated, analyzed and then applied to improve the future work tasks carried out by the same humans, as well as other humans in the same sector (and beyond). In short, cognitive computing will play a key role in management.

A scenario where the boss in practice is an app can be either utopia or dystopia, or both. Such management by app is currently best observable within the so-called "platform economy", also referred to as "gig economy" or "sharing economy". In this chapter, platform economy is used, as it best describes the condition of an intermediate platform to facilitate the transaction of labor that occurs (Söderqvist, 2017). In the platform economy, workers find short-term employment, often simpler tasks such as "deliver a pizza from address A to address B" or "man this reception for two hours", through online platforms, often downloaded as apps to their smartphones.

The potential comparative advantage for workers, companies and in some cases customers (as in the case of pizza delivery) is that platforms can be superior in finding the right worker for the right task. Who the right worker is could be dependent on a specific skill set, the physical distance between a worker and the location where the task is to be carried out, or anything else that could be deemed relevant depending on the task. The platform gains this advantage through designing its computer systems in a manner that increases the likelihood of successful matching. There are obvious benefits for utilizing cognitive computing here. Indeed, one US-based but globally operating platform refers to their matching process as "data science magic".

What is previously described is a situation where software plays a central role in management of work. The software programming will strongly influence which worker is matched with any specific task, or which three to four workers a company posting a task will have to choose from. Few, if any, human interactions occur in the time span starting when the task is posted and ending when the worker receives payment. In addition, platforms usually have built-in rating systems. Some gives companies/private individuals the opportunity to rate the worker, others allow for companies/private individuals and worker to rate each other. Through rating systems, the systems do not only organize work in terms of optimal matching, but also produce data that are in effect an evaluation of the quality of said work. Lee et al. (2015) have named this practice algorithmic management in a study of ride-sharing services Uber and Lyft. Lee et al. (2015) argue that algorithmic management should be seen one of the core innovations that enables the business models of platform firms.

4.2. Low pay and gray areas

In reality, the platform economy is not functioning as well as it potentially could. A study of 2676 workers performing 3.8 million tasks on the platform Amazon Mechanical Turk points to very low pay (Hara et al., 2018). The study showed an hourly wage (adjusted for the time invested in searching for tasks, work on rejected tasks and unsubmitted tasks) of ~USD2/h. Four percent of workers earned above USD7.5/h. As there are no long-term quantitative wage studies on platform work, it is difficult to judge if this represents conditions on a broader scale. However, it surely represents working conditions that can be said to be undesirable. In recent years, mass media reports on the platform economy have painted a rather grim picture of the impact on both workers and sectors of the labor market.

In addition to poor working conditions, there are growing concerns over the unclear employment relations in the platform economy (De Stefano, 2015). As platform work sometimes constitutes neither independent freelance work nor traditional employment, there is a lack of clarity in terms of responsibilities. Who is responsible for making sure work conditions are decent and pay is properly provided, if workers interact only with computer software, as opposed to human management? In cases where a clear chain of responsibilities can be established, who ensures that rights of workers are respected in cases where platform owners do not see themselves as employer, but merely as an intermediate? Some platforms, perhaps consciously, operate in legal gray areas that circumvent labor market laws and/or standards (Söderqvist, 2017).

As suggested previously, the platform economy is not yet delivering on its potential. Nevertheless, the platform economy poses a challenge to the political system: Regulate the platform economy rapidly, lest you find yourselves in a situation in which you have to regulate in accordance with (bad) practices that have become industry standard. But then again, regulation with haste risks putting legislation in place that is not sustainable in the long run, as well as potentially hampering genuine entrepreneurship. We will return to the issue of regulation later in this chapter.

Implementation of algorithmic management will not be reserved to new phenomena in the labor market, such as the platform economy. The deeper penetration will likely occur within traditional firms and will take various shapes. More workers are likely to have fewer interactions with humans in the organizing of their work. As discussed previously, measurement of data generated by the work itself and IoT push such developments forward. Whether an increase in the use of algorithmic management is a positive or negative development for workers is not deterministic.

4.3. Black boxes, trust and accountability

While a welcome scenario could be that humanity embraces and interacts with cognitive computing in the same way that we seamlessly have integrated the internet into our lives, such an acceptance will not come by itself. On the contrary, in order for algorithmic management to be accepted and trusted, transparency is of key importance.

Cognitive computing is to most people as incomprehensible as the human brain. Input data is fed to the computer system/brain, something occurs, resulting in output data (be it speech, a structured analysis of a large dataset, etc.). How the human brain carries out this process is a knowledge reserved for a few. However, we do not demand of neuroscientists to explain the process to us in order for us to accept human-to-human interaction regarding a new task at work. This is because we accept receiving instructions on a new work method or task (albeit sometimes grudgingly) from beings we recognize and understand, and therefore trust.

Algorithmic management on the other hand is characterized by opacity. What input data is used to organize and evaluate work? Who put that data there? What are their biases? Was that data personal information? In whose interests did they design the system? How is this data shared with other licensors of the software? And so on.

Today, few developers of cognitive computer software are willing to answer these questions, at least not without a *quid pro quo* that is likely to involve a financial transaction. Such secrecy has stimulated a development toward a critical classification of cognitive computing as something taking place inside "black boxes". We know that something is going on inside these systems, but we have no way of knowing what that is or how it functions.

This is an ethical problem that is likely to (if unanswered) push people in the direction of the more dystopic popular culture portrayals of cognitive computing. Suspicion is a logical reaction to a black box that is to heavily influence your daily work, if no one is willing to tell you how that box is designed or how it reaches its conclusions. If there is reason to believe that the box is biased, who is to be held accountable if the box stays opaque? If workers are to accept and embrace algorithmic management, or at least accept that algorithmic management will influence human decision making, workers need to be able to understand and influence how algorithmic management is designed and how it functions. Transparency is crucial.

4.4. Black boxes and democracy

We now arrive at a situation where algorithms must come out of their black boxes, if the cognitive computing influencing the organization of work is to have any legitimacy. At the same time, we should not require of people to learn programming or data science in order to be able to decipher how algorithmic management functions. On the contrary, the vision should be equal access to the ability to understand and interact with cognitive computing, as opposed to it being an activity reserved for society elites, data scientists and engineers. In some circumstances, this will require some form of intermediary that can interpret the system for the layperson. Then again, a wiser course of action here would probably be to avoid discussion being about the code, in favor of discussion being about principles and what outcomes that are desired. Also desirable is a development of cognitive computer systems that can explain to the user what the system is doing.

Black boxes constitute a fundamental challenge for democracy in the twenty-first century. Indeed, the societal aspects of cognitive computing are probably much more difficult to solve, compared to technical aspects.

4.5. Data ownership

A concern similar to the challenges put forward by black boxes is ownership over data. If labor is characterized by a high penetration of IoT, a growing number of work tools (physical and digital) will be data generating. In many occupations, workers will generate data through their physical presence and how their bodies interact with their surroundings. This constitutes the generation of a new type of value for the employer. Data on labor can be a valuable commodity, if cognitive computer software can organize such data from a multitude of workers.

The question of ownership of such data is almost philosophical, yet it presents very real problems. If the ownership of data lies with the person inhabiting the corporal presence generating the data, will that person be compensated when that data is shared by an employer? If so, what does such compensation look like? Should data generation motivate a pay rise, or should perhaps workers license data generated by them to employers, while employed? What happens with data that transcends company boundaries and exists after a worker leaves a job? Will the worker have the right to offer data generated by them to their next employer, as part of a skill set? These are concepts that deserve to be analyzed further. The guiding principle of such analysis should probably be that some form of compensation is reasonable.

5. The Nordic social partner approach and digitalization of labor

Digitalization has a profound impact on labor. It challenges existing labor laws and practices and has the ability to largely transform how labor is managed and organized. As with previous technological shifts in labor, digitalization is a harbinger of different scenarios and outcomes for different actors in the labor market. All have in common that there is no technocratic, value-neutral method with which to approach them. We shall be analyzing them through the lens of the Nordic social partner approach.

5.1. Sweden: business as usual

> *In Sweden, if you ask a union leader, "Are you afraid of new technology?" they will answer, "No, I'm afraid of old technology."*

These words emanated from the Swedish Minister for Employment and Integration Ylva Johansson, succinctly describing the Swedish response to the advancement in automation, in a 2017 *New York Times* article (Goodman, 2017, para.9). This article contends that 80% of all Swedes hold positive views on robots and AI. The article elaborates by drawing a connection between Nordic countries' comparatively high investments in labor-market policies, and workers' optimism regarding new technologies. The article can, in short, be summarized as follows: If the government promises to assist you in adapting to a new labor market, you will not fear that labor market.

Embracing that which is new while simultaneously ensuring that citizens can engage in it, is one of the key components of the Nordic social partner approach. In the Nordic approach, employers' organizations and trade unions represent the interests of capital and labor in negotiations that ultimately regulate the labor market – wages, work conditions, et cetera – through collective bargaining (Lundh, 2010). The state ensures that citizens have access to education, health care, day care for children and other social services.

In addition, if job loss comes knocking, the state provides unemployment benefits, often topped up by the union. Further, wages of workers in companies filing for bankruptcy are guaranteed by the state for a certain period. In the Nordic approach, entrepreneurship is crucial, as the model cannot harbor companies that are not making a profit. Incidentally, Swedish workers have enjoyed real wage increases for decades.

With such characteristics, the Nordic approach is an organization model of the labor market that with no small benefit can be applied in meeting the challenges of digitalization. Digitalization brings new issues and conundrums to the table, such as the aforementioned issues of black-box transparency and data ownership. Within the framework of the Nordic approach, all partners have a strong interest in maintaining productivity gains while keeping the peace on the labor market. High levels of conflict and/or discontent are simply poor for business.

This means that employers and unions have a joint interest in solving problems emerging in new contexts, be it changes brought on by technological leaps or sharp turns in the global economy. Within the Nordic approach, both employers and unions have strong incentives to reach agreements and work in concert. Such a mutual and interdependent situation is fertile ground for innovative solutions. When negotiations in the end produce a way forward, it is a direction anchored in both employers and unions. Lastly, there is a clear advantage of regulating the new components of the labor market through collective bargaining, compared to regulation through legislation.

Collective bargaining agreements can be tailored to the specific context of each sector of the labor market, whereas legislation applies in the same way to all different contexts. Collective bargaining is flexible and has its point of departure with the stakeholders, whereas legislation by default needs to be “popular”. Regulating through legislation hence risks a situation where the public opinion wants to deal with a problem specific to one sector of the labor market, not taking into consideration that perfectly healthy sectors might be disadvantaged. In addition, agreements can be renegotiated. Changing legislation on the other hand is (rightly so) quite difficult to amend.

5.2. Outsmarting cognitive computing and opening black boxes?

What then, is the Swedish way of dealing with cognitive computing and black boxes? The short answer is that it depends on which sector of the labor market, with some 650-odd collective bargaining agreements, one refers to. The upside of avoiding a one-size-fits-all approach, such as legislation, is that the incorporation of cognitive computing can be tailored to very specific opportunities and limitations of a sector of the labor market. Employers and unions responsible for that sector can cooperate on how new technology should be implemented in a way that benefits growth, while not used to the disadvantage of workers.

What does this mean for cognitive computing and black boxes? As Swedish workers can be expected to have a generally positive view on technology, Sweden has a bit of a head start in the implementation of Industry 4.0-esque ways of organizing work. However, quite a few situations will likely occur where cognitive computer systems do not function as intended. Limitations in system design is one factor, another is subpar input data. It is therefore crucial that employers and unions mutually allow for unintended consequences to occur, with the understanding that they will be corrected.

Then again, there will be cases where employers will try to use management by app as a method for keeping workers in check and/or pressure workers to perform beyond healthy limits. Strong unions (69% of Swedish workers are unionized, 90% of workers are covered by a collective bargaining agreement) will play a key role in opposing such activity (Kjellberg, 2010). But unions will need the support and cooperation from employers. The incentive for the latter being that companies not adhering to good working conditions are using social dumping as a business model, which is bad for employers both in terms of unfair competition and in the undermining of the Nordic approach.

Transparency of black boxes is a potentially harder nut to crack, as it does not only involve the motivations of employer and worker, but also that of computer system developer. Companies that develop and license cognitive computing systems have no obvious incentive for opening up their software to scrutiny. Employers have a role to play here as a safeguard, refusing to license and implement systems unless employers and representative bodies in unions are able to fully understand as well as exercise real influence over the system. This is crucial for levelling the playing field between system and user. Keeping the algorithms in a non-transparent black box will feed mistrust among workers, resulting in non-cooperation, strikes or sabotage – as seen throughout the history of industrial revolutions. This is ideally where the interest for the developer to be transparent manifests – it is the only way to stay in business.

6. Conclusion

As digitalization has such high prospects, it is likely that actors on the Swedish labor market will dive in quite happily. This has potentially high effects for a large group of people while it at certain stages might be a bumpy ride. The Nordic approach does provide quite a few methods for smoothing out the road, but at the same time, evolution of the Nordic approach is (as always) necessary. Problems will not solve themselves. Currently, the partners within the Nordic Approach can be said to be asking the right questions. There is, for example, a consensus on the great need for worker retraining, as some jobs will disappear, while far more will change in nature. On the other hand, there is yet no consensus on how such retraining should be organized or funded.

Asking the right questions is often a good way to start and digitalization is not the first time the Nordic social partner approach faces a great challenge. But as challenges go, digitalization can be said to be a rather complex one. It is worth stressing that the challenges of highest importance are not necessary the technical aspects. The hardest part will probably be making the mental transition of the conceptualization of cognitive computing. Trust will be a crucial issue.

The robots, digital tools and computer systems that are increasingly more entwined in the daily routine of work, do not constitute threats in and of themselves. Of greatest importance is to keep in mind that the impact from digitalization of labor markets will be different, depending on what values and policies inform key decisions. Different responses will have correspondingly different outcomes for workers, management, shareholders and customers. These responses will be guided by values as well as policies. There are choices to be made, by states, enterprise, unions and citizens.

Regardless of exactly how many percentage points of jobs that will disappear or radically change in nature, we should expect that many millions of workers will be out of a job or at least struggle to retain their job. It is imperative that societies not allow that to transform into neo-luddism, social unrest or a fertile ground for populist sentiments. Digitalization, in order to be successful, must benefit the vast majority of people it will affect. The way to achieving that will be a political endeavor that will require profound deliberations, compromise and action, from all who in one way or the other have an interest in the future labor market.

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Notes

1 A computer system is a functional computer, including all necessary hardware and software to make it functional. Computer systems vary in size from a single device to large multiuser systems.

2 The first three being (1) mechanization powered by water and steam; (2) mass production and assembly lines powered by electricity; and (3) the digitization and automation of production, respectively.

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7 AI leadership and the future of corporate governance

Changing demands for board competence

Fernanda Torre, Robin Teigland and Liselotte Engstam

1. Introduction

When discussing digitalization and its impact on the future of labor, much of the practitioner and academic literature tends to focus on labor in general. However, this chapter takes a different approach and focuses on one subset of labor that to date has attracted considerably less attention in the literature: corporate boards. Corporate boards may be the organizational unit that has the most influence on firm performance and behavior as they influence decision-making and are involved throughout the different phases of a firm's strategic process (Huse, 2007). Leblanc and Gillies (2005, p. 6) even argued, "Nothing is more important to the well-being of a corporation than its board of directors". This should not be too surprising as corporate boards and executives are responsible for major strategic decisions such as mergers and acquisitions, new product launches, and digital transformation (Libert, Beck and Bonchek, 2017). Today, however, corporate boards are increasingly struggling with taking the right decisions. For example, a 2015 McKinsey study found that only 16% of board directors said they fully understood how technological advances were changing their company's trajectory and how the dynamics of their industry were changing (Sarrazin and Willmott, 2016).

Due to this increasing complexity of board tasks, it is expected then that digitalization will not lead to the automation or obsolescence of board directors within the foreseeable future (Bankewitz, Åberg and Teuchert, 2016; Libert, Beck and Bonchek, 2017). Rather, research and industry both point to the need to continuously develop the competence of boards to successfully tackle the many challenges brought by digitalization, especially as the external environment continues to become more volatile and uncertain due to digital technologies. For example, a recent study by MIT found that firms whose boards of directors were *digitally savvy*, i.e., members had "an understanding, developed through experience and education, of the impact that emerging technologies will have on businesses' success over the next decade" (Weill et al., 2019, p. 17), significantly outperformed other firms on key metrics – such as revenue growth, return on assets and market cap growth (Weill et al., 2019).

Of all the various digital technologies, artificial intelligence (AI) has been predicted by global leaders across industries to have a greater impact on the world than the internet (PWC, 2019). Indeed, it has even been predicted that AI will become the basis of essential competitive advantage when employed for strategic and operational decision-making, similar to electricity in the Industrial Revolution and enterprise resource planning software (ERP) in the information age (Libert, Beck and Bonchek, 2017). However, AI is still poorly understood by firms and their leaders, and the majority are still unsure as to when and how AI should be implemented (EY, 2018).

To date, the majority of activities by researchers and practitioners alike have focused on the implementation of AI at the operational level of firms (Acemoglu and Restrepo, 2019). Few are investigating what impact AI will have on the governance of organizations and how corporate boards may need to develop their competence to successfully lead their organization in this new evolving AI-based era. This seems surprising as the governance of AI, and the "big data" on which AI is based, is predicted to become one of the greatest board issues in the next ten years (Featherstone, 2017).

In order to address this research gap, we embarked on a two-year study investigating how boards will govern and leverage AI. This chapter presents some of the preliminary results from this study based on a literature review and a series of interviews with leading global experts in corporate governance and AI as well as with chairmen, board directors and top management in some of Sweden's largest multinationals. In particular, we limit our discussion in this chapter primarily to two competence areas that we propose corporate boards need to develop in order to successfully govern in a world where AI is increasingly the basis of competitive advantage: (1) guiding AI operational capability and (2) supervising AI governance capability. We also present the *Boards 4 AI Leadership Matrix*, a tool that we suggest boards may use to facilitate the development of these competence areas. In addition, we touch briefly on how AI may change the future of board work such as new board processes and augmenting board tasks (Libert, Beck and Bonchek, 2017).

The structure of this chapter is as follows. The next section presents the background for this chapter. Section 3 presents the first competence area – Guiding AI operational capability – while Section 4 presents the second competence area – Supervising AI governance capability. Section 5 then introduces our *Boards 4 AI Leadership Matrix*. Section 6 presents a reflection on how AI may influence board work in the future, followed by our concluding remarks in Section 7. Again, it is important to note that the aim of this book chapter is not to focus on the future of labor in general, even though boards will themselves have a major impact on organizations and the future of work. Rather, the primary focus is on labor at the board level and how the implementation of AI in industry will require boards to develop new competence areas to successfully govern. Furthermore, we should note that while there are different models of corporate governance based on a number of factors, e.g., ownership models, development stages, jurisdictions, this study takes a more generalist approach and applies a broad view on the competence areas that boards need to develop to ensure AI leadership.

2. Background

Corporate boards and top management are ultimately responsible for a firm's success as they are the ones taking strategic decisions and thereby putting the firm at risk. Today's competitive environment is becoming increasingly more volatile and uncertain, leading boards to take on even more strategic risk. The challenge arises when board members lack the necessary competence to take such strategic decisions, in what has been labeled "ungoverned incompetence" (Cebon, 2017). In other words, ungoverned incompetence occurs when the board tries to make the right decision, yet it ends up making the wrong one due to a lack of competence by board members (Cebon, 2017). One of the most well-known examples is Lehman Brothers during the global financial crisis when the board took the decision to invest in a product that it did not understand (Cebon, 2017). Since then many boards have failed to take the right decisions for their firms, especially when it comes to digitalization and new digital business models. For example, more than 50% of the firms that were on the Fortune 500 list in the year 2000 have disappeared from this list due to digital disruption (Nanterme, 2016). Furthermore, MIT research in 2018 on more than 1000 multinationals with over USD1 billion in revenues showed that firms with boards with a relatively low level of digital competence had significantly lower revenue growth, lower ROA, and lower market growth than those firms with digitally competent boards (Weill et al., 2019).

One of the authors of this report, under the auspices of Digoshen AB, investigated further how firms and their boards are meeting changing competitive environments due to digitalization. Building on research on digital transformation by organizations such as MIT, Institute of the Future, and the Centre for Creative Leadership and Altimeter as well as their own research and work with clients, Digoshen AB found that those firms that are digital leaders in their industry have relatively high capabilities in two areas: "digital *business* capability" and "digital *leadership* capability" (Engstam and Caroan, 2016; Pagano, 2017). In other words, as the risks continue to rise due to an increasingly complex and uncertain environment, it is not enough for a firm to merely have a high level of *digital business capability*, i.e., the use of digital technologies in areas such as local and global marketing efforts as a means to enable collaboration across firm boundaries, as the basis for a new customer value proposition or business model, and as a driver of rethinking the firm. Rather, the firm must also have a strong *digital leadership capability* to ensure successful digital transformation, i.e., digital competence at the board level, participation by the board in the identification of digital opportunities, the board's monitoring of risks related to digital transformation, and the board's use of social media and other digital technologies to share knowledge, listen to customers and increase visibility of their company.

To learn more about firms' digital business and digital leadership capabilities, Digoshen administered a survey to board directors within the European Confederation of Directors Association (ecoDa) and the Swedish Academy of Board Directors during 2016. Approximately 400 board members answered the survey with the majority of respondents from ten European countries and others from the US, Australia, China and Africa. A second survey was then conducted with approximately 400 board members from 2017 to 2019, including participants from the Swedish Academy of Board Directors Chairman Program and members of the INSEAD Directors Network, a global network.

Comparing the Digital Business Capabilities results from the surveys revealed that digital transformation was predominantly at the functional level, with only some firms starting to have their strategy influenced by digital trends. While only 30% initially had a digitally influenced vision, this more than doubled to 73% in the second survey. As for using digital technologies to understand customers better, this increased from 40% to 58%. Another interesting change was that the percent of firms launching new business models rose from 40% to 58%, with 47% starting to sacrifice existing revenue – up from 25%. While only 14% had started to look into the next wave of digital opportunities, such as AI, robotics and 3D printing, this only increased to 19% in the second.

Looking at digital leadership capabilities, more than 50% responded in 2016 that their CEOs had been leading key strategic digital business initiatives, and this number climbed to 73% in the second survey. While initially 25% had clarity in roles and responsibilities in governing digital initiatives, this only improved to 36% in the second round. One area that surfaced as critical for success was the monitoring by boards of the risks related to digital technologies and digital transformation. However, 60% of the companies were not clear about, nor did they monitor, their digitally related risks, and this number remained the same in the second set of results, even though the digital risks for most organizations had increased. A notable change was that 66% of board members claimed in the second survey to be listening via social media to customers, employees, partners, competitors and industry experts, up from 50% in 2016.

This research and these surveys revealed that digital transformation is affecting not only firms but also the work of boards. Boards are adapting their focus, changing their behavior and increasing their competence. However, the focus by boards has been primarily on understanding digitalization's influence on a firm's operations and less on how to lead digital transformation.

In our current research project, 4boards.ai, we built on the previously mentioned findings to further investigate the impact of digitalization on corporate governance by narrowing our focus to AI. We have chosen this specific focus since AI is the digital technology that is expected to have the greatest impact on firm competitiveness, and as previously noted, AI governance, and the "big data" on which AI is based, is predicted to become one of the greatest board issues in the next ten years (Featherstone, 2017). Thus, one of our underlying research aims is to examine the competence that board directors need to develop in order to successfully govern their firms in a world where AI is increasingly the basis of competitive advantage.[1]

To fulfill this aim, we present the preliminary results from our research based on extensive firsthand board work experience by one of the team members, a systematic review of academic and practitioner literature on corporate governance and AI implementation in industry, and a series of interviews with board members of leading multinationals and with global AI experts. In short, we found that while boards are aware of the importance of AI implementation as a key competitive advantage, they do not yet have sufficient competence in two key areas to best steward their companies within AI Leadership: (1) guiding AI operational capability and (2) supervising AI governance capability. Next we discuss each of these competence areas in depth, basing our discussion on our preliminary findings from our research.

3. Guiding AI operational capability

As representatives of shareholders and stakeholders, boards cannot ignore the extraordinary value-creation opportunities that AI is enabling in today's digital era characterized by a constantly changing strategic context, short-term strategizing, availability of large amounts of data and crowd-approaches to knowledge sharing (Bankewitz, Åberg and Teuchert, 2016). Through applications such as recommendations, live translations, facial recognition, autonomous vehicles and smart cities, AI offers tremendous opportunities and already is changing how value is created by firms and delivered to end users. By 2025, some 75.4 billion devices will be connected globally, compared with 26.6 in 2019 (Statista, 2019). This hyper-connectedness will generate unique innovation opportunities as well as completely new relationships between customers, suppliers, stakeholders, regulators and the greater ecosystem. Looking into the future, these relations will manifest themselves in the dissolving borders of traditional pipeline-based firms toward multi-sided business models and collaborative platforms, which will, in turn, enable new business structures in the form of networked ecosystems (Ringel et al., 2019).

Digitalization in general, and AI in particular, creates a unique context for sensing and seizing new opportunities, i.e., both the process of identifying opportunities before they arise and the process of responding to these same opportunities (Bankewitz, Åberg and Teuchert, 2016). In order to both sense and seize opportunities, boards need to have sufficient competence to guide AI operational capability, which we discuss next.

3.1. Guiding the gathering, harvesting and analysis of big data

Data are a new type of asset that organizations need to consider since our digitized society has brought to light a key aspect of technology: the connectedness between different nodes in the system. The 2018 New Vantage Partners annual executive survey shows that today, for the first time, large corporations report that they have direct "access to meaningful volumes and sources of data which are providing AI solutions with sufficient meaningful data to detect patterns and understand behaviors" (NewVantage Partners, 2018, p. 7). This is probably because it is now widely accepted that the size of available data sets represents a competitive advantage (Lauterbach and Bonime-Blanc, 2018). Indeed, data sources are numerous and include publicly available open data sets (external), data created by a company's customers, suppliers and other partners (and collected by the company within the ecosystem) and data created by the company itself (internal). Additionally, firms are beginning to take note of "alternative data", an expression developed by investment companies to label data from non-financial and non-traditional sources to improve investment decisions (Kolanovic and Krishnamachari, 2017). Big and alternative data can come from individuals (e.g., social media, news, reviews, web searches/personal data), business processes (e.g., transaction data, corporate data, government agency data), and sensors (e.g., satellites geolocation, other sensors) (Kolanovic and Krishnamachari, 2017).

Gathering quality data and building a reliable data-lake to train algorithms is no easy task. In fact, one of the most challenging tasks of building an AI program is the cleaning, preparing and labeling (tagging) of data (Lauterbach and Bonime-Blanc, 2018). Accenture suggested in a report that the firm's reluctance of investing in AI is largely driven by data concerns, as 48% of surveyed companies reported data quality issues, while 36% reported a lack of sufficient data for training and 35% reported data existing in silos (Sinclair, Brashear and Shacklady, 2018). Thus, boards need to develop an understanding of not only the gathering but also of the harvesting and analyzing of data. To address this challenge, boards can learn from the *Data Management Life Cycle* as proposed by the World Economic Forum/Accenture (WEF, 2018) that consists of four steps:

1 Data origination: Strong data infrastructure to enable data harvesting
2 Data storage: Robust data warehousing to enable storage (combination of on-premise, cloud and hybrid models)
3 Data structure and analysis: Capabilities to structure and analyze data (data quality over data quantity)
4 Communication and action: Tools and assets to communicate and take action on insights

Furthermore, our research revealed that the timely collection and harvesting of data will become increasingly critical as boards will need faster and more transparent indicators of the status of the business and industry in order to gain insights relative to strategic decisions.

Finally, our research finds that there will be a need for boards to acquire a deeper understanding of the complexities of data ownership and data access rights issues. Boards need to make balanced decision regarding their company's usage of data and who they should protect among their stakeholders.

3.2. Guiding AI-driven innovation

AI presents organizations with the opportunity to innovate their businesses in a multitude of ways, ranging from incremental improvement to complete reinvention (McWaters, 2018). Table 7.1 provides an overview of the innovation that AI enables as well as some examples provided by the World Economic Forum:

Table 7.1 From core to radical innovations with AI.

Leaner, faster operations	AI allows operational enhancements, such as improving efficiency, decreasing costs and freeing capacity. Example: Using automation and pattern detection to improve core business processes.
Tailored services, products and advice	AI resolves traditional trade-offs between cost and customization, enabling tailored products at near-zero marginal cost. Example: Big data analytics for personalization.
Ubiquitous presence	AI expands reach by enabling better self-serve applications that allow more services to be delivered digitally. Example: A suite of offerings that capture new market share by using AI to offer a seamless experience automating the purchasing process.
Smarter decision-making	AI enhances decision-making capabilities, unlocking novel insights that drive improved performance. Example: Identification of unexplored patterns to outperform markets.
New value propositions	AI redefines core offerings, unlocking untapped segments and revenue opportunities through new products and services. Example: Big data analytics to identify new areas of customer demand.

Source: (Adapted from McWaters [2018] and WEF [2018])

In order for firms to take advantage of AI opportunities, corporate boards need to be able to implement a portfolio approach addressing a range of AI opportunities. From exploiting AI for leaner, faster operations to exploring AI for new value propositions, a portfolio approach is important since some projects will generate quick wins while others will focus on transforming end-to-end workflows (Lauterbach and Bonime-Blanc, 2018). It is important not to mistake the mere launch of a few isolated use cases as complete AI deployment. McKinsey & Company has noted that if an AI strategy is not implemented beyond a few use cases, then this is a warning signal of AI program failure (Fleming et al., 2018). Additionally, corporate boards need to understand the strong relationship between successful innovation management in general and AI innovation capabilities, i.e., a firm that is successful at innovation generally is successful at AI deployment (Ringel et al., 2019).

Some of the capabilities common to innovation management and AI implementation are the following:

- Cross-functional, diverse teams working on AI and algorithmic development are a "must-have in the adoption of safe and beneficial technology" (Lauterbach and Bonime-Blanc, 2018, p. 145).
- Strong feedback loops in an iterative development process in close connection with business development are required because "the best algorithms will

not succeed in delivering results if they do not improve a product or a service experience for a customer" (Lauterbach and Bonime-Blanc, 2018, p. 145).

- Clear top-management buy-in since if the "executive leadership team is not ready to redesign business models and end-to-end processes across the whole organization, a company may never benefit from the full potential of AI" (Lauterbach and Bonime-Blanc, 2018, p. 147).
- An innovation culture that embraces both a "succeed fast" approach to innovation and that focuses on finding unmet real needs (Main, McCormak and Lamm, 2018).
- Training and hiring programs with innovation at the core is a key enabler for digital transformation: "whichever strategy it pursues, an organization must offer its workforce an engaging work environment that enhances the employee experience, incubates ideas and encourages creative thinking" (WEF, 2018, p. 15).

Of note is that some of the most urgent opportunities for AI-driven innovation are related to the 2030 Agenda for Sustainable Development adopted by all UN Member States in 2015 (Rolnick et al., 2019). Due to the complexity of social-ecological systems, AI presents specific opportunities within big data analysis and the management and optimization of the global technological infrastructure that extracts and develops natural resources such as minerals, food, fossil fuels and living marine resources. Furthermore, algorithms facilitate global trade flows that form the basis of environmental monitoring technologies (Galaz and Moberg, 2015).

Even though there are strong arguments to use AI in the context of enabling innovation, our research shows, however, that the level of AI implementation varies greatly across organizations. This represents an additional area for board consideration since looking into the future, we see that while organizations struggle to invest in their dynamic capabilities for innovation and AI implementation, the "first-mover" advantage might be of key importance in this innovation game. AI is a technology that lends itself to a "winner-takes-all" strategy due to either potential networks effects of the solutions presented or due to the nature of the technology itself. AI does not allow a "plug-and-play" approach, which generates a performance gap between AI "pioneers" that appear to be "pulling further away" from organizations that are still lagging behind (Ringel et al., 2019, p. 8). The performance gap between AI performers and non-performers might be of particular concern for corporate boards since it might require a more ambitious AI deployment strategy, which also increases the pressure for leadership contributing to a distinct "bandwagon" effect. This effect can be described as "a psychological phenomenon in which people do something primarily because other people are doing it, regardless of their own beliefs, which they may ignore or override (Kenton, 2018). The "bandwagon" effect is known to contribute to speculative bubbles; therefore, corporate boards should be considerate of this bias and aim toward a meaningful implementation of AI according to best practices.

To better guide AI-driven innovation in the firm, boards will, however, need to strike the right balance between development and control activities. Our research has revealed to date that currently, most companies spend the majority of their board meetings discussing control issues, thereby greatly limiting time spent on innovation. A better practice would be to develop processes for control outside the larger board meetings either in committees or through online fora and instead devote more board time to discussing development activities while considering the right KPIs (key performance indicators) to reflect this balance. As a consequence, a bigger focus by boards on innovation will require the development of new competences in the board and capabilities in the firm. In order to develop their companies' businesses, boards will need to better understand innovation, technology and sustainability, and their impact on opportunities, threats and new business models.

3.3. Guiding the growth of a digital business ecosystem

As mentioned previously, there is a strong correlation between companies that consider themselves strong innovators and those that see themselves as being strong at AI (Ringel et al., 2019). One would expect this to be primarily true for technology firms; however, a closer look at a BCG report reveals that the most innovative firms are not all technology firms. Rather the most innovative firms are those that develop not only AI but also platforms and ecosystems across their industry regardless of industry (Ringel et al., 2019). While a platform structure is nothing new per se, for example, newspapers have connected subscribers and advertisers for many years, the enhanced ability to capture, analyze and exchange huge amounts of data will increase a platform's value to all (Van Alstyne, Parker and Choudary, 2016). Furthermore, the usage of digital platforms, APIs, IoT technology and new tools for data collection and analysis will allow for new products and services that go beyond the boundaries of traditional business (Fuller, Jacobides and Reeves, 2019). This is a shift that is predicted to have a significant impact in the near future. For example, a McKinsey study showed that an emerging set of digital ecosystems could account for more than USD60 trillion in revenues by 2025, or more than 30% of global corporate revenues (Bughin et al., 2018).

A platform is a specific kind of ecosystem, i.e., all platforms are ecosystems but not all ecosystems are platforms. A platform leverages "networked technologies to facilitate economic exchange, transfer information, connect people, and make predictions . . . thus a platform drives value from its role as an intermediary" (Fenwick, McCahery and Vermeulen, 2019, p. 3). Currently, seven of the 12 largest companies by market capitalization – Alibaba, Alphabet (Google), Amazon, Apple, Facebook, Microsoft and Tencent – are ecosystem orchestrators (Bughin et al., 2018) that use platforms to create value by facilitating exchanges between different yet interdependent groups (Fenwick, McCahery and Vermeulen, 2019). For example, developers of voice-recognition-based smart-home platforms, such as Amazon's Alexa or Google's Home, make it easy for others to create new consumer services that use their AI-enabled platforms – and in the process to attract the critical mass of applications needed to make their platform and thus their ecosystem a clear leader (Ringel et al., 2019).

For most firms, the relation between the implementation of AI and operating in a business ecosystem becomes increasingly relevant as it will be extremely difficult for a firm to implement an advanced AI program completely alone. Currently, the costs of implementing AI and finding the appropriate data scientists are extremely high, especially as AI technology is becoming increasingly relevant for all business sectors, not only within tech firms. As a result, the search for recruiting and retaining AI talent is also becoming more competitive (Perisic, 2018), in what has been called a war on AI talent (Kelnar, 2019). Boards need to develop an understanding of how organizations collaborate in digital business ecosystems to hasten the pace of implementation of an AI program, reduce costs and to potentially tap into value from ecosystem partners. As identified in Accenture Technology Vision 2017, "The competitive advantage of tomorrow won't be determined by one company alone, but by the strength of the ecosystems chosen, and the company's plans to help the ecosystems grow" (Accenture, 2017, p. 39).

Moving forward, corporate boards must develop their understanding of complex adaptive systems. To implement AI through a platform and even to orchestrate a digital ecosystem can be described as the management of a complex adaptive system, i.e., an understanding of the individual parts does not automatically convey an understanding of the whole system's behavior. The management of a complex adaptive system requires what could be called "competing on the edge" that requires "adaptation to current change and evolution over time, resilience in the face of setbacks, and the ability to locate the constantly changing sources of advantage . . . engaging in continual reinvention" (Brown and Eisenhardt, 1998, p. 19). The goal is flexibility, requiring the board to be able to shape strategy where the organization both influences and is influenced by ecosystem stakeholders, while evolving the ecosystem for mutual benefit (Fuller, Jacobides and Reeves, 2019). In other words, corporate boards will need to support the development of an organization's adaptive capabilities so they can provide real-time responses to strategic issues and opportunities provided by AI (Bankewitz, Åberg and Teuchert, 2016).

An implication of digital business ecosystem participation is that boards will need to be more dynamic in their work. Today many companies have four to seven board meetings a year, which, given the complexities of governing a digital business ecosystem, will probably need to be complemented with more flexible options. For example, board work can be complemented with full or temporary committees for areas such as innovation and technology. Additionally, board meetings could be both physical and virtual, thereby enabling the ability to react more quickly to changing conditions. For example, virtual meetings could occur in between the traditional face-to-face board meetings to discuss upcoming opportunities or threats.

4. Supervising AI governance capability

While AI offers considerable innovation opportunities in both strategic and operational areas (Vinnova, 2018), we have found that corporate boards must also develop the competence to supervise AI governance capability in order to successfully govern and mitigate the risks that go hand-in-hand with implementing AI within an organization. Next we discuss three areas in which boards need to develop their competence in order to supervise AI governance capability.

4.1. Supervising data management, ethics and black box decision-making

Currently, few companies perceive data as a valuable asset, and thus they do not devote sufficient attention to how they manage their data. As a result, they lag behind in implementing clear rules and policies to ensure data are trustworthy, clean and usable (Protiviti, 2019). Accenture found that 79% of executives responded that their organizations were basing their most critical systems and strategies on data, yet many had not invested in the capabilities to verify the truth within (Accenture, 2018). This is a basis for concern for boards because if an AI system is based on incomplete or poor data quality, it could lead to the wrong training of the algorithms, opening concerns for the trustworthiness of the AI decisions.

Besides data quality, algorithms that are programmed by humans may be subject to bias, leading to ethical conflicts. Programmers might inject their judgments into the code and train algorithms with biased data, leading to machines being even more untrustworthy or incapable of delivering neutral results. A recent report by Microsoft identified five areas for potential bias: dataset bias, associations bias, automation bias, interaction bias and confirmation bias (Chou, Murillo and Ibars, 2017). Dataset bias occurs when algorithms are trained on data with low diversity, leading to a generalization that will underrepresent certain elements. Association bias takes place when the data used to train an AI model reinforces and multiplies a cultural bias. In the same way, the automation of decisions might override social and cultural considerations and automate goals that go against human diversity. Interaction bias takes place when the bias comes from humans that have distinctively tampered with the AI in order to make it biased. And finally, confirmation bias takes place when AI algorithms serve up content that matches what other people have already chosen, thereby confirming preconceptions.

The best way to address possible biases is to have algorithms developed in a context of diversity, in terms of disciplines, demographics, experience and knowledge, as this will be the best way to anticipate ethical failures and minimize the risks of unintended AI harm (Pauwels, 2018). Regrettably, we live in what can be called a diversity crisis. For example, it took a group of engineers who call themselves "black in AI" to uncover the scandal of how facial recognition technologies failed to trace the features of individuals with darker skin tones (Snow, 2018).

Furthermore, there are also concerns with what is called AI black box decision-making, which can create a liability minefield. Black box decision-making refers to machine learning and the fact that it might not be possible to trace back to why certain decisions were taken by a firm's AI system, making it nearly impossible for a firm to explain its AI actions to stakeholders, the general public or regulators. AI's black box decision-making can result in considerable accountability challenges since responsibility for a decision or action taken may be difficult to pinpoint – was it the programmer who wrote the initial algorithm, the machine that learned the wrong thing due to improper data, or perhaps the company's processes that led to a failure to update the algorithm? Moving forward, as AI applications are highly complex and many managers do not completely understand how they work, regulators may be reluctant to approve AI systems if they cannot be thoroughly explained in how and why decisions are made (Protiviti, 2019). To avoid this, boards need to ensure that the firm strives for the "explainability" of its AI systems in order to be transparent and provide an explanation for decisions and actions made (AI HLEG, 2019).

Furthermore, in our interviews we have found that boards tend ***not*** to be aware of the current applications of AI in their organization, especially when it comes to off-the-shelf solutions. For appropriate AI governance, corporate boards will need to stay informed of the individual AI application uses in their companies as well as the model reviews done for those algorithms.

In a context of clouded accountability and relatively low expert understanding, AI raises risks of reputational damage and ethical concerns. Major AI leaders, such as Microsoft, Intel, Alphabet Inc./Google and IBM, have recently published social responsibility principles, showing an interest in self-regulation and taking on real-world problems. These documents provide a look into potential foreseeable troubles. For example, Microsoft, in its annual Securities and Exchange Commission (SEC) report filed in June 2018 and referent to the previous year, has put it very clearly:

> Issues in the use of artificial intelligence in our offerings may result in reputational harm or liability . . . AI algorithms may be flawed. Datasets may be insufficient or contain biased information. Inappropriate or controversial data practices by Microsoft or others could impair the acceptance of AI solutions. These deficiencies could undermine the decisions, predictions, or analysis AI applications produce, subjecting us to competitive harm, legal liability, and brand or reputational harm.
>
> (Microsoft, 2018, p. 28)

Following suit also Alphabet Inc. (holding company of Google) has also reported the risks of AI:

> New products and services, including those that incorporate or utilize artificial intelligence and machine learning, can raise new or exacerbate existing ethical, technological, legal, and other challenges, which may negatively

> affect our brands and demand for our products and services and adversely affect our revenues and operating results.
>
> (Alphabet, 2018, p. 7)

Even if some IT multinationals today show concern by showing interest in self-regulation and publishing social responsibility principles, it is unclear as to how regulators will act in the future. Perhaps a set of principles may materialize into standard practices within industry that are sufficient for regulators or perhaps strict regulations may be developed. Looking into the future, even prior to potential regulation, corporate boards will have to take a stance on the ethical implementation and regulation of AI. For example, Microsoft recently announced that it had decided to decline the sale of its facial recognition technology to both a California law enforcement agency and to an unnamed capital city because of human rights concerns (Menn, 2019).

In this context, it seems clear that boards should raise their competence in this area. For example, boards should be able to supervise the creation and monitoring of a data governance framework for the firm. This framework should focus on ensuring that the firm's data and processes are developed with a clear purpose and fulfilling ethical obligations. This is distinguishable from the current practices of many firms that aim to merely fulfill legal obligations. Currently, there is not an established and mature model that is consensual among industry, policy makers and academics, although several models are being tested (Micheli et al., 2018). This is relevant for boards because, in the words of Anastassia Lauterbach, "A visionary board should ask how the company thinks about data to solve strategic and operational problems, whether there is a solid data governance framework in place, and if and when the business considers providing wide access to data, allowing as many people as possible to find valuable insights" (Lauterbach, 2018, para.7). Additionally, the data governance framework should be linked to the firm's regulatory actions and cybersecurity activities, the subject of the next section.

4.2. Supervising AI security

Not only must boards develop the competence to ensure they can adequately supervise data governance, but they must also develop significant competence related to understanding how to best ensure data and AI system security and protection from hackers and similar ransomware activities (Else and Pileggi, 2019).

There are different kinds of cybersecurity threats, and one of the most commonly discussed is hacks, i.e., an unauthorized intrusion into a computer or a network, such as malware, phishing, man-in-the-middle attack, denial-of-service attack, SQL injection, among others (Cisco, 2018). This action can be perpetrated with different intentions, from stealing corporate secrets to executing ransomware attacks such as the 2017 WannaCry that led to losses estimated to reach USD4 billion (Berr, 2017). Robert Mueller, during his time as Director of the FBI, explained this increasing threat in an RSA Cyber Security Conference, "I am convinced that there are only two types of companies: those that have been hacked and those that will be. And even they are converging into one category: companies that have been hacked and will be hacked again" (Mueller, 2012, para.63).

Hacks are not always conducted by external malicious software. They can also be conducted through social engineering, which relates to the action of using psychological manipulation to trick targeted users into making security mistakes or giving away sensitive information. As corporations devote more resources to IT departments and vamp up firewalls, hackers are increasing their social engineering efforts to bypass these defenses, by going further beyond technology and targeting the aspect of a corporation where security has been the weakest – its employees.

An example of this practice is *phishing*, which can be defined as email scams that use social engineering to attempt to trick the recipient into providing confidential information or unintentionally installing malware through the use of links or attachments (Proofpoint, 2019). According to the enterprise security company, Proofpoint, 83% of global info-security respondents experienced phishing attacks in 2018, which is up from 76% the previous year (Proofpoint, 2019).

To ensure AI security, boards should understand the relevant talent issues. Questions arise such as which talent should be outsourced, when, and how versus whether talent should be employed in house? While conventional security principles are about keeping the bad guys out, social engineering raises another type of question: what to do when the "bad" guys are already inside (Gregersen, 2018)? Thus, one area of discussion for boards is how to ensure employee education as employees who feel they have sufficient training and support to deal with technology at work will be better at their jobs and save the company from hacking attacks along the way. In fact, according to Proofpoint's 2018 report, security awareness training had a significant impact on preventing attacks, and nearly 60% of organizations saw an increase in employee detection once their staff was better trained to identify possible attacks (Spadafora, 2019). Looking forward, one suggestion is that boards understand how to drive AI security implementation by applying the same friendly customer-centric experience that companies have with clients on their own employees (Gregersen, 2018), addressing both cybersecurity and talent retention.

Moreover, AI systems are particularly susceptible to attacks (Mitchell, 2019) for two main reasons: 1) machines are being used to train other machines – which scales the exposure of compromised pieces of code, and 2) machines can be fooled by adversarial examples, i.e., inputs optimized by an adversary to produce an incorrect model classification (Elsayed et al., 2018; Lauterbach, 2018). Image classification systems could be attacked by adding a layer of noise distortion, e.g., fool an algorithm to identify a school bus as an ostrich (Szegedy et al., 2013). Autonomous driving systems could be attacked by, for example, placing stickers on a STOP sign to fool the self-driving car to interpret the sign as a "Speed Limit 80" sign (Eykholt et al., 2018). Finally, speech recognition systems could be attacked by, for example, an audio signal changed so that it is white noise to a human but is, in fact, a command to a machine (Carlini et al., 2016). Thus, corporate boards should be extra vigilant and cognizant that such attacks on their AI systems can occur. Corporate boards need to develop the competence to develop and reevaluate a routine to foresee where such attacks may occur and how to both monitor and sufficiently respond if and when an attack occurs.

Finally, besides training employees to avoid attacks, boards need to be ready to handle worst-case-scenario situations that might happen anyway. The board should have a clear process on how to deal with AI security breaches, such as how to handle reputation issues in the media or even how to run offline since "pen-and-paper" operations might be necessary in the case of extensive attacks.

All these different aspects related to governing AI as a black box that is susceptible to cyberattacks will require firms to take an intelligent, proactive and multi-layered attitude toward cyberattacks (Grasso, 2019). The implication for how board work may change is that in the future boards will need to better balance the company's focus on long-term strategies that will have to be clearly communicated with all stakeholders, shifting away from more traditional short-termism.

4.3. Supervising business ecosystem leadership

As AI businesses move into ecosystem configurations and platform models, boards will need to learn to "govern" all the stakeholders and the organization's relation to them. Traditionally, as firms grew, they would develop increasingly hierarchical structures as a way to manage the complexities of scale. Although this system might have been useful in the past, in today's dynamic and uncertain business reality, it raises challenges related to the bureaucratization of firm culture (Fenwick, McCahery and Vermeulen, 2019). Today's reality demands the creation of flat, open and inclusive organizations that take advantage of stakeholder talent. Together with live data drawn from the ecosystem, a flexible organization raises the opportunity to automate decisions in what, for example, Alibaba calls the "self-tuning enterprise" (Fuller, Jacobides and Reeves, 2019). As such, AI ecosystems and platforms should be built around the idea of delivering constant innovation via open and inclusive processes of collaboration and co-creation (Fenwick, McCahery and Vermeulen, 2019). For boards this means a flexible and holistic approach to stakeholder governance, which boards can develop following the three-step strategy (Fenwick, McCahery and Vermeulen, 2019):

(A) Leveraging current and near-future digital technologies to create more "community-driven" forms of organization
(B) Building an "open and accessible platform culture"
(C) Facilitating the creation, curation and consumption of meaningful "content"

Besides governing stakeholders to harvest their talents, boards need to learn to govern specific aspects related to data usage and data rights throughout the ecosystem, similar to what many firms have implemented when it comes to sustainability and supply-chain management. Boards will need to ensure that all participants conform to local regulations for the jurisdictions in which the organization exists (WEF, 2018). This represents a big shift in boards' focus. It will no longer be enough to guarantee a firm's own governance, but it will be increasingly relevant to apply all aspects of governance and risk management to the different partners and stakeholders of the ecosystem.

When addressing stakeholder governance, an extra point for boards to understand is the asymmetry of power between the tech-leaders and the tech-takers. Together with the powerful network effects from digital platforms, this lends itself to a "winner-takes-all" scenario (Lauterbach and Bonime-Blanc, 2018), as addressed in Section 3.2. In this context, boards should be sure to evaluate the benefits and drawbacks when choosing or joining an ecosystem or choosing an AI technology vendor.

Finally, boards should also develop the competence required to enable complex ecosystems. As mentioned previously, the management of a complex adaptive system requires adaptation and indirect shaping in what is called a *shaping strategy*. This still feels counterintuitive to many boards and leadership teams more used to a traditional "plan and execute" controlling approach. A BCG Henderson Institute study found in a strategy simulation game that only 18% of managers succeeded in ecosystem strategy versus an AI opponent, while they would succeed 71% in a classical strategy simulation (Fuller, Jacobides and Reeves, 2019). As a consequence, boards will need to increase their focus on stakeholders from a primary focus on shareholders.

5. Boards 4 AI leadership matrix – a tool for developing board competence

As previously discussed, AI warrants the close attention of the board because firms that successfully implement and govern AI can disrupt the market, drive growth and manage their risk. To support boards to develop the two competence areas necessary to successfully steward the firm to leverage AI, we have developed the tool presented in Figure 7.1, based on the preliminary findings from our research.

To apply this tool, we suggest that a firm's board members should *individually* evaluate where the board is in terms of its competence in the two areas: (1) guiding AI operational capability and (2) supervising AI governance capability. The board can then use the results as a basis for discussion on how the board can improve its two sets of AI capabilities in the firm. For example, a board may not know where or how AI is being implemented in their firm. If such is the case, the board could use this opportunity to address this gap and develop a critical opinion about how the board should develop its competence in order to guide the firm's AI operations and supervise its AI governance. It is also important for boards to relate themselves to others in their industry as there may be differences across industries. For example, the boards of dominant companies such as Facebook, Amazon, Alibaba, Tencent and Google seem to be building their guiding AI operational capability faster than their supervising AI governance capability. However, in the medical service industry with strict regulations concerning patient data, boards may have a very strong supervising AI governance capability but still a rather low

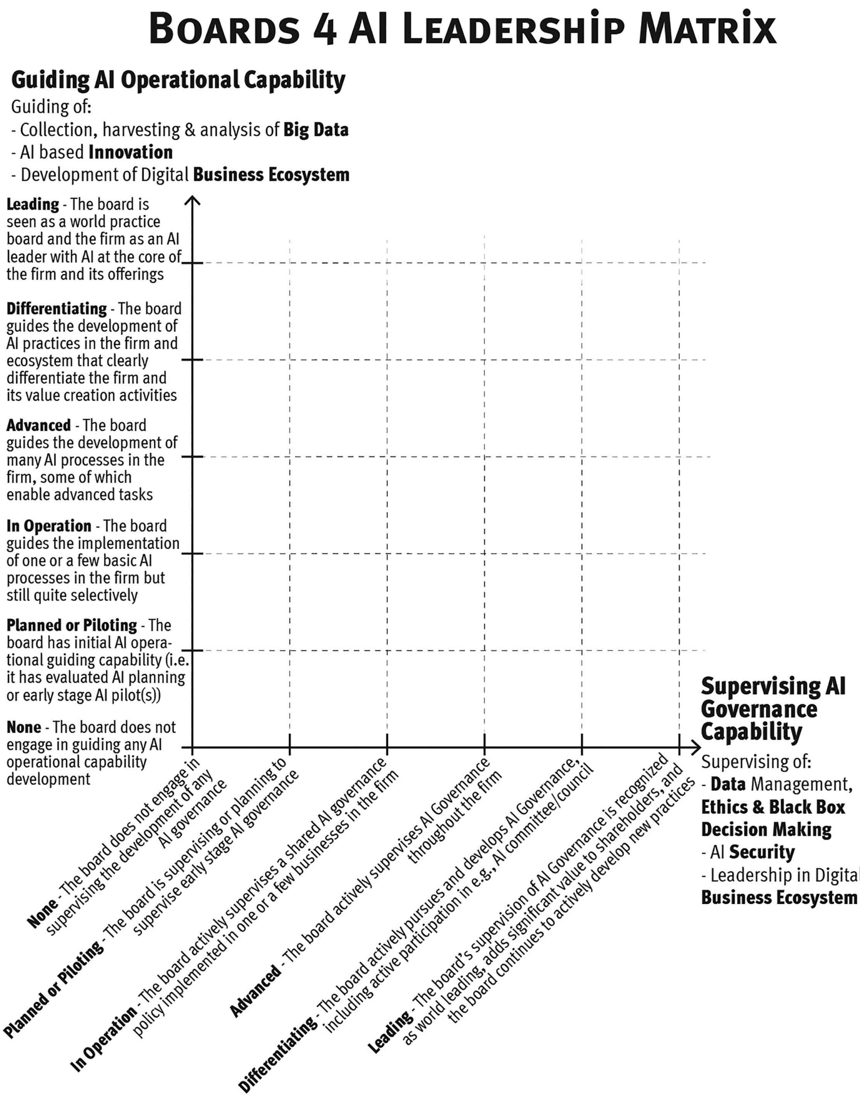

Figure 7.1 Boards for AI leadership matrix.

guiding AI operational capability. Firms in either of these categories would need to leapfrog if they want to become complete AI leaders and need to consider how to fast forward implementation to become the AI benchmark. In this context, as explained in the ecosystem section, it may be faster and more efficient to partner with relevant actors in the firm's ecosystem and build synergies beneficial to all partners. Finally, it is important to note that when a firm's board is a benchmark in both guiding AI operational capability and supervising AI governance capability, then it has the ability to shape the regulatory context, which may prove beneficial in continuing the development of its competitive advantage.

To help boards acquire a better understanding of where they are in terms of the development of their competence, we created a set of questions following the themes addressed in this study. Table 7.2 presents the questions relevant for guiding AI operational capability, following the sections: (3.1) guiding the gathering, harvesting and analysis of big data; (3.2) guiding AI-driven innovation; and (3.3) guiding the growth of a digital business ecosystem.

As mentioned previously, boards need to develop competence not only in regard to guiding AI operational capability but also to supervising AI governance. Table 7.3 presents a set of questions to support boards addressing sections: (4.1) supervising data management, ethics and black box decision-making, (4.2) supervising AI security and (4.3) supervising digital business ecosystem leadership.

6. Beyond competence to the future of board work

Not only will boards need to guide and supervise their firm's AI capabilities, but they will also need to rethink and redesign themselves and their tasks in the context of managing their business to meet the challenges brought on by digitalization (Bankewitz, Åberg and Teuchert, 2016). Through our research, we have identified several areas for board consideration.

One action for boards is to reflect on is how they themselves can become better resources for their organization. For example, should the board focus on personal development or should the board implement specific technical committees that will support the board's digitalization work? In the context of the implementation of an AI program by management, a subset of the board in a technology committee could have a role overseeing and supervising the implementation framework (Lauterbach and Bonime-Blanc, 2018).

Another action is to rethink how to best transition the workforce. One of the biggest issues with AI implementation in firms is job automation in society and the potential rise of unemployment and social unrest (Shewan, 2017). Boards will have an important role in guiding their organization through this important transition. Boards will need to monitor and oversee the decisions regarding the appropriate balance between the automation of processes and jobs versus the augmentation of job tasks, potentially reskilling workers and creating new jobs. Boards should think more broadly about automation and its displacement effect and propose how to create new tasks with AI, thereby engendering a *reinstatement effect* (Acemoglu and Restrepo, 2019).

Table 7.2 Guiding AI operational capability.

Guiding AI operational capability		
Capability level	*Area*	*Questions*
1. None: The board does not engage in guiding any AI operational capability development.	**Data**	How does the board evaluate the firm's internal data collection strategy? How does the board evaluate the firm's routines for exploring data sources?
	Innovation	How does the board assess the relationship between the firm's business strategy, innovation strategy and its data? How does the board challenge itself and management to learn about AI and its implications for the future of work?
	Ecosystem	How does the board rethink the firm's value chain? How does the board evaluate which partners may enable the firm to more quickly ramp up its AI operational capability for faster and more value creating operations and offerings?
2. Planned or piloting: The board has initial AI operational guiding capability (i.e., it has evaluated AI planning or early stage AI pilot[s]).	**Data**	How does the board monitor that the firm identifies and prioritizes both internal and external data to increase value for customers and the firm? How does the board ensure that the firm has the necessary competence to harvest, process and analyze data?
	Innovation	How does the board guide and challenge management to identify use cases to improve offerings or operations through AI in the firm? How does the board evaluate and guide which use cases to further explore?
	Ecosystem	How does the board monitor the exploration of possible partners with which the firm could collaborate within its value chain? How does the board monitor the exploration of possible partners with which the firm could collaborate beyond in the greater ecosystem?
3. In Operation: The board guides the active implementation of one or a few basic AI processes in the firm but still quite selectively.	**Data**	How does the board evaluate the use of third-party data sources by the firm, e.g., external data from an open third party, from the greater ecosystem? How does the board evaluate the firm's data storage, usage strategy and consider data as an asset?
	Innovation	How does the board continuously develop an understanding of the potential impact of AI on the firm's industry, offerings, business operations and business model? How does the board consider which aspects of the business could benefit from increased automation or machine-learning innovation?

	Ecosystem	How does the board ensure alignment with the firm's partners on shared values and communication standards?
		How does the board consider how AI might fit with other emerging technologies in the ecosystem?
4. Advanced: The board guides the development of many AI processes in the firm, some of which enable advanced tasks.	**Data**	How does the board ensure that the firm has a complete data management life cycle and comprehensive data strategy?
	Innovation	How does the board evaluate the firm's use of AI for incremental innovation in its operations?
	Ecosystem	How does the board ensure that the firm allows for all voices to be heard, including all stakeholders?
		How does the board monitor and guide which skills and talents to acquire/develop internally vs externally?
5. Differentiating: The board guides the development of AI practices in the firm and ecosystem that clearly differentiate the firm and its value-creation activities.	**Data**	How does the board work with guiding the development of the firm's data management strategy?
	Innovation	How does the board ensure that it continues to improve its guidance of the firm's data-driven innovation strategy and to evaluate how AI can help transform the firm's products or services?
		How does the board monitor and discourage AI silos and promote collaboration across the firm through policies, processes and systems?
	Ecosystem	How does the board guide the firm to ensure that the hierarchy (competence, titles, reporting lines, goals setting) and agility is compatible with the firm's ecosystem to ensure continued data-driven innovation?
		How does the board guide the firm to continuously explore partners in the ecosystem to move forward faster or better?
6. Leading: The board is seen as a world practice board and the firm as an AI leader with AI at the core of the firm and its offerings.	**Data**	How does the board guide and ensure that the data framework is applied to all aspects of the firm consistently and systematically?
		How does the board guide the work with data science talent management?
	Innovation	How does the board guide and ensure that the firm has a leading AI innovation portfolio?
		How does the board guide and ensure that the firm has the necessary innovation management capabilities to be harvesting both short- and long-term opportunities?
	Ecosystem	How does the board guide and ensure that the firm has the organizational muscle to manage complex relationships across an ecosystem (competing on the edge)?

Table 7.3 Supervising AI governance capability.

Supervising AI governance capability		
Capability level	*Area*	*Questions*
1. None: The board does not engage in supervising the development of any AI governance.	**Data governance**	How does the board learn about data and black box governance and introduce discussions in the board room and with management? How does the board supervise awareness of where AI and algorithms are used in the firm? How does the board supervise the alignment with GDPR?
	AI security	How does the board supervise AI security for the firm, and how is AI security reviewed and reported to the board?
	Ecosystem leadership	How does the board learn about the impact AI will have on different stakeholders and their expectations?
2. Planned or piloting: The board is supervising or planning to supervise early stage AI governance.	**Data governance**	How does the board keep pace of how the firm is registering where AI and algorithms are used in the organization? How does the board keep up-to-date on and supervise what the prioritized use cases and pilots are? How does the board define and agree on relevant data and AI governance to better prepare the firm for the future?
	AI security	How does the board ensure that the cyber risks and data privacy issues related to AI implementation are evaluated and monitored? How does the board review if the implications of a data breach have been fully understood and costed? How does the board encourage the firm to expedite learning related to AI security risks in the broader organization?
	Ecosystem leadership	How does the board continuously evaluate the impact AI will have on customers, employees and society? What are the expectations from shareholders on the board's insights and actions?
3. In Operation: The board actively supervises a shared AI governance policy implemented in one or a few businesses in the firm.	**Data governance**	How does the board discuss and agree on data governance priorities and policies for the firm? How does the board review which data and bias governance policy is relevant for the broader organization? How does the board ensure that the learnings are incorporated in the broader risk and governance system of the firm? How does the board ensure that the algorithms and models used are transparent and reviewed by an independent party?

	AI security	How does the board challenge management to respond strategically to risks associated with AI, including cyber risks?
		How does the board monitor that the agreed AI governance policy is implemented throughout the firm?
	Ecosystem leadership	How does the board ensure the firm continues to build stakeholder trust as the firm implements AI?
4. Advanced: The board actively supervises AI governance throughout the firm.	**Data governance**	How does the board remain updated on developments related to data governance, AI bias and ethics?
		How does the board ensure that the firm matures its data practices and runs them in the most effective way?
	AI security	How does the board monitor and supervise that the workforce is sufficiently and continuously equipped to exercise the emotional and ethical judgement required of them?
	Ecosystem leadership	How does the board ensure that the firm lives up to stakeholder expectations in its AI governance activities?
		How does the board supervise how stakeholders manage compliance with AI policies across the ecosystem?
5. Differentiating: The board actively pursues and develops AI governance, including active participation in e.g., AI committee/ council.	**Data governance**	How does the board ensure that the firm uses state-of-the-art AI, bias and ethics governance practices to create further differentiation for the firm?
	AI security	How does the board evaluate the firm's engagement in industry consortia to further learn and share its insights to increase society protection?
		How does the board monitor and supervise that the employees are engaged with continuous feedback?
	Ecosystem leadership	How does the board ensure collaboration and increased engagement with stakeholders on AI governance issues?
6. Leading: The board's supervision of AI governance is recognized as world leading, adds significant value to shareholders, and the board continues to actively develop new practices.	**Data governance**	How does the board ensure that the firm takes the lead and helps promote improved data, AI bias and ethical governance and research in the society?
	AI security	How does the board ensure the firm takes the lead and helps promote an intelligent, proactive and multilayered attitude toward research in society toward cyberattacks?
	Ecosystem leadership	How does the board ensure that the firm collaborates and leads the ecosystem in its understanding of AI governance?
		How does the board work with regulators regarding the shaping of AI governance policies and regulations?

A final point to consider when stewarding an organization is the importance for boards to maintain a focus on diversity. One growing challenge is that women might be at a disadvantage in the future due to higher barriers to transition in terms of time to reskill and due to their lower participation in the STEM fields (science, technology, engineering and mathematics) (Madgavkar et al., 2019). While entirely new occupations will be created, approximately 60% of the new US occupations created to date have been in male-dominated fields (Madgavkar et al., 2019). Boards need to bear this in mind and work even harder to ensure diversity in these emerging positions.

Moving forward, corporate boards will also need to develop the capability to work with AI at the board level. One of the biggest promises of AI is that it can be used to augment human intelligence, thereby changing how we work together, make decisions and manage organizations – from cognitive overload to intelligence augmentation (Rometty, 2016). Several large firms such as IBM and EY are working on digital boardroom solutions to improve board decision-making and time management. One interesting current development is the use of AI by recruiters to support nomination committees, to both assess the board's talent and to search for new board members (Biswas, 2019). Furthermore, at the board level, AI will be able to enable simpler tasks such as automatic speech transcription of board meetings. In the future, AI should be able to facilitate more complex strategic decision-making processes, such as track capital allocation patterns and highlight concerns, review and process press releases to identify potential new competitors, improve operational decision-making by analyzing internal communication to assess employee morale and predicting churn, and to identify subtle changes in customer preference or demographics impact on product development (Libert, Beck and Bonchek, 2017). Other areas include advice on board-relevant topics, such as acquisition candidates aligned with business strategy (Simonite, 2014).

Besides augmenting board members, AI may also augment the board itself by contributing in the role of a board member (Libert, Beck and Bonchek, 2017). As noted by Jeanne Ross, principal research scientist at the MIT Center for Information Systems Research, "companies are succeeding with AI by partnering smart machines with smart people who are learning to take advantage of what these machines can do" (Ross, 2018, p. 11). Already in 2014 an algorithm named Vital (validating investment tool for advancing life sciences) became the "world's first artificial intelligence company director" at Deep Knowledge Venture*s*, a Hong Kong-based venture capital firm (Zolfagharifard, 2014, para.1). Another example is the Finnish IT service and consulting company, Tieto, that appointed a bot called Alicia T. to be part of the leadership team and went so far to grant Alicia T. voting rights (Suni, 2016).

Boards will furthermore be under increased scrutiny from shareholders and the greater circle of stakeholders, using AI tools to monitor their performance. Investors are increasingly using AI to support their identification of investment objects, and both private and public investors are increasing their use of AI to analyze their portfolio companies in terms of both financial and sustainability performance. Examples such as digital AI analysts that leverage natural language processing and psycholinguistics to analyze nuanced speaking patterns of board members on earnings calls boards will be subject to increased transparency, and boards will need to learn how to act in such an AI world (Sansani, 2018). At this moment the efficiency of these examples could be debated and some even labeled as marketing and communication stunts, but they are still good examples of how AI could support in the creation of insights that will allow more efficient decision-making processes. Indeed, the World Economic Forum reported that 45% of the more than 800 global executives surveyed believed that the first AI machine would be part of a corporate board of directors. However, this would need a change in legal frameworks as the role as board member currently is reserved for natural persons (WEF, 2015).

In summarizing our findings, it becomes clear that boards will need to not only develop their competence to guide AI operational capabilities and supervise AI governance, but they will also need to challenge and adapt their traditional board processes to successfully steward their organizations into an AI future. Next we would like to highlight six additional areas that have emerged from our research to date:

1 Boards will need to better balance their time between development and control activities. Currently, the majority of board work is spent on control, but we foresee a need to move toward a more balanced commitment between development and control as well as the need to develop KPIs accordingly.
2 Boards will need to be more dynamic in their work. Traditional board work will need to be complemented with more flexible options that will allow faster pivoting and strategy adjustments.
3 Boards will need to ensure faster and more transparent insights based on indicators from the business and industry, allowing for better data-led decision-making.
4 Boards will need to expand their focus to include all stakeholders from a narrow focus on shareholders.
5 Boards will need to develop a clearer higher purpose for the firms, raising their ethical standards, versus the status quo of merely fulfilling the lowest legal threshold.
6 Boards will need to better balance the company's focus on the long term with the short term, combining scenario thinking with strategy development and implementation.

7. Conclusion

In this chapter, our purpose was to address one subset of labor – corporate boards – and discuss how one particular digital technology – AI – will influence this subset of labor in the future. More specifically, through extensive board work experience, a systematic review of academic and practitioner literature on corporate governance and AI implementation in firms and a series of interviews with board members of leading multinationals and global AI experts, we found that boards are aware of the importance of AI implementation as a key competitive advantage and that they do not see AI as replacing jobs in the boardroom. Furthermore, we found that boards need to develop two competence areas related to AI to best steward their companies within AI Leadership: (1) guiding AI operational capability – (a) guiding the gathering, harvesting and analysis of big data, (b) guiding AI innovation and (c) guiding the growth of a digital business ecosystem; and (2) supervising AI governance capability – (a) supervising data management, ethics and black box decision-making, (b) supervising AI security and (c) supervising business ecosystem leadership.

In order to facilitate a fruitful discussion among board directors to move toward developing these competence areas, we then proposed our *Boards 4 AI Leadership Matrix*. This tool supports the finding that if a board is only guiding a firm's AI operational capability, while not supervising AI governance, the firm will likely face high risk and strong regulatory headwinds in the future. We recognize that our approach is very general and does not address specific aspects of AI implementation, such as industry-specific questions or in-depth technology issues. Rather, we aim to contribute with a more general understanding of how boards can better develop their competence within guiding and stewarding AI implementation with the hope of further developing modern corporate governance.

Lastly, AI technology and implementation is an extremely dynamic field of research in which there are exciting developments nearly every day. For the next steps, the *Boards 4 AI Leadership Matrix* will be continuously tested and iterated under the project 4boards.ai. For example, it is likely that companies can learn from highly regulated industries, such as financial services or health care. Thus, testing the *Boards 4 AI Leadership Matrix* in these industries could be an interesting point of departure to establish an actionable strategy for AI implementation as supervising AI governance capability may be the preferable starting point. A further area for research is to test the *Boards 4 AI Leadership Matrix* across different governance models as these differ for ownership models, development stages and jurisdictions while keeping in mind specific national legislation and policies.

We conclude by inviting other scholars and practitioners to use the framework presented as well as to build insights and research on the propositions made in this chapter. We believe that the challenges put forward by AI are worthy of a societal discussion that should go beyond the boardroom.

Conflict of interest

The authors have received funding from Sweden's Innovation Agency, Vinnova, for their research project, "4boards.ai", under the coordination of Chalmers University of Technology. The 4boards.ai project aims to identify, codify and disseminate a set of best practices to enable corporate boards to more successfully leverage and govern AI and other exponential technologies in their innovation and sustainability efforts. The project's funding terms require a number of deliverables. This chapter, which summarizes the principal findings from the project's first phase, constitutes one of the deliverables of 4boards.ai.

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Note

1 A note on terminology. We use the term "competence" at the board level to be in line with previous research looking at board competence and incompetence, e.g., (Cebon, 2017). Competence is defined as "the quality or state of having sufficient knowledge, judgment, skill, or strength (as for a particular duty or in a particular respect)" (Merriam-Webster, 2019), and competence is generally used in the context of leadership. Capability, however, is generally used to describe the collaborative processes in a firm, e.g., "the ability of an organization to perform a coordinated set of tasks, utilizing organizational resources, for the purpose of achieving a particular end result" (Helfat and Peteraf, 2003, p. 999).

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Part II

The role of the digital welfare state

8 Polarization, tax revenue and the welfare state

Digital disruption or still standing strong?[1]

Mårten Blix

1. Introduction

Some changes in society are significant enough to warrant a specific name. Digitalization is one of those and is sometimes described as the third industrial revolution. What can we learn from comparing the present situation to the state of society at the outset of the first Industrial Revolution, some two-and-half centuries ago?

From the late eighteenth century and onwards, industrialization led to an upheaval of work and livelihoods at a time when there were little in terms of social safety nets. The rapid transformation of economies and societies became an impetus to create new social and political institutions to manage and reduce the social costs of change. Universal education, social security and pension systems were introduced along with universal suffrage. Spurred by hazardous and difficult work conditions as well as strife over low pay, labor organized into trade unions to become a counterweight to employers and owners of firms. Societies developed methods to handle change and devised ways to resolve conflict mainly through rules and negotiations rather than through force. In Sweden, a general pension system was introduced in 1913, although less generous than today (Blix, 2017). Notably, today people live about twenty years beyond the retirement age compared to at the inception of the pension system, when at least half the population were not expected to enjoy any pension at all.

There is no need to reinvent the institutions and safety nets thus established. Indeed, the modern welfare state has shown remarkable resilience over the years. Especially in the 1980s, industrial action in Sweden was a big concern, with many days lost in strikes. In 1997, the system was reformed through an agreement with industry-wide bargaining, allowing local flexibility and yet retaining elements of centralized wage bargaining with informal coordination with the manufacturing sector in the lead (Driffill, 2006). After the agreement, industrial action declined markedly and the most recent round of collective wage bargaining has resulted in mainly three-year agreements, signaling trust in the institutions. The relative calm, however, may be challenged in the years ahead. Digitalization is now affecting some of the fundamental building blocks, and unless institutions are reformed, the social contract holding society together could crack.

For the welfare state, the balance of protection against a potentially destructive change and the promotion of innovations have from the outset been a central but fragile state of affairs. On the one hand, too onerous rules in the economy can dent productivity growth and undermine rising prosperity. On the other, strained social cohesion can erode the legitimacy of institutions.

The modern welfare state has managed change, but some countries have at times veered off course. Take the example of Sweden. Its welfare state expanded rapidly during the 1970s and 80s but high marginal tax rates dented incentives to work, and fiscal profligacy gradually created an untenable economic situation. Interest payments on public debt began to squeeze out social spending. Trust in the stability of the Swedish economy declined and reached an absolute low in the fall of 1992 when the *Riksbank* (the Swedish central bank) unsuccessfully defended the krona by raising the interest rate to 500%. The deep crisis spurred structural reforms and set the stage for reforming the welfare state during the 1990s.

The effects of digitalization are not dramatic in the short-run, compared to a fiscal or financial crisis when GDP can fall abruptly, and many jobs are lost. Indeed, so far, there is no compelling evidence that employment levels in OECD countries are declining. One reason for this is that the modern labor market has a high capacity for change and continuously creates new jobs, especially in services, as old ones are shed. In Sweden, for example, about 17% of all jobs were destroyed and created during the period 1990–2009 (Heyman, Norbäck and Persson, 2013). In OECD countries as a whole, employment levels have not fallen, though unemployment – and especially youth unemployment – is a considerable concern after the fallout of the financial crisis.

And yet, although the modern welfare state does not face an imminent crisis, over the medium-to-long term the changes due to digitalization will put a strain on existing institutions and labor market arrangements. In addition, the welfare state has to cope with unprecedented high levels of immigration. As I have argued elsewhere, the labor market is changing to such an extent that the social contract could begin to crack (Blix, 2017).

Most descriptions of the Swedish welfare state will at least include the following elements:

- Comprehensive social welfare spending (health care, education and care of the elderly) financed by taxes
- Social inclusion through universal education, progressive tax systems and transfer payments to reduce income inequality
- A balance of power between trade unions and employers through rules to manage and resolve conflicts and a trade union policy to decrease wage disparities by pushing up the lowest wages

Digitalization affects all of these pillars in both direct and indirect ways. Most will acknowledge that consumer behavior has changed due to digitalization, but the most prominent changes are those that affect the labor market.

The changes to the labor market tend to occur more gradually than in consumption, depending on the dynamics of young people entering the labor market, with older persons retiring and others switching jobs. The impact of technology and digitalization on the labor market comes from the accumulated changes of such dynamics. The main impact of technological change and digitalization has been an increase in polarization where middle-level workers have been the most affected (Goos, Manning and Salomons, 2014). Income has become more volatile, and uncertainty in the labor market has been rising (OECD, 2015).

With gradual changes, in principle, there should be ample time to adjust and reform. In practice, reforms necessary to accommodate changes may be too slow – or not made at all. First, the political system often has difficulties in managing reform when the political costs of action tend to be up front and the potential economic benefits come much later. Second, the reform of existing institutions often meets resistance from special interest groups, all from employer organizations to the professions and even regulatory bodies. Changes typically imply a shift in power, resulting in winners and losers.

The risk of not responding to rising labor-market uncertainty and income volatility is that disenfranchisement will continue to expand. Institutional legitimacy risks being damaged and, indeed, in some OECD countries the rise of populist parties may be seen as a sign of declining trust in the establishment and the institutions that represent it.

2. Rising inequality also in the welfare state

A standard measure of income inequality is the so-called Gini coefficient. As can be seen from Figure 8.1, the Gini coefficients have been trending upwards in many OECD countries since the 1980s. Although it is an established measure of income inequality, the Gini coefficient measure has some well-known drawbacks and can be measured in different ways (Blomquist, 1981; Yitzhaki, 1998). In the aftermath of the financial crisis, the relatively modest changes in relative incomes could mask more problematic absolute differences at low levels of income. In addition, the Gini coefficient does not account for publicly provided welfare services. For a country, such as Sweden with comprehensive benefits, this makes some – but not a huge – difference. Other measures such as the share of those earning below 60% of median incomes or measures of risk of absolute poverty can be better at capturing income inequality. However, notwithstanding the measure used, it is unequivocal that inequality has increased in most OECD countries.

Despite increases in income inequality, the Nordics and much of northern Europe (excluding the Anglo-Saxon countries) remain in the lower half in terms of Gini coefficients. But not all welfare states have fared the same. It is especially noteworthy that Sweden has experienced the most substantial increase in Gini coefficient since the 1980s. However, this is an increase from a suppressed low level that turned out to be unsustainable. Wages were compressed due to union priorities in wage-bargaining and due to strongly progressive taxation. Though income inequality was held low, economic incentives for entrepreneurship and

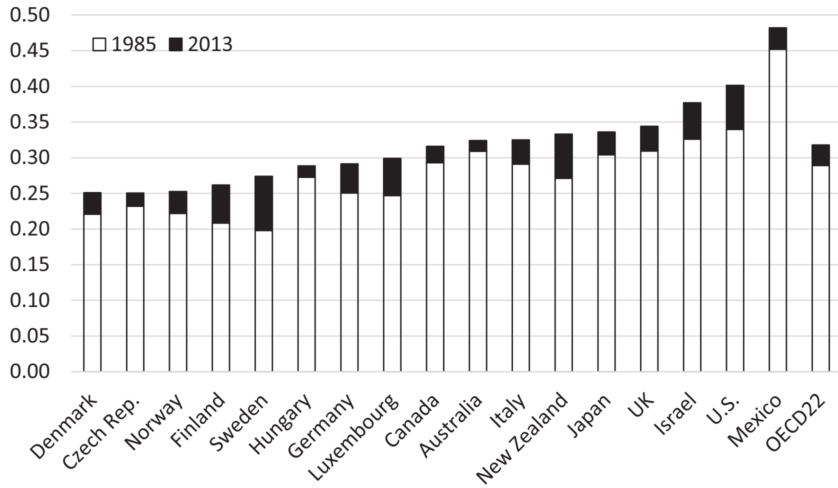

Figure 8.1 Gini coefficients in selected OECD countries. Levels in 1985 and in 2013. Note: The Gini coefficient is zero when everyone has an identical income. The Gini coefficient is one when a single individual has all of the income.

Source: OECD (2015).

work were eroded (Lindbeck et al., 2003). In particular, the 1970s and 80s was a period of economic stagnation in Sweden with a long-lasting decline in GDP per capita growth rates compared to other OECD countries.

Trade and globalization have likely led to lower income inequality in the world as a whole, but most arguments indicate that income inequality *within* countries will continue to rise. Rapidly aging populations will accelerate changes, and new technologies will compete with humans in many new areas, notably also in advanced services and result in damped wage growth for those without special skills: the polarization of labor markets noted in the literature (Goos, Manning and Salomons, 2014). One interpretation is that digitalization results in a common shock that drives up income inequality in some countries. At the same time, other countries with high inequality (such as Chile and Mexico) have seen some reduction but this development is likely linked to other factors. The overall effect may appear as a form of convergence (OECD, 2015) but it is a bit early to make such an assessment. More urgently, however, countries with increasing inequality need to find ways to address these changes or risk see further deterioration in their institutional legitimacy and further populism.

The economist Andre Sapir presents a straightforward way to summarize different models of growth and social inclusion (Sapir, 2006). In Table 8.1, some countries and regions are divided into combinations of low-high equity and efficiency. A useful way to think about the different country models is to interpret the labels rather broadly. Efficiency can be thought of as productivity growth, per

Table 8.1 Combinations of efficiency and equity.

		Efficiency	
		Low	*High*
Equity	Low	Southern Europe	US, UK
	High	Northern Europe	Scandinavia

Source: Sapir (2006).

capita growth or capacity for innovation; Equity can be considered as measuring income inequality or, better yet, equality of opportunity.

The characterization is not meant to imply that there is a growth-equity trade-off. An IMF study finds no such pattern is supported by data (Ostry, Berg and Tsangarides, 2014). Also, the OECD (2017b) emphasizes that there are several policy levers that support both equity and growth, such as promotion of product market competition. Instead, a country may find it hard for political economy reasons to pursue the reforms that would lead to improvements in either long-term productivity growth or equity, not least when the social costs are often up-front.

Most of Table 8.1 capturing the state of affairs in 2005 stands the test of time, but not all. Several countries have been experiencing declining productivity growth. For the UK, the decline actually began before the financial crisis. Even with rising inequality, Sweden remains a country with one of the most favorable combinations of equity and growth. Will the Swedish welfare state be better at coping with technological change than other systems?

3. The social contract in the welfare state is threatened

The welfare state can be seen as a particular type of social contract between different groups: The young and the old; workers and owners of capital; cities and regions. Those in work and good health pay large shares of their income in tax to get social support when they are old or fall sick. Those living in the regions are often subsidized by more prosperous regions.

The challenge for all countries is that substantial relative changes in fortune for some groups or areas can lead to discontent and undermine the willingness to take part in intergenerational transfers or geographical redistribution. Arguably, political events during 2016–18 could be a sign of such developments. The list is becoming long: The election of President Donald Trump in the US, the Brexit-referendum in the UK, Catalonia's unilateral declaration of independence from Spain, Germany's procrastinated negotiations of forming a coalition government and Italy's continued drift toward yet more political fragmentation. Welfare states in the north of Europe are by no means immune, as evidenced by the recent upsurge of populism even in prosperous countries with medium-to-low inequality. This is evidenced by the contemporary developments in Sweden.

Most notably the case of the political fringe party, the *Sweden Democrats* (Swe: *Sverigedemokraterna*), which went from having failed to reach past the election threshold prior to 2010 to becoming the third largest party following the Swedish general election of 2014. Some pre-election opinion polls also anticipated that the Sweden Democrats would increase their mandate following the 2018 general election and become the second largest – or even the largest – political party in Sweden.

Resentment against the elites that are perceived to benefit from changes can, in turn, lead to undermining the social contract that holds the welfare state together. This is especially the case in countries with aging populations and significant immigration levels. Stagnant wages thus risks fanning the flames of disenfranchisement even further.

3.1. The labor market and stagnant wages

The labor market is essential to the welfare state. Without a well-functioning labor market prosperity cannot increase and support for the social contract may wane.

Productivity growth and slack in labor markets are traditional explanations for understanding how wages develop. One reason for concern in recent years is that wage growth has been stagnant in much of the advanced economies. According to the International Monetary Fund (2017a), these can account for a significant share of the recent stagnant wages. As can be seen in Figure 8.2, wages in advanced

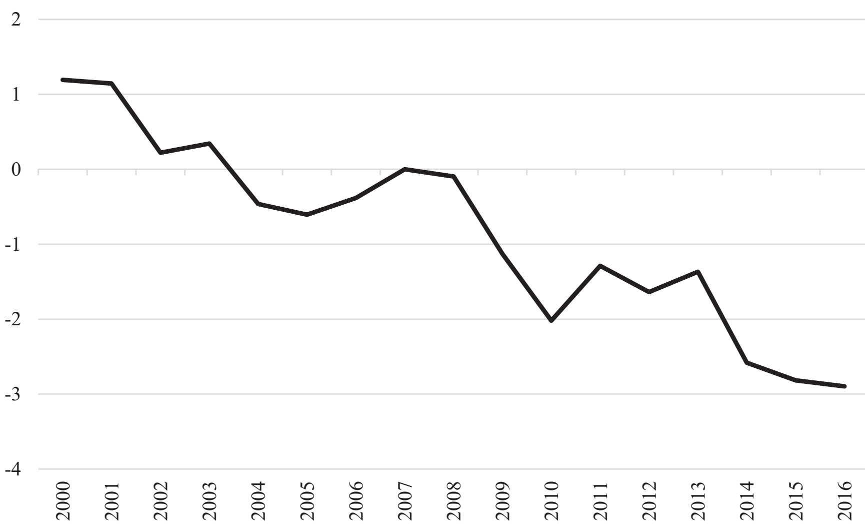

Figure 8.2 Nominal wage growth in advanced economies compared to the level of wage growth in 2007, percentage points. Note: Wage growth is normalized by subtracting the change in 2007.

Source: International Monetary Fund (2017a, p. 78).

economies have been in gradual decline; a process that started well before the financial crisis.

Though low productivity growth and the ample availability of workers can explain some of the stagnant wages, they cannot explain the full slowdown. Other explanations include advances in technology and automation that result in stronger competition between humans and machines (OECD, 2017a). Even if past technological advances have had far-reaching influence on work, advances in digitalization are being implemented faster than before (Comin and Ferrer, 2013, p. 14).

An overall effect of digitalization on the labor market is to reduce the bargaining power of workers. In many professions, the "middle man" is a function that is under pressure from robots. Such pressures are in evidence in banking, insurance and retail just to name a few. In banking, for example, the continued fallout from the financial crisis in combination with technology is leading many banks to reduce staff and automate a range of services. In Sweden, the Financial Supervisory Authority has granted licenses to financial institutions that provide automated advice. Back-office operations are especially prone to automation, as they are routine and occur on a regular basis. Such automation can also incorporate better risk-management as well as regulatory compliance. Some banks are testing so-called "Robo-branches" which are in effect local bank branches largely without professional staff. There are examples of insurance companies introducing completely automated claims-processes.

At the aggregate level, jobs are not disappearing. Rather, technology is creating additional downward pressure on wage growth. Other parts of the economy are also set to be affected. The increase in e-commerce is affecting many retail stores and boutiques. Semi-autonomous checkouts where customers scan their own goods have been available for many years and are growing more common. The next step is completely automated checkouts. Amazon has been experimenting with such technology for some time and opened its first such grocery store in Seattle, Washington in the beginning of 2018 (Wingfield, 2018). Though the technology is thus far in its infancy, it may ultimately obliterate the need for cashiers altogether.

Shopping for goods and clothes online has become large commerce. As the e-commerce companies become better at knowing their customers and can deliver goods quickly, the pressures on physical shops will grow. The company Zalando has plans to let their customers order tailor-made clothes from measures deduced body scanning (Bränström, 2018), which could help reduce costly returns and make ordering online even more attractive. In other words, technology is set to further increase the push toward e-commerce.

Advances in technology have reignited the angst that automation will destroy jobs. For example, in an oft-quoted paper, Frey and Osborne (Frey and Osborne, 2017) argue that about half of US jobs can be automated within the next two decades. Others have used different methodology and found substantially lower estimates (Arntz, Gregory and Zierahn, 2016; Nedelkoska and Quintini, 2018). More generally, evidence for EU countries continues to point to the labor market's ability to adapt (Gregory, Salomons and Zierahn, 2016): Job losses in one area are compensated by demand spillovers in other areas so that the net effect is mostly stable employment levels. Overall, there is so far no support for the notion that human work is disappearing.

However, there is ample evidence for the notion that the content of work is changing (Acemoglu and Autor, 2011). Improvement in technology has led to a process favoring those with high-skills regarding cognitive or social abilities, so-called skilled-biased technological change. For such workers, wage developments have been positive, and the share of such work has increased in the economy (see Figure 8.3). By contrast, routine work has been in decline. The overall result has been an increased polarization of the labor market that has been occurring over an extended period (Goos, Manning and Salomons, 2014).

The polarization of work has occurred in most OECD countries. We can expect that automation of work will put further pressures on wages for those with middle-level skills. The tools and technology that are now available could accelerate polarization compared to previous periods. There is a risk that those who are slow to upgrade their skills will experience further wage stagnation. Admittedly, there are historical examples where new technology did not cause downgrading of skills. For example, when automated teller machines (ATMs) were introduced, bank cashiers often moved up the skill ladder by instead providing financial advice to customers (Bessen, 2015). But this is not an inevitable development. For instance, jobs that disappear in stores might instead become software programming jobs elsewhere and thus much less likely to occur.

At the overall level, a combination of developments could lead to a decline in the wage-bargaining power of labor. Apart from technology, both demography,

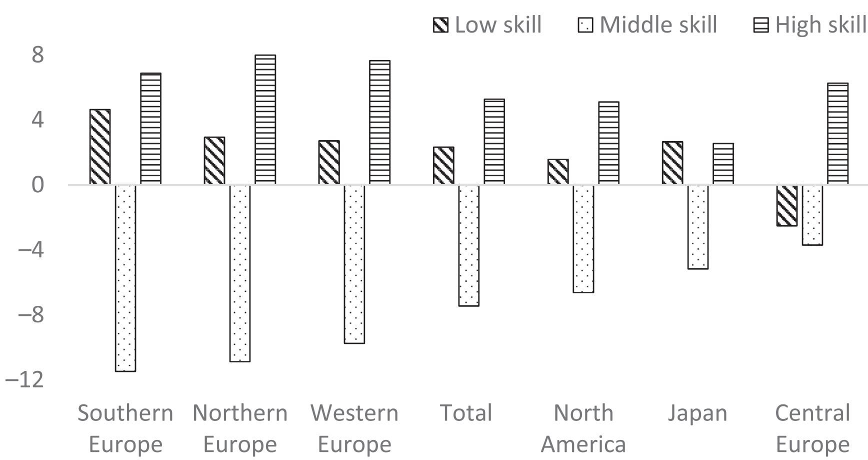

Figure 8.3 Percentage point change in share of total employment 1995–2015.

Source: OECD (2017c, p. 86).

and more flexible employment legislation protection serve to accelerate changes in the labor market. Aging populations imply fewer young compared to the old, and so in principle, the young could fill the jobs of those retiring. With large cohorts leaving the labor market, some areas will even experience scarcity of workers. In practice, young workers can only seldom directly replace older workers, especially not in positions where on-the-job experience is essential. What this means is that the incentive to automate work will be stronger due to aging populations, as firms find it hard to find workers with the right skills.

Technology is of course not the only thing that affects the bargaining power of labor (OECD, 2017a). In many OECD countries, protection for temporary or fixed-term contracts has been in decline since the 1990s. By contrast, permanent positions have remained mostly unchanged. As a result, the *duality* of labor markets has increased, and especially so in Sweden, for example (Cahuc, 2010, pp. 150–53). Young people are overrepresented among temporary workers, and their share has increased. OECD calculates that in 2015 about 40 million youth or 15% of those in the ages 15–24 are neither in education nor employment, so-called NEET (OECD, 2016).

Technology is not only changing the landscape of work through automation and robots. With so-called platform-based labor market, non-standard work is on the rise. Platform-based work has been given many names, such as the sharing economy or gig work. In what follows, I will use the term gig work to denote a situation where a worker performs tasks organized through the conduit of a digital platform and where the platform owner does not take employer responsibilities, such as paying payroll taxes and value-added tax (VAT).

Gig work has always existed, notably in entertainment, such as in music, art or television. Non-standard work without employment protection is also prevalent in journalism. Non-standard work contributes to rising inequality (OECD, 2015). For example, the self-employed enjoy fewer benefits in social security. Besides, the self-employed are also excluded from additional benefits in collective wage bargaining agreements, such as topped-up pensions, parental leave and sick leave.

Gig work is increasing on broad fronts (Sundararajan, 2017; Katz and Krueger, 2016). A common misconception is that gig work is only about simple tasks, such as driving taxis (for example Uber) or household services (such as TaskRabbit). The services are much broader, all from medical to legal professions. While it has increased sharply over the last few years, in terms of overall share of employment it remains small in Sweden. Despite its limited size, it could be set to affect the labor market in fundamental ways. By creating a situation where work is on permanent standby, 24 hours a day, seven days a week, it lessens the need for permanent workers. One of the largest platforms is Upwork. It has more than 12 million workers worldwide – doing tasks ranging from web design to data analysis (Sundararajan, 2017).

Consider the thought experiment that today's digital gig platforms had existed for as long as there have been firms. In such a world, would firms have hired workers to the extent reflected by today's medium and large size enterprises? Probably not. Ronald Coase, recipient of the Nobel Memorial Prize in Economic Sciences in 1991, argued that the existence of the firm supersedes the price mechanism of hiring individual workers on an atomistic market (Coase and Coase, 1937). When the cost of individual contracts is higher than organizing work into employment, the existence of the firm can be explained. With gig platforms, the cost of hiring temporary staff on a needs-only basis is much smaller than in the past. Hence, it is likely that permanent works would be much fewer in numbers.

What are the possible implications? The main channel of change is through the regular churn of the labor market: retirement of older workers, hiring of new workers as well as voluntary or involuntary employment changes. These changes occur slowly and mostly without drama. In countries with collective wage agreements, bargaining over wages and benefits may occur over various yearly intervals. In Sweden, for example, some wage agreements cover two-to-three years.

Gig markets pose a direct threat to the Swedish labor market model where the trade unions and the employer organizations are responsible for setting wages (Blix, 2017). Gig contracts bypass entirely collective wage bargaining agreements and the transaction occurs in the cloud. Moreover, the buyer and seller of services can even be in different countries. As a consequence, the traditional trade union threat of a boycott is more difficult to use compared to a shop or a factory. Also, non-payment of taxes is an issue for the government. A tilted playing field in taxation can lead to unfair competition, where tax and regulatory differences have an outsized role in success compared to the efficiency of services.

So far, the changes are occurring gradually, but most of the incentives point to a clear direction of change toward work and jobs becoming more loosely tied to a single employer and with a shrinking share of permanent employment. Exactly how far this process will continue is hard to say. It will, among other things, depend on the policy responses of governments, employers and trade unions.

For the welfare state, it means more flexible labor markets and also that security through work will be lower than in the past. In Sweden, the collective wage bargaining agreements cover about 90% of the labor market today. A system of collective wage bargaining can likely survive a small share of gig work in the economy but begins to lose its legitimacy if gig work becomes large.

3.2. Financing the social welfare state: tax base on labor becoming more mobile

The mobility of capital has been a feature of world economies for a long time. Of course, workers have a long tradition of moving to jobs, even if not as readily as capital. But as outlined in the previous section, technology is now increasing the mobility of labor in ways that were not possible before. Technology makes it easy to outsource work with the simple press of a button to global gig markets. Moreover, the expanding possibilities of automating all from simple to advanced services will make it easier for firms to substitute away from labor to machines. This substitution has consequences for government revenue, as the tax on labor is one of the largest tax bases. On average, about 50% of government revenue (in 2013) stems from tax on labor in OECD countries (Blix, 2017). The implications may be even more significant in countries with high tax rates on human work; most notably, of course, welfare states. It is not that governments will not be able to collect revenue. Instead, the challenge is that the distortions of a high tax on labor may increase further, which poses risks to productivity growth.

The threat to government revenue and the advent of rising distortions are not immediate. Instead, labor markets are likely to change over many years, but there are already some indications that the relation between machines and humans have shifted. As illustrated in Figure 8.4, the wage share of national income has fallen in most industrialized countries during the last three decades (Karabarbounis and Neiman, 2014; International Monetary Fund, 2017b). This result implies that as the GDP is expanding, humans are no longer keeping the same share of the pie.

The IMF calculates that about half the decline in the wage share of labor can be explained by technology (International Monetary Fund, 2017b). Notably, this development has been observed years before smartphones became ubiquitous and before the so-called "Frightful Five" of big tech, i.e., Amazon, Apple, Facebook, Google and Microsoft, gained dominance in global markets (Manjoo, 2016). Since the capacity of software has significantly expanded, it stands to reason that the wage share of labor is set to fall further. The result could be an even more significant shift away from human labor to machines. Evidence from other areas shows that high tax rates can give rise to significant shifts. High tax rates can lead to a sizeable substitution between the legal and the shadow economy as well as between unpaid household production and market production (Davis and Henrekson, 2005). The effects of automation could be even more substantial.

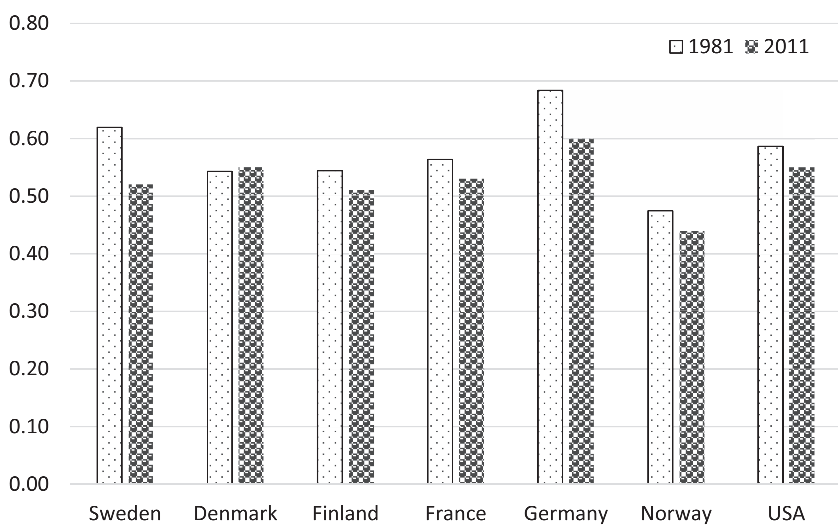

Figure 8.4 Wage share of national income. Percent.

Source: Karabarbounis and Neiman (2014).

4. Conclusions

As labor markets are becoming more polarized, inequality increases, and income uncertainty becomes more pronounced. What happens to the legitimacy of institutions when a large number of persons get fewer of the benefits of growth and when the share of labor market outsiders grows?

Welfare states may be more resilient to these changes than other countries. Notably, they have more well-developed and comprehensive social safety nets. They are geared toward providing social security and support workers to find new jobs through retraining and education.

But the welfare state also carries some weaknesses: The high level of taxes supporting the welfare spending creates even stronger incentives for firms to automate work or to buy services on global *gig* markets. This results in the bypassing of the high taxes and collective wage agreements that are vital pillars of the Nordic labor markets.

The outcome of the welfare state depends on policy responses of governments, trade unions and employer organizations. Trade unions that adapt and provide new forms of support and safety to its members could remain relevant to workers and serve as a counterweight to some of the increases in income uncertainty. Governments may also try to broaden tax bases to support welfare ambitions, especially for the self-employed.

It is hard to say how likely institutions are to step up to the challenge. One political difficulty is that the changes tend to be gradual and it may be tempting to postpone reforms rather than address the hard choices early on. Reform of institutions may also be hampered by special interest groups and lobbyists that act to protect the status quo.

Low inequality is core to the welfare state, yet it is set to rise even further in the years ahead. Without judicious reforms, the welfare state will not be immune from cracks in the social contract. One way or another, the outcome for the welfare states hangs in the balance in the years ahead. Will the welfare state be able to reinvent itself once again?

Acknowledgments

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Note

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9 Welfare states and digitalization

Bent Greve

1. Introduction

The aim of this chapter is to discuss whether welfare states will be prepared and able to cope with the possible strong transformations on the labor market and how this will interact with the ability to finance the welfare states in the years to come. This will be done within a framework where the focus is on using the existing studies related to possible changes on the labor market when new technologies are integrated in production, including the digitalization of work in several sectors of the economies.

Based on the discussion of change on the labor market, focus will be on how this might, in a variety of ways, influence the ability to finance the welfare states using the classical welfare regime approach (for a recent overview see Von Kersbergen [2019] and Vis [2019]). This as the possible impact can be expected to vary dependent on the welfare regime a country belongs to (Greve, 2018), and for an overview of individual countries see Kuhlman, Schubert and de Villota (2016). The expectation being that universal welfare states, as the Nordic, to a larger degree will be influenced by the development and their ability to finance, relatively more generous welfare states, than liberal welfare states with less state influence on the societal development. The reason for this expectation will be explained more in Section 3, which presents a few data on overall spending and ways of finance welfare states in Europe.

Section 2 will present possible changes as a consequence of the fourth industrial revolution. This scenario is, in turn, based on several studies presented in recent years connected with the theoretical understanding of "insiders" and "outsiders" on the labor market (Schwab, 2016). This will include how there might be different viewpoints on the impact the use of new technology might have. Section 3 will briefly depict spending and financing across welfare states as part of the risk for welfare states in the wake of strong technological changes.

Section 4 will thereafter connect these debates as a way to depict the possible connection between technological change and welfare states development. This is mainly done in an explorative way, given that the expected changes are more extensive than the previous actual changes.

There are as always delimitations. This includes what kind of competences is expected in the future (Kaplan, 2015). The consequence of trade globalization,