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Chapter 8

Peering into the future: long-run economic and social consequences of automation; with an epilogue on COVID-19

This final chapter reviews and considers speculations on economic and social development in the context of further automation and progress in artificial intelligence (AI).¹ The treatment is naturally less theoretically and empirically rigorous than that of previous chapters. The intent is mainly to create awareness of these possibilities and to stimulate corresponding discussions—not to describe how we think the future will unfold. Thus, these discussions are more in the nature of conjectures and speculations than forecasts and predictions.

The main reason for this exercise is to raise important questions that society needs to address to prepare for and enable a desirable future in the age of automation and AI. The good news is that many of the potential developments will depend strongly on our own choices and policy responses, such that technology-driven scenarios of the future are not predestined but can be influenced to a substantial degree. Of course, technological progress itself is unlikely to reverse—provided that we manage to prevent catastrophic outcomes associated with, for example, large-scale wars, pandemic diseases, a plethora of extreme weather episodes, and other low-probability but high-impact events (see, e.g., Taleb, 2007 for discussions). Therefore, we must make certain choices to prepare economic and legal systems to contend with the evolving technology and culture. We can shape these choices to try to distribute the benefits of automation and digitalization so that as many people as possible will benefit. If we fail to ensure that wide parts of the population benefit, we risk increasing inequality and that some parts of the population will become disconnected from economic development. These parts of the population might face economic misery, which, in turn, could lead to social, political, and economic instabilities. In addition to the looming

1. We thank an anonymous reviewer for suggesting that we delve deeper into many of these topics and for interesting literature suggestions.

economic developments, more fundamental and dramatic changes lie ahead: our daily interactions with personal robots could transform society as we currently understand it. These changes range from more standard applications that we have already grown used to, such as personal digital assistants, algorithms that help judges and probation officers form their decisions, robo advisors, and robo counselors; to the next step of personalized pricing of different items based on the analysis of big data; on to social credit scores (described in the following) and deployment of robots in the realms of old-age care and sexual interactions; and finally to human–machine interfaces.

8.1 Joblessness, misery, and deaths of despair or “the happy leisure society”?

Failure to address the problems associated with rising inequality in the course of automation raises a strong possibility of negative repercussions on economic and social outcomes. Plenty of evidence indicates that inequality has risen in many countries in the world and that technological progress plays a major role in explaining this growing divide (Acemoglu, 2002; Atkinson, 2015; Atkinson, Piketty, & Saez, 2011; Autor & Dorn, 2013; Chetty, Hendren, Kline, Saez, & Turner, 2014; OECD Organisation for Economic Co-operation & Development, 2011; Piketty, 2014). Rising inequality, in turn, tends to reduce intergenerational income mobility, a phenomenon known as the “Great Gatsby Curve” (Chetty et al., 2014; Corak, 2013). If this process continues because, for example, the parts of the population with lower incomes cannot invest in their own education or in the education of their children (Galor & Zeira, 1993; Prettnner & Schaefer, 2020; Prettnner & Strulik, 2020) or because low-income households often lack access to adequate health insurance such that catastrophic expenditures loom in case of illness, then poverty traps emerge from which escape is difficult. Because a decent education and good health are themselves important drivers of economic growth (Becker & Woessmann, 2009; Bloom, Canning, Kotschy, Prettnner, & Schünemann, 2019; Cervellati & Sunde, 2011; Hanushek & Woessmann, 2012, 2015; Strulik, Prettnner, & Prskawetz, 2013), a feedback loop would emerge between higher inequality and overall sluggish economic development (Eggertsson, Mehrotra, & Robbins, 2019; Galor & Zeira, 1993; OECD, 2015; Summers, 2014).

However, some effects of high inequality and low social mobility are arguably more worrying than negative repercussions on economic growth. For example, the economic hardship of certain parts of the population could contribute to the phenomenon of “deaths of despair” (The Commonwealth Fund, 2019). Case and Deaton (2015) show that the mortality rate among white, middle-aged U.S. men has been rising over the last two decades, mainly due to suicides, alcohol abuse, and drug addiction. The problem is already so severe that despite the falling mortality of other population

groups, average life expectancy at birth in the United States is falling—a problem now spreading to other countries as well (*The Economist*, 2019c). The wide disparities between the health of low- and high-income groups in the United States are best illustrated by the differences in the probability of a 50-year-old person reaching age 85. Based on the predictions of the [National Academies of Sciences, Engineering, and Medicine \(2015\)](#), this probability is 29% for the lowest income quintile and 72% for the highest income quintile, which translates into a gap in life expectancy of 13 years between these two groups ([Kufenko, Prettner, & Sousa-Poza, 2019](#)). Deaths of despair might be one phenomenon explaining the rise in overall health-related inequality among different socioeconomic groups.

Rising inequality not only results in those with higher incomes affording ever more material goods and staying healthier longer than those with lower incomes, but it also implies advantages in terms of political influence. [Page, Bartels, and Seawright \(2013\)](#) and [Gilens and Page \(2014\)](#) analyze U.S. voter preferences by income group and compare the results to enacted laws. They find that laws are much more likely to pass when the top 10% of income earners prefer them because these “elite” persons are more likely to donate to political parties or to interact with their representatives than people from lower income groups. Thus, clear signs indicate that we are exacerbating cronyism in society, with high inequality, plenty of political influence of the elites, poverty traps and low social mobility, and widespread despair among the poor. This polarization can be reproduced in the political process, which risks becoming increasingly dysfunctional as the discontent of the masses is reflected in “anger votes” in favor of candidates with immoderate views, or in favor of measures that claim to restore national strength such as Brexit. Such extreme measures are, however, often not in the best interest of the disadvantaged themselves. [Ford \(2015\)](#) draws an even more dystopian scenario in which the rich use robots and AI to suppress the poor, keeping them in line while preventing them from sharing in the gains of economic prosperity.

Fortunately, another possibility exists. As [Keynes \(1930a, 1930b\)](#) imagined, technological progress could be beneficial to the population at large and might enable people to enjoy greater material well-being, more choices, and the luxury of spending more time doing things they are interested in and at which they excel. Widespread automation in its strict sense could indeed, for the first time, lead to a situation in which wealth is created purely with the input of the production factor physical capital and the role that humans play might be to lie in a hammock reading and reflecting on “Das Kapital.” Less benign interpretations include projections that the masses would need to be contented with certain forms of “tittytainment” ([Martin & Schumann, 1996](#)) or pursue working in “bullshit jobs” ([Graeber, 2018](#)) from which deriving any meaning is difficult.

How can we ensure we are on a path to a bright future with widespread benefits of automation and digitalization? Chapter 7 discussed potential

policy measures that could point us in this direction. While many of the ideas are controversial (to say the least), there are some policy measures on which many economists and policymakers might be able to agree. First and foremost among them is the proposal to invest massively in education in general and, more specifically, to ensure that disadvantaged parts of the population have access to quality education (e.g., via means-tested or merit-based stipends, tuition fee waivers, student housing) (see [Cohen, Bloom, & Malin, 2006](#)). Revamping curricula to ensure that future generations have the hard and soft skills needed to adapt to fast-changing technological environments as smoothly as possible is also important. High-quality education is a first and invaluable step to increase the share of the population that benefits from automation, though we have seen that education will not solve all potential challenges.

As a second and complementary measure, ensuring that those who lose the race against the machine do not end up without social protection is thus important. Of course, designing policies that help to reduce inequality and, at the same time, do not hinder economic development can be difficult ([Prettner & Strulik, 2020](#)). Therefore, devising nondistortionary ways of financing social security and wealth redistribution that benefit the disadvantaged but do not influence their choices *a priori* will become more important. We have discussed some innovative ways of doing this, such as an alternative tax system based on taxing harmful activities or taxing more heavily those groups and sectors with a more inelastic tax base.

Third, we have described different measures that help low-income parts of the population benefit from automation (e.g., by ensuring that employees have a stake in future earnings generated by highly profitable firms in the age of automation and digitalization). Overall, we hope to have contributed in providing the basis for more intensive discussions and debate in these areas and think that, however they might unfold, such deliberations are imperative. In the following, we discuss some more profound social changes that could occur in the wake of automation and to which it might be even more difficult to adjust. In this context, keeping in mind that institutional change is usually evolutionary—which is not well suited to adapting to technological change, which is often revolutionary—is important.

8.2 Spatial and regional implications: the future of cities

Fundamental social and economic changes could emerge via progress in autonomous driving or when fully automated factories, with physical locations that will be diminished in relevance, become operable. We have already reflected on the potential economic consequences of millions of taxi drivers and truck drivers being replaced by algorithms. However, autonomous driving might also fundamentally change the way we live and the way that our cities are designed. First, if the driving time that is required to

commute to and from work could be put to alternative uses such as sleeping, preparing for meetings, reading and responding to emails, or simply watching movies, the opportunity costs of commuting decrease substantially. This could lead to a change in urbanization patterns such that living areas might move even farther from city centers into areas with—at least initially—a more beautiful landscape, less pollution, less noise, a better microclimate, etc. In this case, cities might become mainly business districts and centers for entertainment in which people meet to interact because of work or for social reasons. The convenience of autonomous driving and the prospect of not owning vehicles but just hailing them on demand could potentially substitute for public mass transport and, in conjunction with increasing traffic because of urban sprawl, also exert negative environmental and congestion effects. However, as the creator of the problem, technological progress also might offer a solution to the problem. First, better management of private transport could become possible by implementing congestion-dependent toll systems on roads (because every vehicle can be location-tracked accurately) and by incentivizing car sharing (e.g., by giving shared cars access to priority lanes) such that one car might not only transport more than a person or two, but also packages, which *ceteris paribus* would reduce the overall amount of traffic. The uniform speed with which autonomous cars operate could also plausibly benefit traffic flow, as compared with the current situation in which individual drivers are inclined to drive at variable speeds, which tends to be inefficient. Also, fewer accidents might result from autonomous driving, reducing not only the number of deaths and injuries on the road (Chen, Kuhn, Prettner, & Bloom, 2019), but also congestion, allowing the average speed of vehicles to increase.

Furthermore, a new mode of transport—in between the extreme cases of mass public transport systems and private cars—could conceivably emerge: small autonomous buses could connect popular places cheaply and at a relatively high frequency, or they could be used to transport people on demand between locations that only have occasional traffic spurts (e.g., in case of sporting events, concerts). This could be a much more convenient form of transport than mass public transit, but it would also be more environmentally friendly and safer, and create less congestion than private car use.

As far as the environmental impact of increased traffic is concerned, technology could facilitate a reduction in combustion engines in favor of electric cars and changes in the way that electricity is produced and distributed. This way, traffic could become so efficient and clean that the environmental impact of transportation is reduced despite the potential overall increase in traffic. Also, the need to produce cars at all might decrease because, currently, private cars tend to sit idle more than 95% of the time (Fortune, 2016; NRMA, 2017). Using shared autonomous cars could thus reduce the overall number of cars because of a more efficient use of already extant cars. The reduced need for car production, in turn, would have

positive environmental repercussions. Finally, the need for designated parking areas that tend to be sealed by asphalt would decrease. These areas could partly be used for public parks and recreational areas, which might improve the microclimate in cities.

Even more radically and over a longer time horizon, the network effects of cities and their economic attractiveness in terms of economies of scale could change because it becomes ever more convenient and efficient to (1) work from home and nevertheless stay connected, (2) produce goods where land is cheap (e.g., by means of three-dimensional printing or by fully automated factories) instead of where numerous suitably trained workers are available, and (3) transport goods from different locations to customers who live far apart (e.g., by means of delivery robots and drones). If the network externalities are greatly reduced in such a way, the benefits of urbanization would shrink drastically and urbanization could reverse.

While many of the aforementioned forces could reverse urbanization and reduce land and property prices in cities, major forces would still pull in the opposite direction. For example, (1) living in cities has a social cachet and some people prefer to live near bars, pubs, restaurants, theaters, etc., and to enjoy more options for goods and services on which to spend their money;² (2) in many countries and areas, population growth remains positive, which raises demand for housing and infrastructure; (3) incomes are rising, which allows more people to afford second homes or to increase the size of their first home by moving into a larger apartment/house; (4) the need for space for some types of activities could still grow dramatically (e.g., office space for doctors and psychotherapists, sales areas of luxury stores that tend to be located in city centers, theaters, and amusement parks); (5) zoning restrictions might prevent residential development and constrain housing supply, contributing to rising property values and land prices; and (6) the creation of public parks and recreational areas as mentioned previously might also require additional amounts of space.

8.3 The question of how we care for each other

But even beyond these changes, more fundamental shifts and corresponding decisions to confront are to be expected. How will robots change the way we interact with and care for each other? As far as the adoption of robots as nurses and caregivers is concerned, Japan is a forerunner (Moro, Lin, Nejat, & Mihailidis, 2019; *The Economist*, 2017) and will thus act as a model. Robots that become ever better substitutes for assisting with the care of older people could revolutionize the way we spend the last years of our lives. Instead of institutionalized care away from home or close family members

2. In addition, social services and infrastructure spending are more efficient in cities due to economies of scale (Bloom, Canning, & Fink, 2008).

having to shoulder the burden of care, robot nurses could help with showering, going to the bathroom, preparing food, distributing medication, and promoting adherence to drug protocols. In addition, robots appear to help to alleviate loneliness in old age and may even help in combating diseases such as dementia (Costescu, Vanderborght, & David, 2014; Vitelli, 2014).

That sex robots will revolutionize the pornography industry and prostitution is easy to imagine. However, they might also change the nature of human interactions altogether, and the legal and ethical challenges of interacting with sex robots are nascently understood (Sharkey, van Wynsberghe, Robbins, & Hancock, 2017). Will sex robots be banned in some countries—or states—and allowed in others? How will the use of sex robots affect psychological well-being and loneliness? How will sex robots change actual and perceived gender roles in a society? Regarding these aspects, much will depend on the evolution of the legal system and whether it treats robots like property or more like independent entities that deserve protection. For example, the debate on whether to ban programming sex robots as nonconsenting victims, which simulates sexual assault, is ongoing (Danaher, 2014; Sharkey et al., 2017; Sparrow, 2017).

In the judicial system itself, algorithms already help judges and probation officers with their decisions. While a first glance might suggest that decisions made by algorithms would be fairer than those made by humans because they are deemed to be free of biases and preconceptions, algorithms often tend to have or develop racial and gender biases that are difficult to trace back (see, e.g., O’Neil, 2016). In addition, the line between employing algorithms to assist humans in judicial decisions and crime prevention and suppressing (parts of) the population is fine. Using AI and big data for public surveillance and to induce “good” behavior in people is easy.³ This could be done, for example, by means of a social credit system, where a social credit score is calculated for citizens and points are deducted for behavior classified as detrimental, such as crimes, traffic violations, and the late payment of bills (see *The Economist*, 2019b). While some claim that such systems lead to socially desirable outcomes, one should keep in mind that autocratic governments can deploy such systems to impair free speech, for example, by deducting points for criticizing the government.

In addition, other potentially highly disturbing possibilities lie ahead related to the use of military robots. These could be used to outsource the decision of whom to attack to an algorithm (Hellström, 2013). Furthermore, of course, nothing would prevent the use of these robots against internal enemies, raising the question of how much autonomy the robots will have in deciding who qualifies as an “enemy.” In this case, we would be close to the

3. This observation brings to mind the 2002 blockbuster movie *Minority Report*, in which individuals are (based on a psychic technology) arrested to prevent future crimes they would otherwise commit.

dystopian scenario mentioned previously that [Ford \(2015\)](#) describes, in which an elite relies on robots and AI to suppress the rest of the population.

8.4 The meaning of being human

Future technological progress could even shake the foundations of what it means to be human. While a rather conventional way of racing against the machine is to invest in education, another way is human enhancement. Enormous progress has taken place in transcranial direct current stimulation, transcranial magnetic stimulation, and neuropharmacology over the last decade ([Bavelier, Levi, Li, Dan, & Hensch, 2010](#); [Coffman, Clark, & Parasuraman, 2014](#); [Luber & Lisanby, 2014](#); [Sale, Berardi, & Maffei, 2014](#)). For example, [Chi and Snyder \(2012\)](#) show that humans who struggle to solve very difficult problems are better able to solve them after stimulating the anterior temporal lobe—a part of the brain important for the knowledge of objects, people, words, and facts. According to the authors, none of the trial participants were able to solve the so-called nine-dot problem (to connect nine dots in three rows by means of four lines without raising the pen) before treatment, whereas after 10 minutes of temporal lobe stimulation, 40% of participants were. In another example, [Nelson, McKinley, Golob, Warm, and Parasuraman \(2014\)](#) used transcranial direct current stimulation in a simulated air traffic control exercise for which performance among participants tends to drop over time. As compared with a placebo treatment, those who received the real treatment exhibited improvement in the rate of detecting planes on a collision course and higher cerebral blood velocity and cerebral oxygenation, which are associated with higher levels of vigilance.

While some physical devices for human augmentation, such as smart sunglasses that take videos of the surroundings and place them in the view of the wearer or exoskeletons that strengthen body parts, make physical work easier, or allow the paralyzed to walk, are already quite common and rather uncontroversial, the question of what it means to be human will become somewhat more blurred with the feasibility of genetic engineering, neural implants, and brain–machine interfaces ([Li, Walker, Nie, & Zhang, 2019](#); [Ma, 2018](#); [The Economist, 2019a](#); [Velleste, Perel, Spalding, Whitford, & Schwartz, 2008](#); [Young, 2017](#)). Overall, the most radical prediction related to the interaction between humans and AI is that of the “Singularity” made by futurist Raymond [Kurzweil \(2005\)](#) as mentioned in the introductory chapter. According to this prediction, machine intelligence and human intelligence will merge at some point and become infinitely more powerful than what we understand as intelligence today. If and when this happens, it will transform human life in a way that is currently difficult to comprehend.

Most developments in human augmentation are currently in their infancy, and assessing their potential effects is very difficult as of 2020. Altogether, however, evidence and trends indicate that increasing the performance of the

human brain—sometimes with little effort—and, thus, staying competitive with machines for longer will be medically possible. Furthermore, developments in the area of CRISPR/Cas tools (by which genes can be removed or added at specified locations in the genome of a cell) make genetic engineering as another form of human augmentation ever more feasible—one that has already been used based on very questionable ethical foundations (Li et al., 2019). That people would be willing to use these methods/devices is easy to imagine, such that increasing prevalence of human enhancement by more controversial methods might only be a matter of time. The moral and legal questions of whether human enhancement should be welcomed or treated like doping in sports will definitely provide food for thought for ethicists, philosophers, and lawmakers in the near future. How society evolves in these areas will depend on the laws and regulations that governments and citizens choose to enact to cope with the new technologies and their potential challenges. What will civilization accept as the new normal of an automated society? Much will depend on the choices we make and the answers we give. So we had better engage in a serious and inclusive process of social discourse on these matters.

8.5 Epilogue on COVID-19

This book was written, reviewed, and finalized in 2019 and early 2020, before the COVID-19 pandemic engulfed the world, claiming the lives of hundreds of thousands, infecting millions, and significantly constraining the mobility and the social and economic interactions of billions.

The COVID-19 pandemic (and the realistic prospects of other dangerous pathogens lurking in our future) confirms or sharpens many of the key messages this book covers and brings some others into focus.

In support of this point, we offer four observations.

First, automation, robotics, modern information and communication technologies, and artificial intelligence (AI) enabled many enterprises to continue to operate, many workers to continue to work, and many individuals to socially distance effectively. Generally speaking, more educated, more skilled, and higher-income individuals have been better positioned to take advantage of these opportunities. As such, automation and related technologies are channeling the COVID-19 shock into greater social and economic inequality. The disproportionate impact of COVID-19 infections on disadvantaged racial and ethnic minorities, those with poor nutrition and health care access, those reliant on public transportation, and those whose economic situations are relatively precarious further magnifies this effect.

Second, the COVID-19 pandemic is likely to accelerate the development and implementation of automation, robotic, and AI technologies. This acceleration reflects greater incentives to substitute capital for labor—incentives associated with the fact that machines are immune to the pathogens that

infect humans (though they are vulnerable to digital pathogens, as demonstrated by disruptive and costly episodes running the gamut from worms and viruses to malware and ransomware). In addition, working from home—which smart technologies facilitate—is likely to become a significantly more prominent feature of economic activity.

Third, smart technologies have tremendous value in enabling social distancing, disease surveillance, and contact tracing. Indeed, apps have already been designed and implemented in various countries to cross-classify symptoms of COVID-19 infection (both self-reported and direct measures) with a continuous set of smart-phone-derived geographic information system coordinates to monitor patterns of movement and interaction. Such apps can minimize the inconvenience, unpleasantness, and cost of large-scale COVID-19 testing and allow policymakers to get a fix on the progression of COVID-19 (and other dangerous pathogens) and the appropriateness of different social and economic policies. Smart technologies can also facilitate the provision of health diagnoses and advice without face-to-face contact. However, they are limited by network coverage, access to devices, and willingness and ability to engage with the app.

Fourth, the supply chain, trade, and travel disruptions caused by the COVID-19 pandemic are likely to undermine the integration of national (and perhaps some local) economies and to increase the value of self-contained and self-reliant economic systems, possibly offsetting the impulse in favor of increased social and economic inequality in the process. Diminishing the opportunities to take advantage of efficiencies in the international division of labor will increase costs of production and prices, slowing the pace of economic growth and changing the incentives for developing new technologies.

The bottom line is that COVID-19 is seeding the future of automation with both opportunities and challenges. These are accentuated by the realization that humanity faces the prospect of other major outbreaks and epidemics. Whatever the mix of defensive and offensive economic postures adopted by the private and public sectors, we are confident that smart technologies will play an increasingly significant role.

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