Fourth Industrial (R)evolution

Blind spots, risks, opportunities, and wildcards in a new era of technological change

PICTET 1805 Asset Management

COPENHAGEN INSTITUTE FOR FUTURES STUDIES

The Fourth Industrial Revolution is upon us. But how much of the technological change we are seeing today is indeed revolutionary and how much is a continuation of past trends? Which blind spots, wildcards, opportunities, and risks are on the horizon, and which potential futures are we not paying close enough attention to? The report aims to provide a multifaceted and thought-provoking take on this important topic, exploring both familiar themes surrounding the Fourth Industrial Revolution and asking and answering some of the questions that are otherwise forgotten or ignored.

SCENARIO reports

FOREWORD

Pictet Asset Management has been working with the Copenhagen Institute for Futures Studies (CIFS) for over a decade to establish a deeper understanding of megatrends – the powerful secular forces that are changing the environment, society, politics, technology and the economy.

CIFS is a leading global think tank and consultancy. CIFS uses a wide range of research methods, developed over the last 40 years, which include megatrend analysis, scenario planning, risk management, innovation initiatives and strategy development.

Through our partnership with CIFS, we have devised an investment framework that incorporates CIFS' 14 megatrends. The framework – which includes trends such as Demographic Development, the Network Economy, Focus on Health, Sustainability and Technology Development – enhances our thematic equity capabilities and informs the construction and development of our thematic equities strategies such as Water, Robotics or SmartCity.

As CIFS' partner, Pictet Asset Management has access to research into areas not normally covered by the investment analyst community such as changes in societal attitudes and beliefs, the impact this has on the environment and the business sector, and the acceleration of technological development. We are proud to be associated with CIFS and would like to share some of their research with you. We have sponsored this publication and hope you find it as insightful as we do.

HANS PETER PORTNER
Head of Thematic Equities
Pictet Asset Management

PHOTO: LILIANA DREW

Content

Introduction Since the 18th century, the world has gone through (at least) three industrial revolutions, each with its key technological innovations, and a wide range of societal knock-on effects resulting from their adoption. The first revolution involved mechanisation, the second mass production, and the third automation. We are now in the midst of a fourth one, which has digitalisation as its driving force. An extended list of key terms includes data ubiquity, information transparency, machine-to-machine communication, decentralised real-time decision-making, and cognitive computing. Taken together, these developments point in the direction of a merger of increasing intensity between the physical and digital worlds, which is expected to greatly impact everything from how things are made to how we work.

On the one hand, the Fourth Industrial Revolution (also referred to as *Industry 4.0*) is an observable phenomenon. It can be measured in the rapidly increasing number of industrial or collaborative robots supplanting human workers, or in the amount of data being produced and used, which contributes to the ongoing digitalisation of daily life. On the other hand, it is worth asking how much of what we are seeing today is indeed revolutionary and how much is a continuation of past trends – perhaps rebranded to fit today's agendas. Can we really proclaim a revolution as it happens, or do we need the benefit of hindsight to assess which were the truly transformative developments and technologies? It is also worth asking what changes we might not be paying close attention to, but which might turn out to be more significant in the long run than the ones in plain sight.

We can be certain that we do not know the full spectrum of

change stemming from the technological developments happening today. The future is never singular or determined, and the consequences of new technologies depends on how, by whom and to what end they are developed and applied. Speculations about what the Fourth Industrial Revolution might mean for, say, the future of work, will depend not only on how new technologies of connectivity enable us to work differently (such as more remotely, as we have experienced during the pandemic), but also whether remote work is a goal that we want to reach in the first place. Likewise, whether the technologies of the Fourth Industrial Revolution will lead to a shorter working week, more 'pseudo work' or the introduction of 'universal basic data income' (all of which are questions explored in this report), will depend on our choices – for example in the political arena, or at the workplace.

Too often, explorations of technology and its consequences fall into the trap of viewing social change as a direct result of invention or innovation, ignoring the human interests and agendas that push the technologies forward and give shape to the future. These narratives promote the idea that the success or failure of the transition towards the Fourth Industrial Revolution will depend on how society adapts to new technology, rather than the other way around. This is why a multidisciplinary approach to the topic, encompassing both the technological and the human aspects in combination, is necessary. With this report, it is our aim to provide a multifaceted and thought-provoking take on this important topic, asking and answering some of the questions surrounding the Fourth Industrial Revolution that are otherwise forgotten or ignored.

We hope you will enjoy reading it.

INDUSTRIAL REVOLUTIONS – not just machines

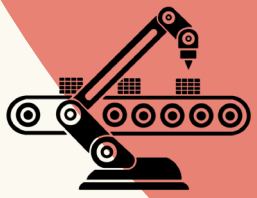
The scope of change stemming from the application of new technology is often massive and unpredictable, but the truly transformative aspect of any industrial revolution comes from the societal knock-on effects of these technologies that often takes years or decades to materialise, and which are driven by human decision-making. Which deep changes occurred in the wake of previous industrial revolutions, and what can we expect in the future?

1.0 – late 18th century

Mechanisation of manufacturing

Key technologies: water & steam power beginning to replace human and animal labour. Rise of the machine tool industry and new methods for manufacturing interchangeable parts.

Knock-on effects: Beginning of the transformation from agrarian to industrial society. A wider wealth distribution and decline of land as the main source of wealth (this with its own knock-on effects, including more people marrying earlier in life due to less of a need to obtain land before marriage). Increased international trade and a growing specialisation of the workforce. Many women entering the workforce for the first time.



2.0 – late 19th century

Mass production

Key technologies: Assembly lines allowing mass production, steel construction, electricity, and combustion engines.

Knock-on effects: Accelerating urbanisation and rapid economic growth. Availability of work rising and falling with the demand for goods. The rise of mass politics, labour unions, collective bargaining, and reforms. The beginning of modern business management. Growth in car ownership, commuting and suburban life.

Sources

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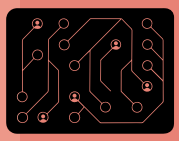


3.0 – mid 20th century (ca. 1970)

Automation

Key technologies: Automated production using electronics, programmable logic controllers (PLC), IT systems and robotics, the Internet.

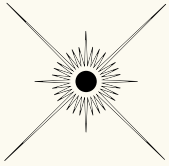
Knock-on effects: Beginning of modern corporate culture - workforce transitioning from factory to office. Outsourced manufacturing in West to overseas (esp. China). Rise of service economy with automation of traditional industrial jobs. Upgraded value of mental labour and downgraded value of manual labour. Higher standards of living but also exacerbated (global) wealth inequality.

4.0 – today

Ubiquity of data

Cyber-physical systems allowing real-time flow of data and decision-making. From islands of data to data-ecosystems allowing near-instant response time. Information transparency, machine-to-machine communication, decentralised real-time decision-making, and cognitive computing.

Knock-on effects (current and possible): Rise of the data economy and wider integration of deep learning and AI in more and more aspects of society. The transformation of urban spaces as a result of digitalisation impacting our behaviour. New tensions between technology and politics including questions of surveillance and privacy. The rise of digital, personalised health. The possibility of a higher degree of trust between individuals and institutions facilitated by digital ledger technologies, especially benefitting current 'low trust' societies.



5.0 – Far future

What comes next? Speculation about what the Fifth Industrial Revolution will entail is (at best) an educated guess. The next era of technological change could revolve around mass-customisation made possible by AI becoming ubiquitous. We may also see a deepening level of cooperation between human and machine with cyber-physical systems extending from data-machine to data-machine-human. Finally, the combination of nanotechnology, self-assembly, and biological manufacturing could have a major impact on manufacturing and fundamentally change the way products are made.

INTERVIEW

INDUSTRY 4.0
Evolution or revolution?

David Hardt is a Professor of Mechanical Engineering and a founding member of the Engineering Systems Division at the Massachusetts Institute of Technology (MIT). His interests lie in Manufacturing Process Control, Large Scale Additive Manufacturing, and Smart Manufacturing. We met online with Professor Hardt for a talk about the future trajectories of technological change. What is The Fourth Industrial Revolution (or Industry 4.0), how did we get here, and what comes next?

We are in the beginning stages of what is often referred to as the Fourth Industrial Revolution (or Industry 4.0). Are we really living through an era of revolutionary change or are we seeing an evolution of past trends?

I guess I would downplay the term revolution. The interesting thing is not when some new ground-breaking technology comes along, but when the rate of adoption skyrockets. When we look at what has been labelled Industry 4.0, it is something that is sitting on a continuum of development of more and more sophisticated technology. A lot of the things we are doing today under the heading 'smart manufacturing' are things we have been wanting to do for decades. It might have already been possible to do in a lab or for some of the biggest corporations but was either too expensive or unreliable to be widely implemented. Reduced cost is probably the main driver of what we are seeing today.

The tipping point in Industry 3.0 was automation becoming ubiquitous because of low cost and ease of use. Now, small manufacturing enterprises as well as multinationals can and have to automate to keep up with global standards. I don't see this as a revolution. There was, to put it in marketing terms, a price point where companies were able to rush in. There was also a 'knowledge point' where suddenly, you didn't need a huge staff of automation experts in order to use the technology.

Looking at Industry 4.0 and smart manufacturing, we are still not at the point where it's turnkey. The prospect is that that will happen, and when it does, 4.0 technologies will likewise become ubiquitous.

Are there things that set Industry 4.0 apart in this continuum of change?

While there are these different progressions in technology, the fundamentals of manufacturing are invariant – and what we need the technology to do is still the same. We need to make products at a certain rate, cost, and quality that are useful to society and sustainable as a business.

What sets 4.0 apart is an almost complete 'lifting of the veil' on manufacturing. There is so much that goes on in a manufacturing industry and within a factory, and so many factors that come together in a continual flow of materials and information. And it all ends up in these discreet products that must meet certain cost, quality, and rate goals.

What we are seeing now is that this process has gone from almost being an act of faith – you put everything in there and hope it comes out right at the other end – to learning more and more about what is going on. Now we can look inside a process, a factory, a supply chain and even the real-time financials of the operation and understand exactly what's happening.

Our response time is going from months to weeks to days to minutes to

seconds because we are able to gather information with great fidelity and bandwidth. But, as is often the case, we have the data but not necessarily the information and knowledge of what to do with that data. That's the great challenge right now.

When it comes to manufacturing, do you see 4.0 affecting the balance between centralisation and decentralisation? As an example, some have speculated that 3D printers could move production much closer to the consumer. Some of the wilder speculations suggest that production could even be moved into people's homes.
It is an interesting question, but I can't say I have a huge amount of specific knowledge about it, so this will be within the realm of speculation.

3D printing seems to hold a special place in everyone's hearts. The experience I have had with it, going back to its inception, is that it's an interesting new process that has some unique characteristics. But it is not a universal process, and it is not going to allow you to make everything from car parts to wind turbines. It is finding its way into some important applications, but I don't think it's key to highly distributed production systems.

Instead, decentralisation of manufacturing could mean more regional micro factories instead of one mega factory. So, why would you want a small factory? You could save on transportation and logistics costs. It could also have a significant economic impact and create jobs in regions that need good economic engines. It's unclear to me whether adding to the burdens of the emerging megacities is a good long-term strategy.

The question is: why would micro factories be viable now when they have not been for the last many decades? I think what has really changed is the ubiquity of information technology. The flow of data needed to run such a factory no longer needs to come locally. Sure, you would need local skills, but you could have regional or global support on the technical, logistical, and business side. The local staff would just have to be big enough to operate the facility on a day-to-day basis. I also think that this information technology creates opportunities for staff to not only be working and producing, but to learn remotely as well.

This development at least opens up the possibility of more distributed manufacturing. But it doesn't take away from the fact that we have yet to come up with economically viable designs, materials, and processes that can produce high-quality, low-cost goods in the volumes that are required, in ways that are easily distributed.

We are becoming more and more aware of how our production and consumption

of goods impacts the environment, which also puts into question whether growth through increased productivity is still a good measure of progress. How does Industry 4.0 address this issue?

Again, my reply to this question will be in the realm of speculation, but I will give you a semi-scientific answer. By lifting the veil in the smart factory, we can further reduce waste and inefficiency. This means that we can decrease wasted material and machine motion, wasted heating or cooling, and wasted fluid or chemical use. So, in some ways, smart manufacturing could allow us to add one additional knob for optimisation. I do think there is a prospect for that.

As we become more productive and get the ability to produce more, the question then becomes: should we do it? What should we produce? That's the much bigger question.

With the greater reliance on integrated data ecosystems that comes with the ubiquity of cyber-physical systems – the lifting of the veil as you put it – is there a risk of monopolisation? Will we see a winner-takes-all-situation in manufacturing like we have seen with the digital platform economy?

I understand your parallel with the digital platform economy. But I think of manufacturing being more democratic than that. When I think back to the introduction of computers in corporations in the 70s and 80s, it was initially only the major companies that used them, and they developed their internal expertise around these systems. Then, an interesting thing happened; these companies realised the benefit of helping their smaller suppliers integrate these systems as well, causing a proliferation of computer technology to happen.

The cost curve with information technology has made the hardware side very accessible. It has gotten to the point where today, my iPhone has more 3D shaded graphics capability than GM had in their massive, centralised computing system back in the 80s. Not only do I not have to pay much to use it, but I also don't need to know much to use it.

Whether there are big players who will say 'if you want to be 4.0, you have to be us', I don't know. However, I am tempted to say that it means that even the smallest enterprise will need some staffers in their early 20s. When I bought my first electric car, the salesman didn't know that I was an engineering professor. So rather than sit in the car and tell me how to use it, they had hired a high school student to explain to me how to operate it – because he understood computers and touch screens.

What will happen to jobs within manufacturing as Industry 4.0 gets rolling – will more new jobs be invented than those that are replaced by machines?

What we know is that the jobs in manufacturing per unit of production continues to decline. It takes less human labour to make products. That's been happening for 20-30 years, since Industry 3.0. Whether or not we have reached a bottom on that, I don't know.

20-30 years ago, you would think that advanced education and manufacturing should never be used in the same sentence. Today, the technical sophistication required for even the simplest manufacturing operation is very high. It may lead to fewer jobs, but it will also lead to higher skill needs.

That's why I'm very keen on the idea of using these highly enabled information technology platforms that are already numerous within a manufacturing operation as educational tools. They can be used to bring your workforce along, rather than them losing your jobs and having to learn a new trade.

The goal of all universal information technology in manufacturing is to make better stuff cheaper and faster. But it's almost as important to say that we can make the jobs available in manufacturing much more fulfilling and creative.

What comes after Industry 4.0?

Obviously, it's 5.0. Beyond that, I wish I knew.

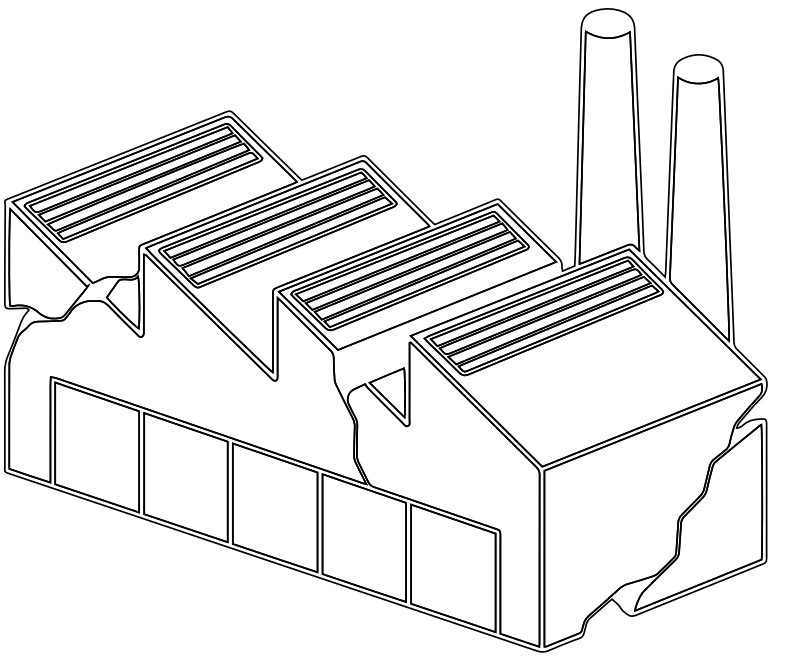
If you look at it from a purely technological point of view, historically there has always been a supporting science or technology that has grown to where it has an ability to really push things, alongside market factors and other things that drive the need. I'm not sure what the next big technological growth will be that will have an impact comparable to information technology.

Back in the mid-1980s I was giving a tour of our manufacturing labs to someone from MIT's computer science department. He was shocked and surprised to see that we had computers in our labs because they were unusual at that time.

But computers have been a part of manufacturing almost since before computers even existed. Numerical control was used before digital computers but using similar technology.

Here we are, 70 years later, and what's the big deal? Well, it's still computers! But they have gone from being isolated islands of data to being ubiquitous. So, what's something that could have that kind of impact 20-30 years down the line? It's hard for me to say, but the popular notion would be something like the combination of nanotechnology, self-assembly, and biological manufacturing. Even in 4.0, we still make a car the way we have always made a car, but this could be something that will have a major impact on manufacturing because it would fundamentally change the way we make products. It's still a long way off. From when something is demonstrated until it's in common use, that usually takes around 30 years. ■

With the Fourth Industrial Revolution kicking in, an important and often debated question is whether or not technologies of automation will replace more jobs than they create. For now, the question is undecided, but one possible outcome is that the machines will liberate us from work, and that we humans will have a lot more freedom on our hands. In such a future, we may need to redefine what 'freedom' means – so whose job is it to do that?



FREE DOM

In the fourth industrial revolution

Automation is arguably one of the most discussed and controversial topics of our times, and hardly a week passes by without new and surprising applications for collaborative robots (cobots) and AI being covered by the media. One sure thing about this new industrial revolution (the fourth one, also called Industry 4.0) is that it is a growing, global phenomenon and that it is not going to stop anytime soon. At the same time though, the impact it will have on the job market and society at large is still unclear.

Among institutional actors and tech companies alike, there is a widespread expectation that if the transition to Industry 4.0 will be handled correctly, automation will create more jobs than those it will render obsolete, and humans and machines will peacefully complement each other, just like the narrative about the previous industrial revolutions goes.

Both the marketing material of many cobots producers and the reports from actors such as Manpower and the World Economic Forum (WEF) present scenarios in which machines will increasingly take over repetitive, wearing, and dangerous tasks, and humans will be free to pursue more skilled and fulfilling jobs, all while increasing productivity and efficiency.[1]

Clear win-win.

Or not? Because not everyone shares this optimistic view. For instance, in his bestseller *The Rise of the Robots*, technology expert Martin Ford argues that, unless significant structural changes are made to our societies, the impact of this new wave of automation on capitalism as we know it will inevitably turn it into a dystopian techno-feudal system in which the rich control both capital and labour (collapsed together into the machines) and most people simply will be left with no bargaining power in economic relations.

These two narratives, the optimistic and the dystopian seem to be the opposite of one another, but they actually share a common starting point: namely the idea that the success or failure of the transition towards Industry 4.0 will depend on how society adapts to automation, rather than the other way around. Indeed, the WEF report referenced above includes recommendations for governments, for industries that will deploy robots, and even for workers on how to handle the transition to this new wave of automation. But what about the companies that develop these technologies to begin with? Do they not bear any responsibility?

It was with this question in mind that I [writer Luca Collalti, ed.] recently conducted anthropological fieldwork in one of the most successful firms of the blossoming robotics cluster in Odense, Denmark.

During my research, I learned that, whereas the form of robots' liberating potential appears to be clear in the minds of roboticists (i.e. taking care of undesirable tasks), the engineers' vision of what this new freedom looks like (from the point of view of a worker whose job is automated) is more blurred and mostly limited to mentions of the possibility for re-skilling or up-skilling the work force. This is not only because robots can be deployed in many different contexts, which makes it difficult to imagine a single way for such freedom to actually be practiced, to borrow philosopher's Michel Foucault's terminology. It is also because the responsibility of envisioning and realising such practices of freedom (basically how to do freedom) is seen by engineers as external to

1 WEF: "The Future of Jobs Report" (2018), bit.ly/3xYqtCt. Manpower Group: "The Skills Revolution" bit.ly/3A0ZFTX.

them. Hence, the roboticists themselves share the idea that others, typically decision-makers and industrialists, will not only have to prevent the robots from causing unemployment but that they will also have to define the practices of freedom through which unemployment can be avoided to begin with.

This view (along with many popular narrative about previous industrial revolutions) is challenged by historical analyses of the implementation of industrial machines which show that down-skilling has often been an effect of the implementation of automation. Sometimes this was even intentional from the part of the industrialists, who could then benefit from the shift in power balance between them and the down-skilled workers who therefore could leverage much less bargaining power.[2] Likewise, contemporary anthropological research shows how the introduction of new technologies, in both the private and public sectors, is often an imposed, top-down process that can be a threat not only to employment but also to employees' professional identities and job satisfaction.[3]

Embedded in this widespread omission of the responsibility of tech companies lies the core assumption that technologies in themselves are neutral tools with no built-in politics or ethics, which is why the focus is often only on how they are used, rather than also on how they are designed.

But this assumption is simply not true.

Since the early 1980s, scholars within Science and Technology Studies (STS) and Philosophy of Technology have shown compelling evidence that technologies themselves are always political and, as such, always bear ethical implications. Design is never merely a technical process but a social one as well because technologies, like laws, are attempts at ordering the world and therefore embody the ideas and assumptions of their designers with regard to their purpose and the context in which they will be used. In other words, technologies 'can embody specific forms of power and authority', as STS professor Langdon Winner claimed already more than 40 years ago.

Consequently, designing any artefact is not just a matter of problem-solving; of pragmatic 'how do I get X to do Y' type of questions in which engineers usually frame their work, since doing so also includes establishing what X and Y are to begin with, and what they ought to become.

In the case of automation then, designing new technologies that aim at liberating human beings is first and foremost a matter of how to define and redefine human work and freedom and how to inscribe these views and values in the different technical features of the robots. What is a workplace to the people working in it? In what ways will this new robot change the relationship that workers have with their job and the dynamics within the workplace? Who gets to decide the purpose of collaborative robots and through which mechanisms? These and many other questions need to be asked and answered to the best of our abilities if we really are to design robots that will free humans from the undesirable aspects of their jobs.

At first, these questions might sound outlandish, but make no mistake: asking them does not mean creating them out of thin air. These questions already exist and, as a matter of fact, some of them are already being answered on a regular basis, just in an implicit way. When

2 Andrew Feenberg: Transforming Technology: A Critical Theory Revisited (2002). Langdon Winner: "Do Artifacts Have Politics?", Modern Technology: Problem or Opportunity? (1980).

3 Cathrine Hasse: "Artefacts that talk: Mediating technologies as multistable signs and tools". Subjectivity (2013). Jeanette Blomberg: "An Anthropologist in Silicon Valley", Anthropology News website (2018), bit.ly/3A5UqSQ. Jessica Sorenson: "Decisions and values: Engineering design as a pragmatic and sociomaterial negotiation process". REELER Working Paper Series (2018), bit.ly/35UTi6T.

a robotics company designs a new robot based on the feedback from its customers, 'the customer' is a construction that mostly means whatever manager is in charge of the automation of the company. In theory, the workers on the factory floor are just as much 'the customer', in the sense that they too are part of the company that materially buys the robots, but it is usually not with them that tech companies talk. This is to say that, by running their operations based on the assumption that the person overseeing the automation process (or the CEO, or the CTO) is the one whose feedback matters, robotics companies are implicitly answering the question about who gets to decide the purpose of collaborative robots and through which mechanisms.

While engineers might (and, indeed, often do) see these questions as not related to their work and/or not being part of their responsibilities, things are not so easy. Ignoring them will not make them go away. Instead, it will just move them beyond the limit of what is considered up for discussion, making the answers that are given to them seem like some unavoidable destiny, instead of the political matters that they are.

However, while in the field of AI at least some conversations about ethics and politics are happening, during my fieldwork I have learned that it seems like the same cannot be said for robotics. Indeed, concerns about the ethical and political implications of robots were often met with scepticism and perplexity by my informants because they usually could not see the need nor imagine a place for such concerns in the way technological development at large is currently structured, conceived, and incentivised. Therefore, in their eyes, the non-conformity of such considerations with the current system makes them unworthy of even being discussed.

Conversations about ethics and other values in robotics (but, really, in engineering in general) are further complicated by the fact that engineers are taught to see themselves as problem-solvers whose motivation is to work on technical solutions and whose focus on efficiency and problem-solving. This leaves little room for considering other values. Ethics is generally not part of the background nor of the everyday decisional processes and considerations of engineers, and it is understood mostly in terms of not causing physical harm. This is not to say that engineers do not feel empathy for workers that may lose their jobs because of robots, but they do not feel accountable for it, both because, again, they think the responsibility is to be found elsewhere, as in the management of the companies they or the unlucky workers are employed by, and because they feel that they do not have the agency nor the power to deviate significantly from what 'the man with the money' wants.

However, this belief is at odds with the fact that highly skilled STEM workers are arguably among the last groups of workers who can indeed exercise pressure on their employers thanks to the high demand that exists for their skills. In fact, in the past few years, workers in the biggest tech companies in the world have already started to raise their voices against issues such as women's rights at the workplace and questionable aspects of the development and sale of surveillance technologies.

Limiting ethical reflections only to not causing direct (physical) harm to people is reductive and problematic. Unsurpri-

singly, my informants are well aware of the famous 3 laws of robotics devised by sci-fi author Isaac Asimov, and particularly of the first one, which states that indeed 'a robot may not injure a human being or, through inaction, allow a human being to come to harm.' But even Asimov later found these laws to be insufficient and added the Zeroth law, which overrules all others and establishes that 'a robot may not harm humanity, or, by inaction, allow humanity to come to harm'.

Of course, Asimov recognised that this new law made life way more complicated for his characters, but he also recognised that the world is complicated and that the point should be finding ways to deal with this complexity, however difficult and imperfect, rather than shunning away from it and pretending that it is either not there or that it is up to somebody else to figure it out.

If we have learned anything from the development of social media platforms, the public perception of which largely shifted from democracy-enhancers to democracy-underminers in less than a decade, it is that the ethical and political implications of technologies must be addressed, no matter how difficult that might seem, and the sooner the better.

This is not to say that the task is easy – very much the opposite, which is why this responsibility cannot be placed solely on the shoulders of corporations or public institutions, nor on engineers alone.

Rather, a truly successful and liberating version of Industry 4.0 requires a multidisciplinary effort that includes all of these actors plus, I believe, a particular contribution from the side of the Social Sciences, particularly Techno-Anthropology, tasked not only with observing and reflecting on the different forms in which questions about the future of work and the role of technologies in society will present themselves in various contexts, but also with bringing attention to such questions and providing engineers and the companies they work for with some of the tools to address them. ■

SCI-FI AUTHOR ISAAC ASIMOV
PHOTO: ED McDONALD

INTERVIEW

ETHICAL ENGINEERING

How can tech be encoded with democratic values?

Inese Podgaiska is the Secretary General of the Nordic Association of Engineers, which represents more than 500,000 engineers across the Nordic countries. She is an advocate for strengthening the role of engineering in advancing responsible AI and achieving sustainable development goals.

We met online with Inese for a talk about ethics in technology, challenging the tech industry, what the social sciences and technical fields can learn from each other, and what a Nordic approach to AI should look like.

You have said that you believe democracy needs to be encoded into the process of technological development. Can you explain what you mean by this?
It means making sure that the new generation of technical developers have a broader perspective of the societal implications of new technology. This includes ethics, democracy, freedom, and human rights, as well as the risk scenarios stemming from their products. These principles should be understood before the process of development is begun. It also means asking: do we always need to develop new technology just because we can do it? Very few workplaces engage actively with these questions today.

One of the things we do at the Association of Nordic Engineers is to gather technical developers and engineers to initiate the shift of mindset. That said, it is of course not just the engineers who bear the responsibility. There is also a political responsibility in deciding how the technology is going to be used, by whom and for which purpose.

Take facial recognition. Today, in the EU, some Member States deploy facial recognition in public spaces, and it is being used actively by the police. More than 50 different organisations have written a letter to the EU commission calling for a ban, stating that this is an infringement on our privacy and human rights. We still need to see what the result will be, as security is used as an excuse for a wider use of this biometric technology.

You believe that both ordinary people and technical developers need to be empowered to challenge the authority of the tech industry. How do you see this happening?
In April 2021, the European Commission tabled a proposal for AI regulation, which is going to be under negotiation between the Council of the EU and the European Parliament. It is the first proposal for AI regulation at EU level that has been tabled, so it's quite an important milestone.

But when you dig into the proposal, you see that its overall focus is on providing a legal framework for industries, and that the whole supply and demand chain is missing. Notably, the impact on people, workers, and end users is not properly addressed. This perspective is important because people who are not technicians and specialists often lack a basic knowledge of how new technology impacts their life. Again, let us take privacy as an example. When we talk about the consequences of facial recognition, many people reply: 'well, I am not doing anything wrong, why should I be sceptical of it?' We already give so much data away without knowing it, and we have no control over how that data is used or misused. Empowerment means bringing our experts closer to the public and providing insights on the benefits and challenges of new technology – including informing people of new risks.

From a trade union's perspective, empowerment means providing knowledge of how the deployment of technology impacts workers. It's not only the automation of work and jobs that's relevant here, but also labour and employment conditions, which are changing with the emergence of new kinds of employment contracts and changes to labour protection. We also see a growth in workplace surveillance and performance tracking. In this context, a big task for trade unions now is to step up in their role and safeguard workers' working conditions, rights to privacy, and the 'right to disconnect'. These things, also, are not mentioned in the EU regulation at all.

The Nordic Association of Engineers has campaigned for ethics to be included in the curriculum of engineers. What are the obstacles in doing this?
It's already being implemented. For instance, the Technical University of Denmark (DTU) already has ethics in engineering on the curriculum. For me, it's difficult to see the obstacles. It is a matter of willingness to see an added value in doing so. But it's not only engineering that needs an understanding of social sciences and humanities. These fields should also have a component in their curriculum providing them with a basic knowledge of technologies. A lawyer specialising in technology today probably didn't learn it in school because it wasn't taught. It's no longer a spiritual statement to say that everything is connected. It is a fact in our interconnected society, and that needs to be embraced in our education systems.

Ethics in AI is often considered a hinderance or a luxury that can't be afforded. Do you think that making AI that is somehow encoded with Nordic values could provide the Nordics with a competitive advantage?
I think a Nordic cooperation on AI would be great. And I do think the Nordic countries could gain a lot if there was a Nordic lighthouse of research on AI. It would boost innovation and allow us to retain our talents instead of having them move to Silicon Valley.

When it comes to AI research and development, we need a triple helix approach encompassing academia, business, and politicians instead of the current, very scattered approach. It is usually the industry's business models and development strategies that define what kinds of products they end up developing. And politicians talk about technology either in terms of dystopian scenarios or as something that will solve all problems.
Regarding the claim that regulation will hinder innovation – I don't buy it. Rules within a certain framework, if defined well, don't necessarily prohibit the actors from innovating – because they all know and play by the same rules. Some years ago, I discussed this topic with someone working in the industry

who told me: I and many others want to have dialogues with you and politicians. We *want* to know what the rules are so we can play by them.

We also took up this topic last year at our hackathon. Here, we asked: should we make certificates for companies, such as to be labelled as an ethically friendly AI company or should we certify the products as ethically aligned, which in turn could be used as a competitive advantage. It was the latter approach that prevailed. In the Nordics, trust is a societal cornerstone. If there is no trust, there is nothing. A certification of products could likewise make trust the cornerstone of a Nordic approach to AI.

In my work with engineers, I have been met with different reactions to the possibility of including approaches from the social sciences in what they do. Some are sceptical of the idea because they 'want to do math and build stuff'. What do we say to them?
My response would be: do you really see the world as black and white? True, some engineers do, as they do in other professions. But it's a question of integrating it into the curriculum in a reasonable way. You could have a course on societal issues – law, politics, ethics of philosophy – without requiring a written exam on it, but as a reflection or dialogue, I don't see how this would be a problem. My daughter studies political science, but she also has a course on macro-economics even though she is not going to be an economist, because it is needed for a general understanding how politics and economy are interlinked. It's a part of broadening up your field of view.

There is a quite lively debate about ethics in AI, but we don't really see this in other facets of the engineering profession, even those that have to do with the Fourth Industrial Revolution like collaborative robots. What's your take on this?
I think you are right. The deployment and automation of AI were the catalysts for looking into their impact on our values, ethics included. So I imagine that the focus on ethics, privacy, and human rights will only increase in the coming years, and it will encompass other fields of engineering as well. The essence of engineering is to be in the forefront of technological development, and the pressure for responsible development of technology is ever growing. I represent engineers and I have an enthusiasm for progress and innovation – but in recent years there has been, in my view, too much focus on productivity and economic growth with too little focus on people. The Covid-19 pandemic and its aftermath has enhanced this discrepancy. We need to ask: does our economic system really function if it doesn't benefit people in the lower part of the income chain? I am almost tempted to say that the consumer society has consumed itself. I think we need to rethink our approach going forward. ■

ROBOTICS - a rapidly growing market

The market for service and industrial robotics has grown significantly in the last decade and has branched beyond conventional assembly line manufacturers such as in the automotive and electronics industries. In the coming years, the market for robotic technology is expected to also grow substantially within sectors such as agriculture, health and the military. Among the trends driving this development are increasing global manufacturing labour costs, decreasing robotics production costs, greater technical sophistication, increasing variety of available robot models, and a growing pool of technicians with the ability to design, install, operate, and maintain robotic production systems.

Sources

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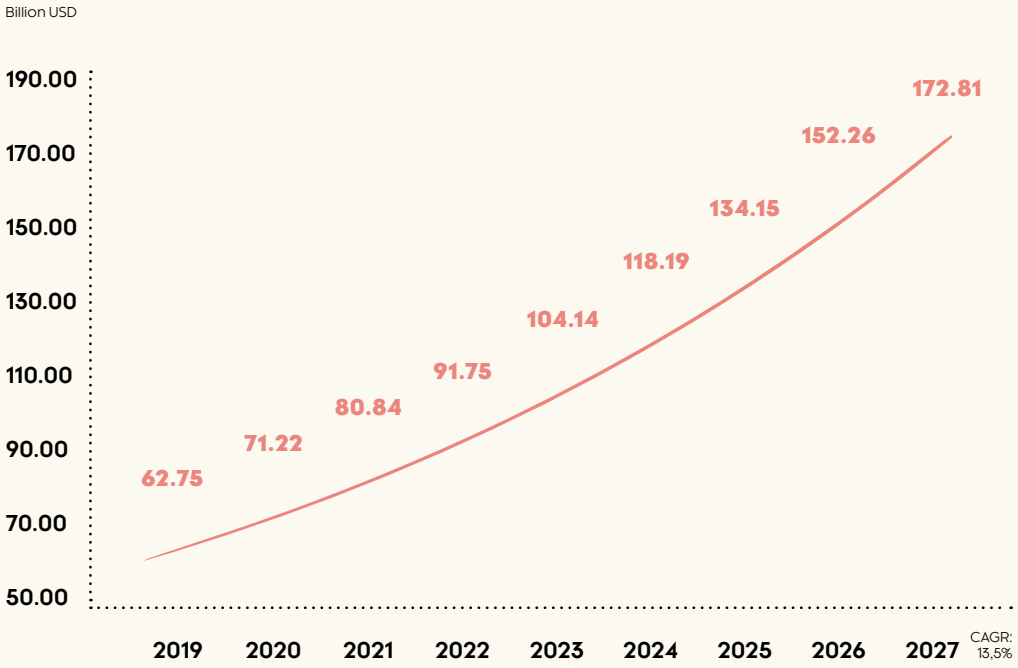
McKinsey & Company: Industrial Robotics (2019), mck.co/3hao6G1.
International Federation of Robotics: World Robotics Report (2020), bit.ly/3A9viLk.
Allied Market Research: Robotics Technology Market Statistics – 2027 (2019), bit.ly/363Xotf.

Projected growth of global robotics technology market



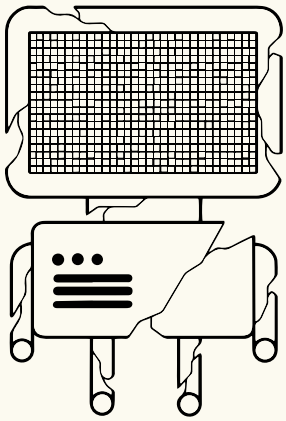
88% *of companies in the automotive, consumer electronics, and pharma industries expect their investments in robotics and automation to increase.*

Since 2004, each new robot installed in the manufacturing sector has displaced an average of **1,6** *workers from their jobs (globally).*

150.000

– the amount of people employed in the robotics industry globally

Collaborative robots (cobots) will make up **34%** *of global robot sales by 2025*



China in the lead

Since 2010, the global stock of industrial robots has more than doubled.
As the growth in robotics continues, China, being the largest provider of robot technology in the world with 36% of global annual sales, will have a significant influence on the development of the market. Currently, approximately every third industrial robot worldwide is installed in China.

Polarisation or equality?

One of the biggest questions associated with the Fourth Industrial Revolution – especially artificial intelligence (AI), robotics, and the Internet of Things (IoT) – is if future advances in these technologies will lead to further polarisation of wealth and power, or conversely to greater equalisation. Arguments can be made for both scenarios. We will examine the case in this article.

PHOTO: NAVEEN ANNAM

POLARISATION AND EQUALITY IN THE PAST

If we examine economic inequality in the past, there are several indicators we can look at. One is the Gini Coefficient, which measures income inequality on a scale from zero (fully equal income distribution) to one hundred (all income goes to a single household). The International Monetary Fund (IMF) notes that, measured by Gini, global inequality has declined since the 1990s and is now lower than at any time since the 1930s, as developing economies in general have grown faster than developed economies. However, IMF also notes that since 1985, inequality has grown in more than half of all countries worldwide and in almost 90% of developed countries. This is supported by research from Brookings showing that in the period 2005 to 2015, income equality has grown in almost every country where it has been low (mainly developed economies) while it has declined in almost every country where it has been high (mainly developing economies). Differences in income equality between countries seem to be diminishing, approaching global universality in income equality. Brookings, however, notes that this does not include the i ncomes of the top 1%, which would make the rise in within-country inequality 'much starker'.[1]

Our World in Data provides information on the income share going to the top 1% of the population in a variety of countries. As can be seen in Figure 1, this share declined throughout most of the 20th century, only to rise again from ca. 1980, in developed as well as developing countries.

Yet something remarkable happened in the US in the 1970s. During this decade, worker compensation became decoupled from worker productivity (see Figure 2),[2] while the ratio of CEO-to-worker compensation began to skyrocket, from 23:1 in 1973 to 31:1 in 1978 compared to 61:1 in 1989 and 320:1 in 2019. From 1978 to 2019, CEO compensation grew 1,167%, while productivity grew only 72%.[3] While the US is at the extreme end of income polarisation, similar patterns are seen all over the developed world.

What exactly happened to create this reversal of equality? One common explanation is that it was caused by the oil crisis of the 1970s and the subsequent rise of neoliberal economics. However, it is also notable that the sudden reversal of equality coincides with the rise of the digital age, with inexpensive computers, the internet, and growing power of the tech giants. If this is the case, then further digitisation with AI, robots, and IoT could well herald further economic polarisation – though there are also aspects of the digital revolution that could lead to greater equality.

Additionally, as the IMF notes, it isn't enough to look at gross income inequality, since progressive taxes and income transfers reduce inequality as measured in *disposable* income (after taxes and benefits). This is an effect that is most pronounced in advanced economies, especially the Nordic countries, and is even higher when counting social spending on things like education and health. The IMF points to these factors as key in reducing inequality.[4]

WILL AUTOMATION LEAD TO GREATER POLARISATION?

In a recent report, McKinsey & Co. predicts that more than 100 million low-wage workers globally may need to find new jobs by 2030 because of increa-

1 IMF: "Introduction to Inequality", bit.ly/2RW113D. Brookings: "Is inequality really on the rise?"(2019), brook.gs/3waDPKz.

2 "The Productivity–Pay Gap", Economic Policy Institute 2021, bit.ly/3yqNZt2.

3 Lawrence Mishel & Jori Kandra: "CEO compensation surged 14% in 2019 to $21.3 million", Economic Policy Institute 2020, bit.ly/3bGwPO4.

4 IMF: "Introduction to Inequality", bit.ly/2RW113D.

FIGURE 1: Share of total income received by the top 1% (1913-2017)

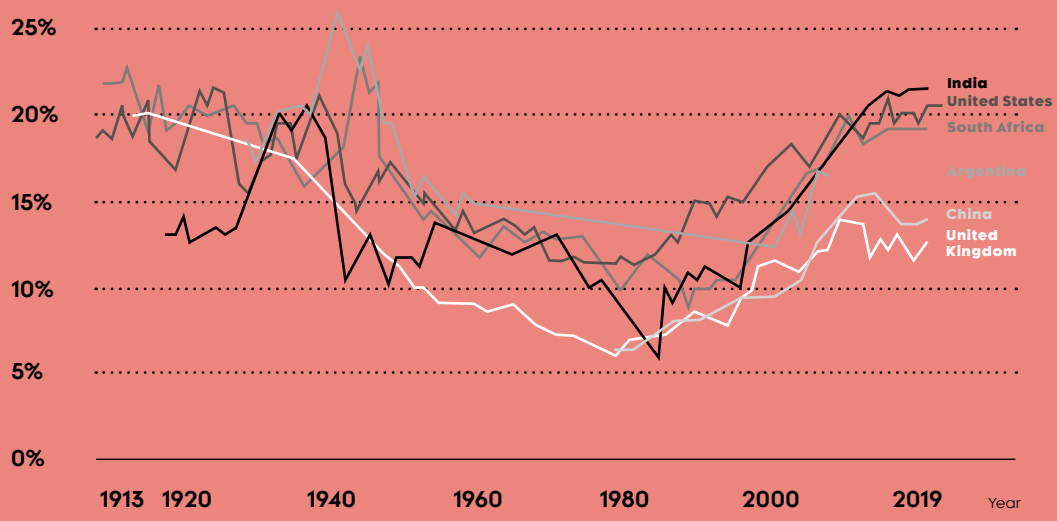
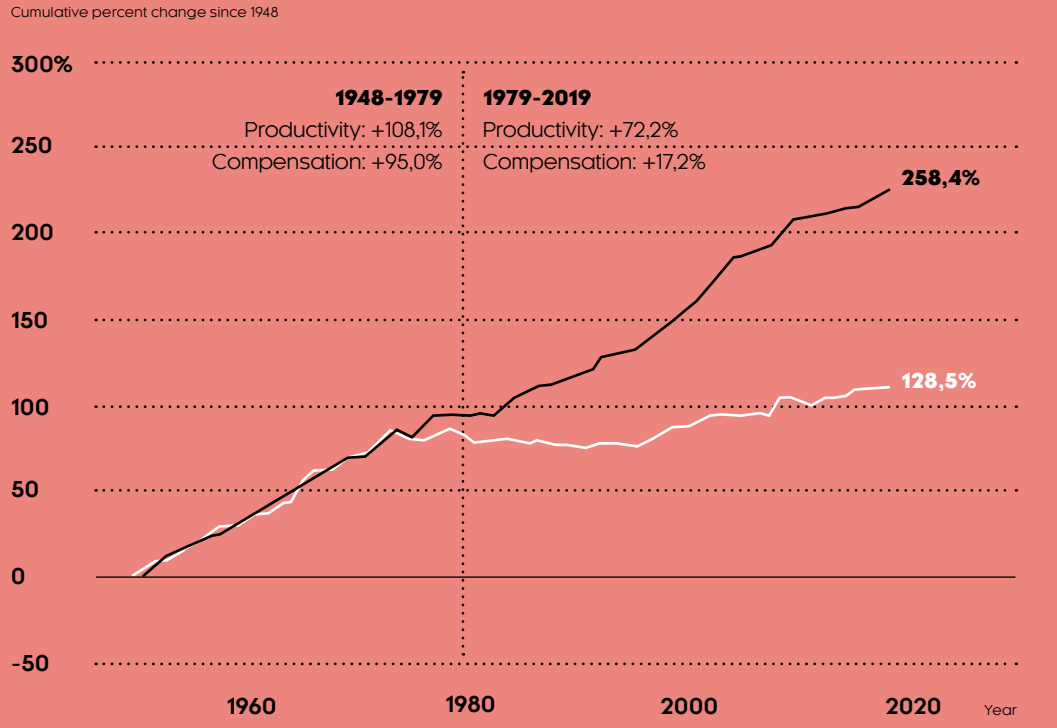


FIGURE 2: Productivity growth and hourly compensation growth 1948-2019



sed automation post-Covid. Jobs with high physical proximity, manual tasks, and low-wage jobs in general are most likely to be disrupted, and more than half displaced low-wage workers will need to upskill to find employment in higher wage brackets that require different skills.[5] A recent report from WEF and PwC likewise states that we are at a critical juncture in the age of automation, and that programmes of rapid upskilling and reskilling of the global workforce have become necessities. If done right, meaning that we see wide-scale investment in upskilling and reskilling starting today and a closing of skill gaps by 2028, the global GDP could be boosted by as much as USD 6.5 trillion by 2030. In such a scenario, we would see an improved matching of people's skills with the jobs created by the Fourth Industrial Revolution, and people across the world would then have 'the ability to participate fully in the future of work, whatever that might be,' as the authors of the report put it.[6] A win for both potentially displaced workers and the global economy, resulting in reduced polarisation.

If we don't manage the transition, the results could well be higher unemployment and hence greater polarisation, which has been the case in recent history. A 2020 study from MIT finds that since 1987, jobs lost to automation haven't been replaced by an equal number of similar employment opportunities. Since 1993, each robot has replaced 3.3 workers across the US.[7] Firms that quickly adopted robots became more productive and hired more workers – but their competitors fell behind and fired workers, leading to a decline in the overall number of jobs available. Low-skilled workers who lose their jobs to automation are often forced into lower-paid, unskilled jobs. The study finds that automation is the main cause behind both lacklustre productivity growth and declining worker wages, as seen in Figure 3.[8] With future automation shifting to AI, we are likely to see the same pattern in increasingly skilled knowledge work as we have seen in manufacturing and service. Automation in service has often been in the shape of self-service solutions; an example of what the authors of the MIT study calls 'so-so technologies', which save labour by shifting the service burden to customers without really increasing productivity. Therefore, automation doesn't necessarily lead to greater productivity; there is little incentive to focus on increasing productivity if there are easier ways for management and shareholders to increase their earnings by cutting down expenses engendered by maintaining a permanent workforce.
While automation drives wages down for many workers or forces them into the uncertain gig economy, others benefit financially from the change, or else there would be no incentive for the transition. As tasks in a company become automated, a smaller share of profits goes to workers, with more left for management and shareholders as reflected in the skyrocketing CEO wages and shareholder dividends. From 1972 to 2016, shareholder payouts rose from 1.8% to 3.1% of the total assets of publicly traded US companies, while wage expenses declined from 21.6% to 11.4% of assets.[9] Depending on the tax regimes in a given country, some of these profits are redistributed back into the broader population.

In some cases, skilled workers can also benefit if the tasks they are perfor-

5 Susan Lund, Anu Madgavkar et al: "The future of work after COVID-19", McKinsey.com 2021, mck.co/2SuTWED.

6 WEF, PwC: "Upskilling for shared prosperity" (2021), bit.ly/2SWQ3cc.

7 Peter Dizikes: "How many jobs do robots really replace?", MIT News (2020) bit.ly/2Umxq1C.

8 Peter Dizikes: "Study finds stronger links between automation and inequality", MIT News 2020, bit.ly/3hlZJRK.

9 Christopher Ingraham: "The race for shareholder profits has left workers in the dust, according to new research", The Washington Post 2019, wapo.st/3woKfWZ.

ming are partly rather than fully automated. This means that these workers can perform tasks faster and are thus able to handle a greater workload, allowing them to ask for greater compensation (if they aren't self-employed). For instance, an architect can save a lot of tedious labour associated with their work if the visualisation of a project can be done more efficiently with a virtual reality simulation rather than a physical scale model. Some architects have even begun letting AI handle aspects of the design process through *parametric* design, where the architects establish detailed parameters for the requirements for a building and then let AI explore and test different designs against these parameters until a superior design is found. This type of part-automation often means that the most skilled or in-demand actors in an industry can handle a greater share of the available projects, leading to a 'superstar economy'. In this system, all the most profitable and prestigious projects are handled by a few elite actors while the next layer must accept projects that are neither profitable nor prestigious – simultaneously, the remaining layers struggle just to get enough projects to survive.

10 The Sky is Rising report, 2019 edition, skyisrising.com.

HOW CAN TECHNOLOGY BE USED TO ACHIEVE GREATER EQUALITY?

While most of the above factors point to a likely risk of greater polarisation because of automation, there are ways in which digital technology can and probably will create greater equality – if not in monetary wealth and power, then in wealth of personal opportunities. Personal technology empowers its owners to handle tasks that were formerly restricted to professionals or gatekeepers. Today, most people can reach out to worldwide audiences with messages or job applications, and interested people or organisations interested can quickly find and contact them. Of course, the flipside of this is that it may become increasingly difficult to break through the noise and have one's message heard.

More and more educational resources have become available online for free or at low cost, and it easier to find partners and investors for certain types of projects, as evidenced by the success of crowd sourcing and crowdfunding. Free, automated translation is in the process of removing language barriers, while satellite internet promises internet access in the remotest parts of the world. Ideas, designs, and how-to manuals are shared freely for everyone to use in a 'maker culture' where citizens seek alternatives to perceived poor or overpriced consumer products that often come with restrictions. Self-publishing of books, music, and videos is far easier and cheaper than ever before, resulting in a growth of published content.[10]

Opportunities are abound, but often these opportunities are only available through tech giants that own the vectors through which information is transacted, and who exercise a lot of control over content and profit margins. Hence, more personal opportunity and power often comes with a price tag of submission to the goodwill of these companies who profit immensely from this control, since their services are almost fully automated. To truly take power (and the associated wealth) back into their own hands, citizens may need to find and use peer-driven alternatives to the services of tech giants.

However, such alternatives come with a price tag of their own: that of less streamlined services and a smaller potential audience.

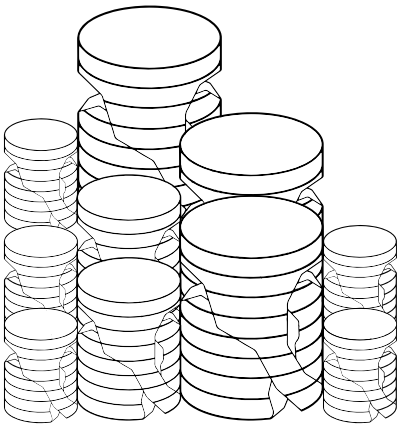
There are also non-technological ways to increase equality. As mentioned above, the IMF recommends progressive tax systems and greater social spending to counteract growing income inequality, as detailed in a 2019 IMF working paper.[11] Raising minimum wages has also shown to be an effective tool for reducing income inequality. A 2019 study by the Economic Policy Institute found that gradually raising the minimum wage in the US to USD 15 would be good for workers, businesses, and the economy,[12] and experiences from China and Brazil show that raising minimum wages is an effective means of reducing inequality.[13]

Read more about vision of future societies of great equality on page 60. ■

11 Djeneba Doumbia & Tidiane Kinda: Reallocating Public Spending to Reduce Income Inequality: Can It Work?, IMF Working Paper 2019, bit.ly/3wsnfqA.

12 Ben Zipperer: "Gradually raising the minimum wage to $15 would be good for workers, good for businesses, and good for the economy", Economic Policy Institute 2019, bit.ly/35krYi2.

13 Carl Lin & Myeong-Su Yun: "The Effects of the Minimum Wage on Earnings Inequality: Evidence from China", IZA Institute of Labor Economics 2016, bit.ly/3xt8bct.
Niklas Engbom & Christian Moser: "Earnings Inequality and the Minimum Wage: Evidence from Brazil", Natiopnal Bureau of Economic Research 2021, nber.org/papers/w28831.




PUMPS
CLOSED
STOP
YOUR
MOTOR
PLEASE
NO
SMOKING
When did you last
change your oil ?

Do we need a 'universal basic data income'?

Universal basic income (UBI) has often been proposed as a social policy remedy against automation-linked job loss in the Fourth Industrial Revolution. The point of departure in the general conversation on UBI is that advances in technology, and a subsequent accelerating shift in the division of labour between humans and intelligent machines, are profoundly shaking up the employment structure, possibly leading to mass technological unemployment. Hence,an unconditional government-guaranteed basic income that each citizen receives can be seen as a way to offset job losses caused by technology.

The idea behind a basic income has been around for a while, and around the world, trials and pilot programs have tested some of the basics behind UBI, with many of these experiments taking place in recent years. But for the most part, it has remained little more than a utopian dream because it has always crashed up against the rocks of reality. Why should people be paid to do nothing? And how could we possibly afford it?

Proponents say that because automation boosts productivity and generates wealth, societies will easily be able to afford a UBI to reduce poverty and income inequality. Opponents, however, argue that it will be way too costly – equivalent to 20-30% of GDP in most countries according to the International Labour Office[1] – and remove the incentive to work, adversely affecting the economy. Most also assume that UBI will be paid from taxes and might take away funds from other government undertakings. Governments could lose the ability to tax workers as machines replace people, leading Bill Gates to suggest a tax on robots that could pay for UBI or something like it.

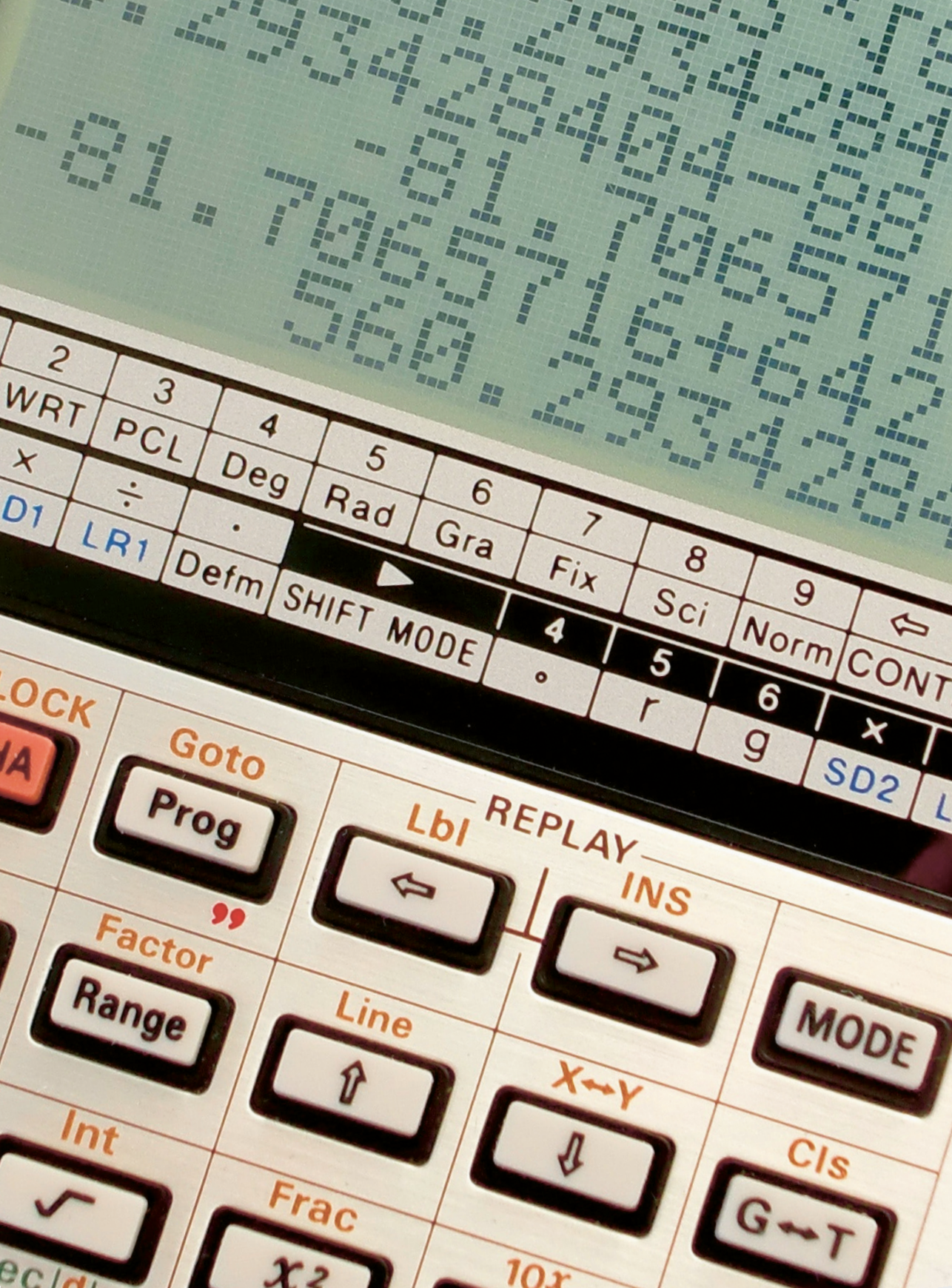
But as we continue to advance into the data-driven technological and digital age, it is nevertheless fair to ask if a universal basic income, as we have known and defined it, is the best fit, or if it is time to think about other ways forward for a universal basic income. Maybe it is time to expand on the concept so that it truly addresses the issues that stem from advancing technology and digitisation, beyond merely technological unemployment. What if we instead received a basic income based on our personal data, paid by the companies who are currently reaping all of the value from it?

DATA AS A PERSONAL ASSET

The line of reasoning to support a universal basic data income would go something like this: there is little doubt that our data is all-important for the functioning and future evolution of the digital age. Furthermore, as the Fourth Industrial Revolution comes into full effect, we can expect a growing need for access to personal data, which will be used to continuously 'upskill' the AI systems that will make the business models of the digital age possible.

So, how about remunerating people for the data they produce, which is used to 'train' the intelligent machines and fine-tune digital business models,

1 Isabel Ortiz, Christina Behrendt et al: "Universal Basic Income proposals in light of ILO standards: Key issues and global costing", International Labour Office (2018), bit.ly/3uYPyLC.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Defm
SHIFT MODE
4
5
6
x
°
r
g
SD2
LOCK
Goto
Prog
Lbl
REPLAY
INS
Factor
Range
Line
MODE
X⇔Y
Int
Cls
Frac
G⇔T

by paying them some sort of 'royalty' for the data that the global commercial tech giants currently have at their disposal free of charge? Essentially, it would be a data-for-basic income swap!

A look at the numbers shows just how large and profitable the data economy has grown in recent years and how much faster it will grow in the years ahead. In 2020, according to the International Data Corporation (IDC), 64.2 zettabytes of data were generated globally from all sources, up from 33 zettabyte in 2018, and with an expected growth to more than 180 zettabytes in 2025.[2] One zettabyte comes with 21 zeros; to give a better understanding of scale, a zettabyte stored in printed books would require a stack reaching to the sun and back five times![3]

While the majority of data is generated by machines and sensors on the Internet of Things, the amount of data created by people has increased rather dramatically during the COVID-19 pandemic. This development has accelerated our virtually enabled lives by moving a much greater portion of our day-to-day activities online, be it working, learning, shopping, socialising or entertainment. Today, at the tail end of the pandemic, there is really no reason to believe that the convergence of our digital and analogue lives will not continue unabated, eventually reaching a state where the physical and digital components of our lives interact seamlessly in a hybrid reality. Despite the already unbelievable amounts of data we produce, we receive very little value in return for it apart from some 'free' services, which, in reality, work to gather yet more data, more often than not without our knowledge or permission.

However, as a prerequisite for a universal basic data income, the data we produce needs to be recognised for what it is: a personal asset. Furthermore, we would need to figure out fair and effective systems of valuing data. The fact that there is no universally agreed upon definition of the 'data economy' does not make this task any easier. In a recently updated study – published before it was possible to fully grasp the repercussions of the pandemic on the collection and monetisation of data globally – the European Commission assessed that by 2025, the value of the data economy (defined as the direct, indirect, and induced effects of the monetisation of data on the economy) could rise to more than EUR 1,040 billion – and this estimate is for the EU27 and the UK alone.[4]

A NEW SOCIAL CONTRACT

Recently, there has been a persistent focus on giving people back their data autonomy, leading to the introduction of data protection laws across the world (such as the GDPR in the EU, the CCPA in California, and the Personal Information Protection Law in China). We have also seen the EU ramp up their efforts to make sure that tech giants pay their fair share of taxes. But beyond reasserting people's data privacy and ownership and collecting taxes from tech giants, the time is ripe to explore how to create more inclusive and equitable models that help every person benefit from the economic value of their data. This scrutiny is especially relevant if the somewhat dystopian promise of jobs being swept away by new technologies holds true, creating an even more unequal world. And, at the end of the day, a government-guaran-

2 International Data Corporation: "Worldwide Global DataSphere Forecast, 2021 - 2025" (2021).

3 As estimated by data scientist Riza Berkan in a 2012 blog post "Big Data: A Blessing and a Curse", bit.ly/2UtsBUo.

4 European Commission: "The European Data Market Monitoring Tool" (2020).

teed basic income might be less feasible in a future where global commercial tech giants could stand shoulder to shoulder with governments in terms of influence and power – and even more so in the wake of the COVID-19 crisis, which have further reasserted the power of tech giants in society. In such a future, we need to build a new social contract for the digital age. A universal basic data income could be part of the answer!

The idea that the value of the digital economy should be shared fairly with the producers of the data – we, the people – as part of an equitable and sustainable renewed social contract was first explored by tech philosopher Jaron Lanier in 2013 in his well-known book *Who Owns the Future?*[5] Later, in the 2018 book *Radical Markets*, Eric Posner and Glen Weyl argue in favour of a social data dividend. The size of this share would depend on how much of the labour market becomes automated, with people receiving a larger data dividend the more jobs that are taken over by artificial intelligence (thanks, in part, to their data). Estimates vary from a dividend that would raise US household median income by USD 500 a year in a present-day scenario, to USD 20,000 some 15 years down the line.[6]

It is beyond any doubt that data is the crucial ingredient of the digital economy and the Fourth Industrial Revolution in general and, hence, is spoken of as the most valuable resource of the digital age — 'the new oil'. The value of data continues to grow in a world where every move in the digital realm is recorded, as data becomes increasingly critical to nearly all aspects of human life. All the while, the number of digital devices and intelligent machines grows exponentially – from intelligent personal assistants and smart home devices to autonomous cars – transforming the way we live, work, and play.

With this in mind, the reasoning for a UBDI doesn't sound so far fetched. After all, it is our data – our preferences, behaviour, dislikes, interests, friendships, consumer choices, activities, and whereabouts — our very identity — that is driving the evolution of the Fourth Industrial Revolution and our increasingly digital world. Shouldn't we be exploring new models that better allows for equitable participation in the digital age? ■

5 Jaron Lanier (2013). "Who Owns the Future?".

6 Eric A. Posner & E. Glen Weyl (2018). "Radical Markets: Uprooting Capitalism and Democracy for a Just Society".

TECH PHILOSOPHER JARON LANIER AND ECONOMIST GLEN WEYL
PHOTO: LEANDRO AGRO

INTERVIEW WITH ANTHROPOLOGIST DENNIS NØRMARK

Will technology mean less work or more ‘pseudo work’?

In 1930, economist John Maynard Keynes famously predicted the coming of the 15-hour work week. He foresaw a future where technological advances and new ideas had boosted workplace efficiency and productivity to such a degree that his own grandchildren would need to work no more than three hours a day. Our labour would produce more products and services, and this would free up time for us so that we could work less.

Keyne's prediction made sense at the time. Since the late 1800s, weekly working hours had declined at a steady pace concurrent with industrialisation and innovations in technology and work practices. Fast forward to 2015, when a journalist tracked down Keyne's actual descendants, one a university professor, another a self-employed psychotherapist, and it turned out that their average weekly work hours were nowhere near 15. In fact, they claimed to work no less than 100 (from breakfast until bedtime) and 50 hours per week, respectively.[1] Obviously, things didn't turn out exactly as Keynes expected.

It's not that productivity hasn't increased since the 1930's. It has, by a great deal. But still, in most of the Western world, average weekly work hours have been on a steady level for three decades.[2] Some countries, like Germany, have continued the downward journey toward shorter working weeks, but for most OECD countries, the downward slope has more or less plateaued since the 1980s.

So why aren't we working less, as Keynes predicted? The answer to that question depends on who you ask. You might point to shorter work weeks and other labour concessions having resulted from the historical power and influence of labour movements, which have waned in many Western countries since the 1970s. Taking this view, the 'rewards' of productivity gains have not gone to workers in the form less hours on the job, but toward CEO compensation and shareholder returns, which have outpaced productivity growth (see page 29). Or you might try to explain away stagnant work hours by reference to a general increase in consumption of goods and services, or how capitalism encourages constant innovation, which means that lowering weekly work hours would result in companies losing out on competitiveness.

Danish anthropologist Dennis Nørmark believes that there is another explanation. The problem, as he sees it, is that we have figured out clever new ways to appear busy by performing what he calls 'pseudo work' – workplace activities that look meaningful and valuable on the surface, but which do not contribute to furthering the goals of an organisation. Pseudo work thrives in the modern corporate office work culture where it comes in many forms, from unnecessary meetings and work groups or quarterly status reports with zero downloads, to internal vision statements and power point presentations that lead nowhere. On the surface, it all looks like real work, and people are paid to do it; but if they didn't, no one would miss it. It will never be automated by an AI our outsourced to a different country because there is no real need or demand for it.

As proof of the degree to which pseudo work exists, Nørmark points to a range of studies done in Denmark and abroad. These include a British survey in which 37% of respondents replied that they believe their jobs contribute nothing to the world, statistics showing that many online private shopping sites reach peak hours

1 Planet Money: "Why We Work So Much", .npr.org/transcripts/426017148.

2 Ourworldindata.org: "Working Hours", ourworldindata.org/working-hours.

on Mondays between 9 am and 4 pm, and research demonstrating that the amount of work we get done is usually not correlated with how busy we feel or claim to be.

Nørmark's new book *Back to Work* (Danish: *Tilbage til Arbejdet*, 2021) contains a set of guidelines that the author hopes can help employees and managers take matters into their own hands to address pseudo work at the workplace. It is a need that will become increasingly pressing in the Fourth Industrial Revolution, with its promises of AI and other digital technologies transforming the workplace and increasing efficiency. The risk, according to Nørmark, is that the new wave of digital technologies will not reduce our workload, but instead might end up doing the opposite.

'The digitalisation of the workplace is one of the primary sources of pseudo work,' he says. **'Digitisation is often treated as a fix-all solution that might automate some processes, but which, if implemented in a careless manner, often ends up creating more tasks related to operation and evaluation.'**

Yet digital technology alone can't shoulder all the blame for why pseudo work exists. The problem, to Nørmark, is compounded by the fact that we still measure the value of our work by the hours spent performing it, rather than the usefulness of its output, something that we lack good measurements for. In industrialised economies, the value-creation output has been decoupled from the input (time). When weekly working hours remain stagnant despite productivity increases – which they have in many nations since the 1980s – that's when 'Parkinson's law' comes into effect.

'Parkinson's law states that completing a work task tends to take the time allocated to it,' Nørmark explains. **'If you have a job that only takes 20 hours a week to do, you will find something else to spend the remaining 17 hours on – stretching out the time spent doing actual productive work so that it makes up a 37-hour work week (the standard Danish work week, ed.).'**

'You can see this law in action in OECD numbers gathered between 1990 and 2012 showing that the countries where people work less tend to be the countries where employees are most productive.'

Nørmark's research into pseudo work leans heavily on the work of the late American anthropologist David Graeber, who spent a good deal of his last years writing about what he called 'bullshit jobs'. Graeber argued that these jobs aren't just unnecessary and pointless, but indeed destructive when this pointlessness becomes paired with a work ethic that correlates one's job with one's self-worth.

Both Graeber and Nørmark rely on the self-reporting of their informants (usually modern workplace employees) in judging what is and isn't pseudo work. As they both point out, the best indicator of that is if the person performing it can see the value and meaning in it.

Still, there are significant differences between the two as well, and while their diagnoses of the problem may be similar, their proposals for solutions are fundamentally different. Because Graeber saw the *bullshitisation* of work as a systemic

problem related to capitalism, he believed any solution would need to be systemic as well. He advocated for political action in the form of Universal Basic Income (UBI), which he hoped would contribute to the decoupling of work and self-worth, thereby allowing people to spend their time doing more meaningful work that wasn't necessarily organised as a job.

Nørmark's *Back to Work* is an attempt at fixing what is broken by addressing the problem locally rather than universally – at the workplace – and providing employees and employers with a field guide to combatting pseudo work. He is suspicious of universal solutions like the UBI, which Graeber was a proponent of.

'The UBI is the tech industry's wet dream, but I think it will create a more unequal society. When the richest people in the world start advocating for UBI, you should think twice. If it is a means to an end – pacifying people while the top hoard the wealth – then that's no good.'

Instead, Nørmark's book includes a series of suggestions for how to eliminate pseudo work at the office. The main advice he offers employers is relatively straight-forward: *ask your employees*. If they have a feeling that some of their work tasks are unnecessary, then they probably are. But combatting pseudo work is no easy task, especially considering how well it hides itself, and organisations are often not aware of the degree to which they are plagued by it. The book is also a call for workplaces to cut down on use of corporate jargon, which is often used to camouflage hollow work tasks or to obfuscate a lack of purpose.

'**Pseudo work thrives in lack of transparency. If you dress up the work task in complex sounding lingo, you can hide the fact that no real work is being done. The problem is biggest in very large organisations where there might not be a strong interest by management to change things. Because ownership is so diffuse, including a C-suite with relatively short-sighted interests, there is no incentive to expose the level of pseudo-work that goes on in that organisation.'**

To Nørmark, unlike Graeber, capitalism itself doesn't necessarily create pseudo work, but certain conditions existing within the market do, including monopolisation. This, to him, is part of the explanation of why pseudo work is allowed to fester instead of being rooted out by a market in constant search for efficiency.

'Pseudo work thrives in massive, complex organisations. Consider the big accounting firms operating in Denmark. There is only a handful of them, and they have the entire market covered. It's almost unthinkable that any of them should collapse,' he says.

'You can survive for a long time on consolidation and acquisitions of your competitors. When you couple this advantage with the relatively unclear structure of ownership, where managers and directors have very little skin in the game, then it's no wonder there's a kind of indifference to the problem. So, my book is also a critique of monopolisation, which creates fruitful conditions for pseudo work,' Nørmark explains.

'I usually come across a very different attitude toward pseudo work in companies where the original founder is still the managing director. They have their own money and prestige invested in the company, and if

something goes wrong, they can't just point to 'increasing complexity' as the culprit.'

If previous waves of technological change are anything to go by, we can expect the Fourth Industrial Revolution to fundamentally change how (and perhaps also how much) we work. When it comes to pseudo work, does Nørmark believe that the Fourth Industrial Revolution will bring about some needed change, or will it be more of the same?

'I don't think it will be any different. We have been surprised in the past about how many new jobs we can create for ourselves. Lots of jobs will be reshaped by the coming wave of automation, but I don't believe in a widespread extinction of jobs," he says. **'I do think it would be a good time to start asking whether we even need to work – have a job – at all costs. We are afraid of joblessness and idleness, but jobs are not useful just because they exist.'**

So, how should organisations and employees prepare for the Fourth Industrial Revolution, avoiding the risks of creating more pseudowork but without falling into the anti-technology trap?

"Technology has always come with the promise of optimisation. The problem is when we think in terms of 'solutions' rather than tools. 'Solutions' are prestige projects designed to disrupt existing systems – and they are carried forth by consultants who are experts in selling this particular need. Tools, on the other hand, are designed to solve specific problems. There are salesmen everywhere trying to sell you 'digital solutions', so be wary of false promises.'

'We also need to start asking better questions. In my book I ask: if digitisation is the answer, then what is the question? Do we really need a digitised version of the MUS? (employee performance review, ed.).' ■

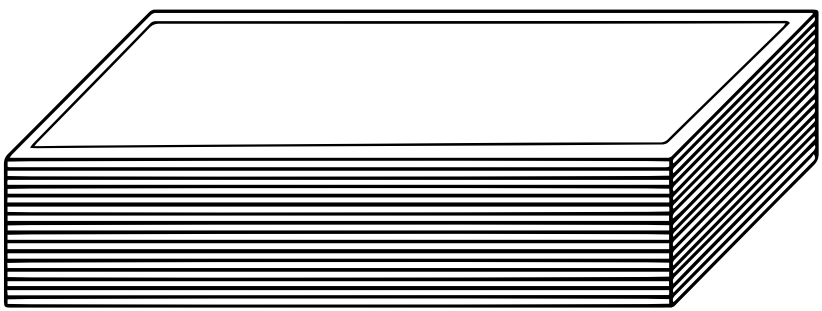


PHOTO: SWAPNIL SHARMA

Technology and the climate crisis

Is advancing technology part of the answer to the ongoing climate crisis, or part of the problem? As is often the case, the answer is a little bit of both. While new technological advances and investments in research and development accelerate the transition toward green energy, the imperative for growth that encourages increased consumption, and the resulting resource and energy use has so far rapidly outpaced our ability to reduce greenhouse gas emissions via green technology.[1]

This fact notwithstanding, it is generally agreed that future advances in technology have the potential to be beneficial for the climate. What isn't agreed on is what should be done to make it happen (and how it should be done). At one extreme we have the 'techno-optimists', who claim that we shouldn't introduce measures to reduce our climate footprint today since market-driven innovation, as a matter of course, will result in technologies that will make effective measures much less costly. If that doesn't happen, then it is because the consumers of the world don't prioritise the climate; why, then, should we force them to? At the other extreme, we have the 'market interventionists' who don't trust that market forces alone will be enough to handle the problem and that government regulationsand other measures are required to curb climate change – the sooner the better.

Both sides have a point. Regulations and measures are likely necessary to reach emission goals. For one thing, the market doesn't always account for externalities that will become costly in the future: without regulation and taxes, oil producers, carmakers, airlines, and drivers would not have to account for their respective carbon emissions and environmental impact. Market forces in the Western world also translate into importing a lot of consumer goods from Asia because they are cheaper, even though the carbon footprint of manufacturing goods in Asia tends to be bigger than in more regulated Western countries.[2] However, regulations and taxes alone aren't enough and can lead to market actors milking subsidies for profit rather than fostering innovations that will benefit both consumers and ultimately the world. In fact, there are clear examples where market-driven innovation directly or indirectly benefits the climate, as we shall see below.

THE COST OF THE INTERNET

The internet is a good example of how new technology can pose a threat to the climate but also benefit it. According to the International Energy Agency (IEA), the global energy cost of data transmission was roughly 250 TWh in 2019, with data centres responsible for another 200 TWH and a total of nearly 2% of global electricity use. With global internet traffic growing about 30% a year, this could look like a recipe for disaster. However, efficiency gains look to offset most or all the increase in traffic. The IEA says that fixed-line network energy intensity has halved every two years since 2000, and mobile-access network energy efficiency has improved by 10-30% annually in recent years. While mo-

1 Thomas Wiedman et al.: "Scientists' warning on affluence", Nature (2020), go.nature.com/3q0wg80.

2 The World Bank: "CO2 emissions (kg per PPP usd of GDP)", bit.ly/2RZ1ole.

bile networks use significantly more power per GB transmitted, by 2025-30, 5G networks could be up to 10 to 20 times more energy-efficient than 4G networks.[3] From 2010 to 2018, the global output from data centres grew sixfold, but their energy consumption only grew by 6%. In addition, large high-efficiency data centres, such as those run by Google, Amazon and Facebook, only use an average 1/6th the energy of on-premises computers for the same calculations. Moving on-premises workloads to large-scale data centres could therefore lower the workload carbon footprint by as much as 88%.[4] These efficiency gains are not chiefly a result of regulation; they lead to significantly lower energy costs for the corporations running the data centres and networks, hence providing a great competitive advantage.

REPLACEMENT TECHNOLOGIES

When we look at the energy cost of a certain technology, it is also important to consider the energy cost of whatever technologies it replaces. LED light bulbs, for example, only use about 15% as much energy as incandescent bulbs and last 20 times as long. While modern TV screens tend to be far bigger than the cathode-ray tube (CRT) screens of old, they don't use more electricity – a 60" LED screen uses roughly the same energy per hour as a 20" CRT screen. Video conferencing has grown manyfold during the COVID-19 pandemic, with an associated increase in electricity use – but in return, energy formerly used on commuting and travel has been saved. Calculations show that a weekly one-hour Zoom meeting with six participants produces annual carbon emissions roughly comparable to driving a non-electric car 15 km or an electric car 50 km.[5] If just one participant refrains from commuting by car one or two days a year because of the opportunity to conference from home, there is a net benefit for the climate.

Digital technology generally has far greater efficiency gains than other types of technology, as witnessed by exponential growth laws such as Moore's Law. This means that when a non-digital technology is replaced by a digital technology, we can generally expect considerable efficiency gains, including energy efficiency.

CLIMATE-UNFRIENDLY TECHNOLOGY

However, not all replacement technologies are climate-friendlier than existing technologies and some new technologies come with an extremely high climate cost. Bitcoin mining alone was responsible for 0.2-0.3% of global electricity use in 2019.[6] In 2021, BBC calculated that in the UK, each hour of streaming, satellite, or cable TV transmission used about three times as much energy as terrestrial (broadcast) transmission.[7] Mobile phones have replaced fixed-line phones, but the short lifecycle of a modern smartphone means that they have a giant climate footprint. The full lifecycle of Europe's smartphones, from production to disposal, is responsible for 14 million tonnes of emissions (CO_2 equivalents) each year, with production and disposal responsible for 72% of this. The average lifespan of a smartphone in Europe is three years and increasing their lifetime by just one year would save more than 2 million tonnes of emissions.[8] Regulations to make smartphones easier to recycle and repair, and that are against built-in obso-

3 "Data Centres and Data Transmission Networks", IEA 2020, bit.ly/3fCmzJ2.

4 Sean Ratka & Francisco Boshell: "The nexus between data centres, efficiency and renewables: a role model for the energy transition", Energypost.eu 2020, bit.ly/3g47Yp3.

5 Peter Cuciu: "Do We Need To Worry That Zoom Calls Use Too Much Energy?", Forbes 2021, bit.ly/3p85aLz.

6 "Data Centres and Data Transmission Networks", IEA 2020, bit.ly/3fCmzJ2.

7 Jigna Chandaria, Natasha Westland, Chloe Fletcher: "How much energy is used to deliver and watch TV programmes?", BBC 2020 (updated 2021), bbc.in/3cFgjhV.

8 Mauro Anastasio: Revealed: "The climate cost of 'disposable smartphones'", EEB 2019, bit.ly/3uKGKJm.

lescence, could be necessary to make smartphones more climate friendly.

Indeed, it is important to note that considerable efforts are made to ensure that new technology is climate-friendly. Yet increased consumption by a growing global population and an expanding global middle class will likely mean a greater overall climate footprint from technology, all else being equal. For this reason, cleaner replacement technologies alone may not be enough to address the pressing issue of climate change. Technologies specifically aimed at counteracting carbon emissions will almost certainly also be required, as will some degree of targeted regulation.

SMART SOLUTIONS

Smart home solutions reduce energy consumption by monitoring the presence of people, sometimes even learning their habits and anticipating needs in advance. Occupancy sensors alone can reduce energy use in homes by 30%, according to the United Kingdom's Carbon Trust. Back in 2013, King's College London cut its lighting energy use by nearly 90% through the installation of sensor-controlled indoor lighting.[9] In a similar manner, smart city solutions can significantly reduce a city's climate footprint by having AI monitor and manage traffic, energy use, pollution, and waste collection. Given that the share of the world's population living in cities is expected to increase from roughly 50% today to 70% by 2050, smart city solutions can potentially play an important role in mitigating energy consumption in urban areas.

Artificial intelligence may be the most important tool for reducing the overall climate footprint of technology. In 2016, Google had its DeepMind AI analyse past data from sensors within one of their own data centres, leading to a 40% reduction of energy used on cooling, which amounts to a 15% reduction of overall energy used by the centre.[10] More recently, the Canadian company BrainBox AI claimed to be able to cut energy consumption in a building by approximately 20-25% by using AI to optimise the use of existing heating, ventilation, and air conditioning (HVAC) systems.[11] With buildings responsible for roughly a third of global energy use, such reductions, if globally applicable, could lead to significant reductions in worldwide energy use and associated carbon emissions.

OTHER WAYS THAT TECHNOLOGY MAY BENEFIT THE CLIMATE

Reshoring is a term used for when production and services that used to be 'offshored' to other parts of the world are relocated in closer proximity to the consumers. Increasing automation through robots and artificial intelligence is believed to lead to a wave of reshoring in the future because the reduced need for human labour will make labour arbitrage less of a primary concern. This will reduce transport and hence the climate footprint. However, loose climate regulation in developing countries could still provide a competitive advantage there to the detriment of the climate, and this could work against reshoring unless appropriate regulations are implemented.

Blockchain technologies can be used to provide greater transparency in carbon credits and thus reduce carbon-credit fraud. This deception is a major problem as an estimated €50 billion a year is lost to European tax autho-

9 Caio Bersot: "Can a Smart Home Really Help You Save Energy (And Money)?", IoT for All 2020, bit.ly/3yRTxwO.

10 Sean Ratka & Francisco Boshell: "The nexus between data centres, efficiency and renewables: a role model for the energy transition", Energypost.eu 2020, bit.ly/3g47Yp3.

11 Aaron Larson: "How Artificial Intelligence Is Improving the Energy Efficiency of Buildings", Power Magazine 2021, bit.ly/3i7NBd3.

rities because of fraud,[12] not to mention the cost of the fraudulent carbon credits to the climate. Blockchain can also be used to tokenise assets in green energy, making investments and trading easier, as well as to track resource extraction and conservation initiatives.

Genetically modified organisms (GMO) can be engineered that break down plastic waste, trap CO_2 in the soil, reduce cattle methane emissions, remove nitrous oxide from the atmosphere, or otherwise benefit the climate.[13] ■

12 Jack Horgan-Jones: "Carbon credit fraud in the EU: how does it work?", Irish Times 2019, bit.ly/3fJgBGm.

13 See e.g. Nanjing Agricultural University: "Engineering a way out of climate change: Genetically modified organisms could be the key", PhysOrg 2020, bit.ly/34G6VpQ.

Regulation and law in the fourth industrial revolution

Explorations of the Fourth Industrial Revolution have a tendency to focus on notions of progress that may be at odds with law and regulation, which many view as rigid fields steeped in opaque procedures. Indeed, regulation of emerging technology is often accused of not only struggling to keep up with current developments, but also slowing the pace of innovation. Articles, position papers, studies, and statements from all levels of government calling for streamlined regulation, smarter and future-proofed legislation, and cutting through red tape abound, as most recently evidenced by a communication from the European Commission in April 2021.[1] The core message, while from many different messengers, is clear: change is needed in the fields of law and regulation in order to meet the challenges and deliver the full potential of the future. In the following, we explore several examples of how regulators are beginning to respond to these calls for change and are adapting to the rise of new technologies, as well as crucial questions that this raises about the future role of law and regulation.

LEGAL PROFESSION AND LAW ENFORCEMENT: Motion to dismiss humans

While law and law enforcement may be among the fields reputed to be the most resistant to change, they may conversely be among those most affected by the Fourth Industrial Revolution. Digitisation, automation, and the broader application of technology in everyday life could upend nearly all aspects of how law is practiced and enforced, while also posing a potential threat to the human workforce and even raising important new legal questions.

For one, the meticulous work of analysing thousands of documents and complex case law and constructing logical arguments founded on precedent, which can take thousands of working hours for even the most skilled professionals, can already be carried by AI-supported digital tools in seconds.[2] There are also impressive applications of AI for taking legal action. The online 'robot lawyer' DoNotPay provides a great example. The AI-driven online platform allows users to undertake both mundane legal activities such as contesting parking tickets (with a success rate of around 60%)[3] or claiming compensations from airlines, as well as high-stakes endeavours like initiating a lawsuit or petitioning for asylum. Of course, while the emergence of mass automation in law could be a boon for some, it could spell disaster for many legal professionals who may soon face an insurmountable army of virtual competitors. For example, a 2020 report from the World Economic Forum identified workers in the legal sector as one of the top ten types of jobs at risk for mass redundancy in the coming years. Already in the United States alone, employment among legal secretaries and information and record clerks shrunk by over 30% in the last decade.[4]

Examining law enforcement, moreover, highlights some of the Fourth In-

1 European Commission: "Questions and Answers on the Better Regulation Communication" (2021), bit.ly/3d9R73e.

2 Erin Winick: "Lawyer Bots Are Shaking Up Jobs", (2017), MIT Technology Review, bit.ly/3xPSvA8.

3 Samuel Gibbs: "Chatbot lawyer overturns 160,000 parking tickets in London and New York", The Guardian (2016), bit.ly/3wSZo3F.

4 WEF: "Future of Jobs" (2020), bit.ly/3h3D14v.

PHOTO: COTTONBRO

dustrial Revolution's most prominent benefits and potential risks. As with legal practice, digital platforms and tools are demonstrating how core functions of law enforcement can be performed with much greater efficiency and strikingly higher levels of accuracy than humans. Massive court backlogs, which delay the pursuit of justice, undermine public confidence in legal systems, and risk unfair treatment of defendants and plaintiffs alike, could be reduced by the automation of many tedious administrative procedures and uncontested cases.[5] A more comprehensive integration of and reliance upon emerging technologies in the courtroom could also ensure more fairness in critical procedures. For example, automated jury selection may produce juries that are more balanced and representative of the population. Moreover, AI judges or, at the very least, AI-supported decision-making tools for human judges could render fairer verdicts and help control for factors that have been correlated with disproportionately lenient or harsh sentencing of defendants such as a judge's mood, prejudices, or whether a judge has recently eaten a meal.[6]

At the same time, increased dependence on technology entails renewed concerns about the fairness of justice systems both in and outside of the courtroom: predictive algorithms and advanced analytics platforms could make it easier to hand-pick juries,[7] and automated jury selection systems could be affected by the biases of the humans that create, test, and train them. By the same token, AI judges could end up exacerbating biases in decision making, thereby reinforcing already institutionalised forms of discrimination against individuals. In a darker scenario, maligned and tech-savvy defendants or hackers-for-hire could engage in new forms of obstruction of justice by manipulating tech-reliant systems or corrupting key processes to force mistrials or acquittals.

Concerns about bias and misuse of emerging technologies are perhaps even more widespread in the realm of policing, which is already rife with both accusations and examples of bias and discrimination related to human activity alone. The emergence of predictive policing – the use of specialised algorithms and massive troves of data collected from crime reports, video and communications surveillance, and historical crime trends to predict where future criminal activities may occur – has especially raised alarms. Some have argued that while predictive policing may help reduce crime, it also presents risks of reinforcing discriminatory policing practices, violating individuals' civil rights, and assigning suspiciousness or assumed guilt to specific groups – most often minorities – simply by virtue of being at the wrong place at the wrong time.

With increasing reliance on technology, the time may also be ripe to consider questions about the overall legitimacy of the use of tools like AI in such consequential contexts. And on an even broader scale, what about cases involving AI and other emerging technologies? That is, who is liable when AI commits, or is suspected of committing a crime? Legal scholars have begun exploring this through the example of an automated vehicle killing someone – a once hypothetical situation that unfortunately became a reality in 2018[8] – highlighting the gap between current technological capabilities and the rea-

5 World Bank Group: "Improving Public Sector Performance" (2018) bit.ly/3vN26Gs.

6 Andreas Glöckner: "The irrational hungry judge effect revisited", Judgement and Decision Making (2016), https://bit.ly/2U3NeGE. | Daniel L. Chen: "Machine Learning and the Rule of Law" (2019), SSRN bit.ly/3wTQZNj.

7 Artificial Lawyer: "Voltaire Uses AI and Big Data to Help Pick Your Jury" (2017) bit.ly/3wYty5q.

8 BBC News: "Uber's self-driving operator charged over fatal crash" (2020), bbc.in/2T17XKU.

diness of legal systems. Here, a multitude of new factors may have to be considered: Was the car hacked? Was its firmware up to date? Did the software or hardware producers create a defective product? Was there human negligence on behalf of an assigned safety operator, the pedestrian, or maintenance technician? And, if any of these parties were found guilty, what sanctions would be appropriate?

On the whole, while proponents of many of the technologies driving the Fourth Industrial Revolution are eager to further integrate them into our lives, issues such as these highlight that there may be a lack of societal readiness, and that playing catch-up, as the law often does, may not be sufficient.

REGULATION AND TAXATION: Unhealthy and wealthy

Rising inequality, characterised largely by the continued accumulation of wealth by an increasingly small portion of the global population and the decoupling of wage growth from productivity growth (a gap which has increased drastically since the 1970s)[9] have garnered greater attention in recent years. Negative attention to this development has particularly grown with the onset of the COVID-19 pandemic, as already well-established billionaires, mostly working in or benefitting from sectors driving the Fourth Industrial Revolution (e.g., big tech, data companies, major financial institutions), have increased their wealth by over 27%[10] due in large part to a surge in the already massive consumer demand for online platforms and services. By contrast, the share of the global population living in extreme poverty has been projected to increase for the first time in over two decades.[11]

Among the many potential factors contributing to the rise of inequality, observers and critics have been keen to point out two: the flaws and failures of 'trickle down', supply-side economic policies and loose or easily circumventable tax codes. One widely proposed solution to the alleged shortcomings of these policies is the introduction of a wealth tax. The claim is that a tax on wealth (that is, the value of one's assets minus liabilities) would provide more sustainable revenue to governments while also limiting taxpayers' ability to reduce their tax liability by stashing liquid assets in offshore accounts and tax havens and reducing the stark economic inequality that has become virtually ubiquitous.[12] As the accumulation of wealth is increasingly driven by the harbingers of the Fourth Industrial Revolution, which, on account of their growing multinational presence and market dominance, are often accused of skirting regulations and tax laws, the introduction of a wealth tax could prove to be a helpful tool in the fight against economic inequality.

Recently, amid the COVID-19 pandemic, conversations for the broader introduction of a wealth tax (currently only five European countries have one) have become more serious. For example, a recent report from the UK's Wealth Tax Commission made up of a wide range of UK experts in law, economics, and accounting provides one of the most extensive analyses of the implications of different kinds of wealth taxes to date and has managed to spur a great deal of public debate in the UK.[13] Even in conservative countries like Singapore discussions about a wealth tax are on the rise.[14]

To be sure, key questions and doubts

9 Economic Policy Institute: "The Productivity-Pay Gap" (2021), epi.org/productivity-pay-gap/.

10 UBS: "Riding the Storm" (2020), bit.ly/362JKHb.

11 World Bank Group: "Reversals of Fortune" (2020), bit.ly/3gYhU3L.

12 Catherine Clifford: "Top economists Stiglitz and Piketty: The US needs a wealth tax on millionaires and billionaires", Cnbc.com (2020), cnb.cx/3gYbiT6.

13 Wealth Tax Commission: "A wealth tax for the UK" (2020), bit.ly/3zSYIT8.

14 Gayle Goh: "In the line of duty: On wealth taxes, Singapore must decide what it most wants to achieve; and know what it could cost", The Business Times (2021), bit.ly/3gS8Qi5.

remain about the impact, enforceability, and fairness of the wealth tax: will a wealth tax really manage to top up haemorrhaging public coffers, patch up fracturing social solidarity, and reduce inequality to the extent that its supporters claim? Do a given country's tax authorities have the capacity to track and assess taxpayers' wealth accurately and efficiently? Will once physical tax havens go digital with the advent of burgeoning markets for NFTs (crypto assets that record ownership of digital items)? Is it even the right of governments to engage in what some might claim to be double, or even triple, taxation? And will a lack of concerted action by states just lead to a regulatory race to the bottom that exacerbates inequalities?

NATIONALITY AND NATIONAL SOVEREIGNTY

More and more of our identities are bounded and even defined by digital spaces. Where and with whom we spend our time and where we conduct business is increasingly a matter of which online platforms we use, not necessarily the physical spaces we occupy. This raises questions about the need to revisit the concept of nationality. Estonia, a leader in digitalisation of the public sector, may be seen as pioneer in this area with the introduction of its e-residency programme in 2014.[15] E-residency allows nationals from outside Estonia, and even outside of the European Union, to register themselves as digital residents of Estonia for the purposes of running businesses within the European Single Market. While the purposes of this programme are currently exclusively commercial, e-residency highlights a growing need for increased mobility and flexibility of people, labour, and capital as globalisation and digitalisation continue to bring humans and commercial activities closer together (at least in cyberspace) and more frequently across borders than ever before.

What if this were taken a few steps further? If we are spending more time in digital spaces (we even have 'digital natives', members of the youngest generations that were born into mature digital spaces rather than following their development as adults), could we move from e-residency to e-citizenship? Would it be possible to attain special rights and obligations by existing in and fulfilling the requirements put forth in certain digital spaces? What might those rights and obligations be? We already see examples of how individuals that have thus far been nearly impervious to sanctions in the physical world faced swift consequences for breaking the norms of digital platforms, such as Twitter and Facebook's bans on Donald Trump in the lead-up to the 2020 United States Presidential Election.

Digitalisation of nationality could also lead to a digitalisation of sovereignty. In international law, the four traditional components of national sovereignty are (1) hosting a permanent population, (2) a clearly defined territory, (3) a single government, and (4) the capacity to engage in relations with other states.[16] However, with booming digital populations, digital commercial interactions, the rise of digital territories (i.e., internet domains), and relations between online actors, new requirements for national sovereignty could arise in the future, such as maintenance of cyberspace borders and a monopoly on the legitimate use of digital force, e.g., the ability

15 Republic of Estonia: e-resident.gov.ee/ (2021).

16 Malcolm Shaw: International Law (2017).

of a state to control flows of (mis)information, protect digital borders (conduct cyberwarfare), and effectively sanction actors and institutions for digital misconduct. With a rising prevalence of cross-border cyber-attacks (the rate of malware and ransomware attacks have increased by 358% and 435% since 2019, respectively)[17] and massive investments in cybersecurity, this may not be too far-fetched. Indeed, protection of a nation's digital space is increasingly fundamental to maintaining a functioning and orderly society and economy, and failure to adequately defend against an attack could be more devastating for a nation's population than some forms of traditional warfare.

Of course, this also raises questions of whether traditional nation states are at all desirable in the world emerging in the wake of the Fourth Industrial Revolution. Is it time to say farewell to traditional ways of bordering and ordering people and capital? Would humanity benefit more by working to not just more easily traverse national borders, but transcend them? Could new forms of collaboration and solidarity flourish, or would the borders of the past and present just be replaced by firewalls and blockers?

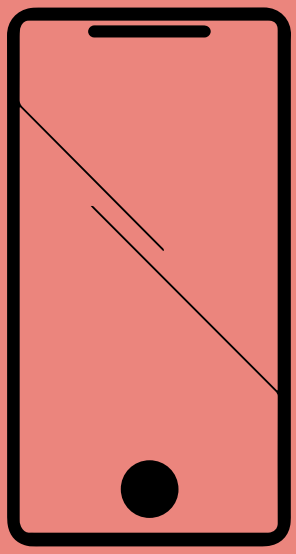
ANSWERS ON THE HORIZON?

Today's discussions about law and regulation in the context of the Fourth Industrial Revolution tend to lead to more questions than answers because, as mentioned above, technological development often outpaces systems' capacity to quickly adapt to change. It is therefore difficult to say with certainty what the answers to many of the questions we have posed are or will be. However, some recent developments, such as the European Commission's proposal for an 'Artificial Intelligence Act' published in April 2021, may provide some early indications.[18] As the first concerted attempt by a geopolitical entity to address looming questions about an emerging and often poorly understood technology, the proposed set of regulations, building on existing patchwork legislation, seek to both balance protections of individuals and society against the need for research- and innovation-friendly environments as well as to address questions about governance and liability as they pertain to the use of artificial intelligence. The proposal has already been met with criticism from many directions, but it may at a minimum provide guidelines for the future. Despite uncertainties around the future, it is nearly certain that the Fourth Industrial Revolution will continue to unfold at a breakneck pace. As the recent European proposals for regulation suggest, it isn't a matter of whether law and regulation will adapt, but how. ■

17 Patricia Stainer: "Alarming Cybersecurity Statistics for 2021 and the Future", Retarus Corporate Blog (2021), bit.ly/3h2U3A0.

18 European Commission: "laying down harmonised rules on artificial intelligence (artificial intelligence act) and amending certain union legislative acts" (2021), bit.ly/3zW5MJi.

As The Fourth Industrial Revolution unfolds, new digital tools will greatly impact both our understanding and practice of health. One of the more promising developments in this area is 'digital therapeutics', which can help ensure a more personalised and holistic approach to healthcare through extensive collection and use of personal health data.



Can we treat diseases with an app?

In April 2021, the Danish government published the new national Danish Life Science Strategy with 38 initiatives to strengthen the health industry and improve treatment of patients. One of those 38 initiatives covers the implementation of 'digital therapeutics', a term which, unless you work with digital health technologies, you are probably not familiar with. The official definition, given by dtxalliance.org, states that 'digital therapeutics deliver evidence-based therapeutic interventions that are driven by high quality software programs to prevent, manage, or treat a medical disorder or disease. They are used independently or in concert with medications, devices, or other therapies to optimise patient care and health outcomes.'[1]

Digital therapeutics are a subcategory of digital health that is based on clinical outcomes from patients and designed to prevent or manage specific physical or mental health conditions. It harnesses the power of technology to impact health by enhancing traditional medical practices, which encourages behavioural change. In some instances, digital therapeutics serve as a direct stand-alone therapy for a health condition.

So, why are digital therapeutics such a big deal? First, by fusing personal behaviour and biology with digital tools and data, it promises to deliver solutions to unmet patient demands that traditional treatment and therapies have not been able to provide. Second, it is the fastest-growing segment in the digital health space. With a current market valuation of around USD 2.88 billion, the estimated global market growth is between USD 11.8 and USD 13.8 billion by 2027. With a compounded annual growth rate at around 20.5%, digital therapeutics vastly outpaces any other digital health technology growth projections.[2] Finally, in a future where many nations will face a severe shortage of health workers, with an estimated global shortfall of 18 million by 2030,[3] health technologies that can supplement human care are sorely needed; digital therapeutics may be key to bridging this gap.

DATA-DRIVEN AND PERSONALISED TREATMENT FOR THE ENGAGED PATIENT

To truly put the 'person' in personalised health, people need to be actively engaged in taking control of their own wellbeing. Digital therapeutics can help support the necessary shift from a 'one size fits all' approach to health toward one that is focused on personalised medicine, where treatment is targeted to the individual. With the right level of health literacy and streams of self-monitored data in their hands, patients can become more engaged and more empowered in their own personalised health care journey.

To do this, digital therapeutics track and use individual health data. These data could be measurements of heart rate, blood sugar, weight, or other relevant input which are collected and analysed on a continuous basis. Upon analysis of the data, providers of digital therapeutics offer individualised activity guidance, nutrition advice or mental and physical exercises to help people reduce stress, pain, high blood pressure, as well as manage or even prevent diabetes. Some of these data are structured in a way that resembles medical records whereas others are more unstructured, such as those produced by wearables. While these types

1 Dtxalliance.org.

2 Allied Market Research: "Digital Therapeutics Market Size Forecast", bit.ly/3qckrLZ.

3 WHO: "Health Workforce", bit.ly/3zKKloR.

of unstructured real-time data can be challenging to interpret and difficult to validate, they are fast becoming a crucial tool to combat non-communicable disease. Heavily impacted by lifestyle and behaviour, these diseases place a growing burden on traditional health systems.

Indeed, the management of chronic and non-communicable diseases ranks as one of the top priorities in the healthcare industry right now. Ensuring patients know how to manage their illnesses and prevent costly health episodes is a fundamental goal of digital therapeutics. One example of digital therapeutics being used to this end is BlueStar, a system that helps patients with type I and type II diabetes handle medication, food, activity, sleep, diet, and psycho-social factors. Patients are encouraged by more than 30,000 automated, tailored, and unique coaching messages, and the actions encouraged by the system – including daily medication administration, physical activity, and smart food choices – are based on recommendations provided by the program and driven by clinical guidelines.[4]

Another example of digital therapeutics in action is Propeller, which is used for asthma patients. It works by attaching a sensor to the patient's inhaler, which tracks medication usage and location data, and then sends that information to an app on the patient's smartphone. Propeller builds a personalised profile, including symptom triggers and disease management tips to help them self-manage their disease. It also provides medication adherence reminders, air quality forecasts, in-app medication refills, and shareable progress reports.

These examples show the potential of digital therapeutics to provide personalised treatment with a more holistic approach than traditional medical treatment can offer, through increased patient engagement and empowerment, 24/7 monitoring of health parameters, and targeting several aspects of a disease at once.

A HOLISTIC APPROACH TO DISEASE MANAGEMENT

Over the past 40 years, there has been a gradual movement toward a more holistic understanding and practice of health and healthcare. Since digital therapeutics often target many aspects of disease management, they play well into this overall shift. Digital therapeutics start-ups are leading the way, but the big players in health are starting to take note as well. As an example, Happify Health, a digital therapeutics provider focusing on personalised mental health, recently entered a partnership with pharmaceutical giant Sanofi about prescription digital therapeutics to address mental health in people suffering from multiple sclerosis. Many other larger pharmaceutical companies have likewise understood the potential of a holistic approach, and have engaged in collaboration with digital therapeutics start-ups to address multiple aspects of their disease area for better health outcomes.

So far, so good. But how do we fulfil the requirement for implementation of digital therapeutics?

There are several prerequisites that must be in place for properly implementing digital therapeutics into existing health systems. One of them is a strong digital infrastructure that supports appropriate and safe usage of data. Such

4 Dtxalliance.org: "Transforming Global Healthcare by Advancing Digital Therapeutics", bit.ly/3hCBUek.

infrastructures must be constructed in a secure and transparent manner that builds trust between users and supports interoperability between systems, both private and public — i.e., the digital therapeutic providers and the healthcare system.

Furthermore, laws and regulations regarding data sharing, consent, quality, and approval of a whole new type of product must be initiated and implemented. Currently, this is happening at a national level and policies and regulations are under development. Countries such as Japan, the US, Germany, and the UK are frontrunners in policy areas and most other developed countries are likely to follow suit in the coming years. Optimally, these national regulations should support cross-border sharing and collaboration where best practices can be shared and utilized.

A major challenge when it comes to digital therapeutics is the question of 'who shall pay' and reimbursement models. Whether or not they should be offered as a part of universal reimbursement, selective payer contract, or private payments though either patients, insurance companies or an employer, must be up to each country to decide.

WHAT'S NEXT?

While there is little doubt that digital therapeutics can play a huge role in the fusing of new digital tools alongside traditional health systems with the goal of managing chronic diseases, it should be noted that most chronic disease come with comorbidities and other risk factors. A 65-year-old smoker with hypertension has a high risk of being diagnosed with type II diabetes, bilateral glaucoma and chronic lumbar pain, making it less likely that they will have the capacity to juggle a different app for each condition. Therefore, the next generation of digital therapeutics must include the ability to manage multiple conditions with high reliability of predictive value simultaneously, so the patient has one integrated interface and only one app to guide them and help manage their conditions.

Assuming such challenges can be overcome, digital therapeutics will be crucial for solving some of the bottlenecks of today's health systems. By combining AI and human intelligence, as well as individual and systemic health data with new reimbursement models that can accommodate early detection, prevention, and cross-border health service, we may be able to establish better approaches to all health needs – be they prevention, treatment, or a health management plan for the person's lifespan. ■

PHOTO: TEONA SWIFT

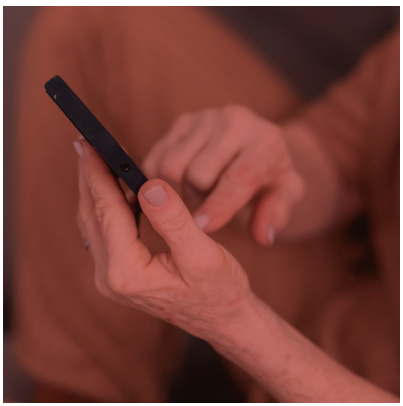


PHOTO: ARTUR ŁUCZKA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Wildcards in the fourth industrial revolution

When looking at future developments in any fields, there are things we can foresee with some degree of certainty while for others, we need to look at several different, likely scenarios. Yet it is often helpful and even necessary to also consider some *unlikely* scenarios that imply radical change. In futures studies, such scenarios are called *wildcards*: possible futures of low probability but high impact if they come to pass. In this article, we look at a few wildcards for how advances in digital technology could change the world.

THE TECHNOLOGICAL SINGULARITY

The ultimate technological wildcard is the rise of the so-called *technological singularity*. The origin of the idea of a technological singularity is attributed to US physicist John von Neumann, but the idea really gained traction in 1993 when noted US computer scientist and science fiction writer Vernor Vinge published his NASA-sponsored essay "The Coming Technological Singularity: How to Survive in the Post-Human Era", where he expanded and detailed the idea.[1] He argued that artificial intelligence (AI) would inevitably surpass human intelligence. Once that happened, this AI would be able to create even more advanced AI, starting a rapid progression of increasingly superhuman AI capable of handling any problem better than human beings, thus signalling the end of the era of human dominance. Vinge wrote that he would be surprised if this didn't happen before 2030.

1 Vernor Vinge: "The Coming Technological Singularity: How to Survive in the Post-Human Era", San Diego State University, bit.ly/3frJQ08.

The technological singularity comes in both utopian and dystopian versions. In the utopian versions, superhuman AI will solve all our problems with energy, climate, economy, sickness, ageing and more, inaugurating a golden age for humanity even if humans couldn't take credit for it. In some utopian versions, the AI makes it possible for people to upload their minds into virtual worlds where they can live forever in the environment of their choice. In the dystopian versions, AI decides to take control of the world, maybe for our own good, or even to kill us all. The mildest dystopian scenario is that we simply become obsolete when everything we can do, AI can do better.

The singularity scenario has been criticised by other thinkers. Some argue that there may be limits to artificial intelligence that prevent the rapid evolution envisioned by Vinge, for instance a lack of self-awareness, while others argue that the fear of a dystopian singularity will make us refrain from developing potentially superhuman AI. Also, if we could develop self-aware AI, we would have to give it rights and consequently, we would refrain from developing AI that far. Better to have imperfect servants that we can treat any way we want than perfect servants that we would need to be considerate of. Yet despite the criticism, the technological singularity remains a possibility that some fear and others hope for. And it could be here within a decade.

A POST-SCARCITY SOCIETY

With robots and AI handling more and more cognitive as well as physical tasks of increasingly complexity, humanity can become liberated from toil. Only jobs requiring creativity, empathy, and other purely human qualities will remain and even in these jobs, all tiresome routine tasks will be handled by robots and AI. With plenty

of clean energy from fusion power or sustainable sources and high-tech replacements for scarce resources, anything we need can be had at infinitesimal costs. It will be a society straight out of *Star Trek*, where everybody can direct their efforts to what really matters to them, whether science, art, family, exploration, or leisure. Such a future may not be far off. In the decade from 2009 to 2019, the cost of solar energy declined 89% while the cost of wind energy declined 70%, with levelized costs for electricity production dropping below any fossil fuel.[2] Assuming future declines on the order of 80% per decade would reduce energy costs to just 4% of today's prices in 20 years, and to less than 1% in 30 years. Of course, costs associated with construction and maintenance may not decline as rapidly, which means that the overall price of electricity will level out and some point. This makes it uncertain that the current rapid decline in costs can be sustained until 2050; but if this should fail, we could very well have commercially viable fusion power by then, given the wealth of current fusion development projects – some of them even promising break even in less than 5 years.[3]

2 Max Roser: "Why did renewables become so cheap so fast? And what can we do to use this global opportunity for green growth?", Our World in Data 2020, bit.ly/3fnOM6f.

3 Tom Clynes: "5 Big Ideas for Making Fusion Power a Reality", IEEE Spectrum 2020, bit.ly/3oVyNQ5.

However, even when we get the means to create a post-scarcity society for everyone, we might not necessarily get one. It is quite possible that the wealth coming from automated labour and inexpensive energy will be very unevenly distributed, mainly benefiting a small elite. See our article on polarisation or e-quality page 26.

EXTREME DECENTRALISATION

One feature of current technological development is that it can be used to empower individuals and small groups, perhaps eventually leading to a world where local communities or even households become far more self-sufficient than is the case today.

One example is energy production. Even today, it isn't uncommon for houses to have solar roof panels. In emerging economies, small solar panels, windmills, and biogas generators make local communities independent of centralised power supply, which is often lacking or absent. We have seen several examples where technologies developed for emerging economies become commonplace in developed economies, with mobile banking being the prime example. Hence, we may well see towns and homes supplying their own power in their future, trading energy with neighbours – selling wind energy on overcast, windy days and buying solar power on still, sunny days. Even fusion power could become decentralised. As an example, Lockheed Martin is working on a reactor allegedly small enough to fit in a truck, but capable of delivering energy to a small city of 100,000 people.[4]

4 Lockeed Martin: "Compact Fusion", lmt.co/3yQvgaz.

Production of some consumer goods could also be decentralised down to the household level with 3D-printers. There are 3D printers available today that can print hard plastic, soft plastic, fabrics, glass, metal, organic materials, concrete and more – sometimes even in combination. While a single household could probably not handle all of these at once, these capacities could be distributed among several households in a neighbourhood or be collected in local print shops. Related technologies like automated milling machines and robotic weaves could supplement local manufacturing. Designs can be bought or shared online and

produced locally (read what MIT professor David Hardt has to say about this scenario on page 8).

Our already very decentralised internet can become even more so with *mesh networks*, where wirelessly linked devices transmit data without the need of a central server, as is already being done in New York City and parts of Spain.[5] Mesh networks can also be used for local telephone connections without the need for service providers, up to a range of 3 km between phones.[6]

Taking advantage of these and coming technologies, local communities and even households can become far more independent than is currently the case and can even save money and energy for transport while doing so. The question is if such independence is desired or if people feel more comfortable with established centralised services that require little or no local effort.

5 Mark Kaufmann: "Mesh networks: An alternative way to connect to the internet gains steam", Mashable.com 2018, bit.ly/3wtY6LM.

6 Kyle Wiggrs: "Oppo's MeshTalk lets phones exchange data up to 3 kilometers without Wi-Fi, Bluetooth, or cell service", Venture Beat 2019, bit.ly/3oTj8Re.

A WORLD RULED BY TECH GIANTS

Over the last few decades, we have seen a handful of tech giants rise in power. Twelve of the biggest tech companies today have annual revenues exceeding USD 100 billion,[7] greater than the GDP of two thirds of the world's nations. Combined, they would rank among the ten richest nations. Due to the global nature of these companies, they are able to avoid paying tax for much of their income. According to new research from ActionAid International, G20 countries are facing a potential gap of USD 32 billion in annual tax revenue from just the five largest Silicon Valley tech companies.[8]

We are seeing tech giants expand into more and more fields, and with this expansion, their influence over customers as well as the amount of data they collect on the world's citizens. Attempts to legally limit the influence of tech giants often run into setbacks and barriers, such as when the EU court in 2020 overruled a ruling by the European Commission that would force Apple to pay EUR 13 billion in back taxes.[9]

A disunited world in the future could well see the tech giants expand their influence further, outside of political control, ultimately becoming more powerful than any nation or union of nations. They would govern almost all global media, communication channels, consumption, and transport, and would even control the space around our planet (as foreshadowed today by Elon Musk's SpaceX, Jeff Bezos' Blue Origin, Richard Branson's Virgin Orbit and Facebook's satellite internet network). These powerful companies would not be subject to political control, but in return neither to political short-sightedness nor populism, which could turn out to be a boon for humanity. Or, in a familiar scenario from dystopian science fiction, the tech giants would wage high-tech war against each other, with humanity caught in the middle.

7 "Top 10 World's Most Valuable Technology Companies in 2021", FXSSI.com 2021, bit.ly/3vx4Url.

8 "World's largest economies losing up to $32 billion in annual tax revenue from Silicon Valley's top five tech companies", ActionAid International 2021, bit.ly/3bZp32e.

9 "Apple, Ireland win €13 billion tax appeal in blow to EU", DW.com 2020, bit.ly/3frqA2T.

CONCLUSION

The above wildcard scenarios do not cover all low-probability, high-impact scenarios; they are merely a selection thereof. Other possible wildcards could be that we soon reach a point where further advances in digital technology, apart from minor refinements, become infeasible (an anti-singularity), or that we develop

self-replicating nanomachines that proceed to transform all organic material in the world into copies of themselves (*a grey goo* scenario), or a *transhuman* scenario where we use technology to transform ourselves into superhuman beings, or ... well, we will leave imagining other possibilities as an exercise for you. The point of wildcard scenarios is not to predict the future, but to illustrate that the future need not necessarily follow the most likely path. They show us that we should be prepared for unlikely eventualities or risk being taken by surprise if they do, in fact, become reality. ■

'The point of wildcard scenarios is not to predict the future, but to illustrate that the future need not necessarily follow the most likely path. They show us that we should be prepared for unlikely eventualities or risk being taken by surprise if they do, in fact, become reality.'

PHOTO: LILIANA DREW

Outro Ask anyone what they think the future will be like and, in all probability, their answer (whether hopeful or pessimistic, or a mixture of the two) will include predictions of wondrous and advanced technology. But just as few people in the past would have guessed the massive impact that the internet has had on our world, there is no telling exactly which technologies – perhaps ones already in existence – will lead to changes that are as significant in the future. Yet while the direction of technological change is unpredictable, some of the challenges that will follow in its wake are not. Many of the anxieties and uncertainties surrounding the Fourth Industrial Revolution, including the degree to which we will see a displacement of human jobs by machines, and the effect this will have on inequality and polarisation, are not new. The motivation that drives the application of new technology in industry also remains the same in many cases: the desire to make products at a higher rate and quality and lower cost that are both useful to society and commercially sustainable.

In spite of these and other continuities, discussions of technology and the future all too often focus on the new and novel, and too little on the slow-moving but powerful shifts that only become visible when we zoom out and see the future on a continuum of change that connects to the past and the present. An evolutionary view of technology – focusing less on invention and more on rate of adoption, less on what separates industry 3.0 and 4.0 and more on what ties them together – often makes more sense when trying to more clearly see changes happening in a wide timeframe.

Yet we can be certain that there will also be rapid and unpredictable shifts ahead as the Fourth Industrial Revolution

kicks into gear. The consequences, however, are not predetermined but will depend on our choices and actions, as we have tried to make clear in the articles and interviews included in this report. This is true on both a local and a global scale. To take the workplace as an example, the possibilities of total connectivity and data ubiquity may support deeper use of data-driven diagnostics to monitor and direct workers in the name of optimisation. On the other hand, they can also support greater autonomy, as evidenced by the recent and worldwide shift towards working from home. They might even be used for both at the same time, depending on the goals and values of any given organisation. On a global scale, questions concerning technology, politics, and power will become ever more relevant. Will the development of AI become more entangled with geopolitics, and will we see 'regional AIs' being developed – for instance a Nordic, European, American, or Chinese version, each encoded with different values that are in alignment with the priorities of decision-makers in their 'parent' nations? Another important question to be explored is which new business models will emerge on top of AI and other impactful technologies – and whether regulators will respond proactively or end up playing catch-up in a poorly understood and therefore poorly regulated environment. One thing we can be certain of is that a reactive approach taken without prior consideration of the many scenarios, blind spots, risk, opportunities, and wildcards surrounding the Fourth Industrial Revolution will be disadvantageous.

We hope that this report has provided food for thought and has helped you to make sense of the possible futures ahead.

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