PUBLIC POLICY IMPLICATIONS OF THE FOURTH INDUSTRIAL REVOLUTION FOR SINGAPORE

Policy Report
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Executive Summary

The Fourth Industrial Revolution has the potential to positively transform the world. It will also herald an era of great uncertainty. This policy report looks into some of the social, economic, political and security repercussions this profound shift will likely have for Singapore. As a small country, Singapore will face difficult challenges in the Fourth Industrial Revolution. But its small size can also be a source of strength by being nimble enough to take advantage of opportunities that arise. As we enter the Fourth Industrial Revolution, the role of the government needs to be enhanced so that it can deal with the repercussions. Only then will Singapore be able to reap the full benefits of this profound shift.

Introduction

This policy report explores how the Fourth Industrial Revolution will impact Singapore in the years to come. Specifically, it attempts to identify what social, economic, political and security implications this profound shift will have for the city-state. It then discusses how Singapore can cope with this uncertain future.

The Fourth Industrial Revolution refers to the convergence of a set of disruptive technologies that will transform the world in the coming decades.[1] This assortment of novel technologies includes artificial intelligence (AI), robotics, the Internet-of-Things (IoT), 3D printing, drones and autonomous vehicles (AVs). While some of these technologies remain under development, the scientists, researchers and engineers working on them are on the verge of major breakthroughs so we may well see many of these technologies becoming a part of our daily lives in the not-too-distant future.

The Fourth Industrial Revolution promises to bring about an age of abundance. From extreme automation and increased productivity to environmental protection and enhanced longevity, this profound shift is expected to benefit humankind in many ways. But as with almost every technological development in human history, the Fourth Industrial Revolution will have a dark side. As a matter of fact, we are beginning to see signs of the downside and this futuristic picture has so far been rather unsettling. In this regard, this policy report asks: what might the downside of the Fourth Industrial Revolution be for Singapore? To date, few studies have answered this question in a systematic manner and this policy report is an attempt to fill that yawning knowledge gap.

As the old adage goes, being ready is the key to success. It should be noted that the Fourth Industrial Revolution is not just about negative implications and dire challenges, because opportunities are abound too. Being prepared for this profound change will not only help us to temper the downside but also to take advantage of the opportunities that come with it. This begs the question: how might we prepare then? Recently, the author posed this question to Professor Klaus Schwab when he met the noted author of *The Fourth Industrial Revolution* and chairman of the World

1 Schwab, Klaus. *The Fourth Industrial Revolution.* Switzerland: World Economic Forum, 2016.

Economic Forum. Schwab's solution was both simple and elegant – to cope with the Fourth Industrial Revolution, we must first understand it. To this end, this policy report is an attempt to help the reader understand this profound change.

The next section explains what the Fourth Industrial Revolution is. It looks into what this profound shift is all about and how it measures up against the previous three industrial revolutions. After that, the assortment of social, economic, political and security implications for Singapore is presented. That section is followed by a discussion of how Singapore might cope with some of the challenges unleashed by this shift. Lastly, this policy report ends with some conclusions.

The Fourth Industrial Revolution Explained

Since 1971, elites have gathered in Davos, a ski resort in Switzerland every January to brainstorm over burning problems of the day. Better known as the World Economic Forum (WEF), the annual event is recognised internationally as one of the most influential meetings in the world – not least because it brings together in one setting prominent politicians, senior government officials, business leaders, civil society figures and academic luminaries from all around the world. The brain-child of German economist, Klaus Schwab, the WEF zooms in on hot-button issues of the day with the aim of preparing attendees with the intellectual capacity to deal with those questions when they returned home after a week or so at Davos.[2] Since last year, a recurring theme has been the Fourth Industrial Revolution, or to be more precise, how this profound shift will soon transform the world as we know it.

Before delving into the Fourth Industrial Revolution, a sense of its antecedents is helpful for context.

The term "industrial revolution" evokes images of rows and rows of machines dominating the production process. The reality is in fact not that far off. The first industrial revolution started in the mid-1700s when steam

2 World Economic Forum. "History: A Partner in Shaping History — The First 40 Years." Accessed August 29, 2016. www.weforum.org/about/history.

power and mechanised production was first introduced in Britain.[3] After that, the second industrial revolution took off in the latter half of the 19th century with the advent of electric power and mass production processes.[4] The third industrial revolution then came about towards the end of the last millennial with the introduction of digital and Internet technology.[5] Fueled by new technologies, these shifts not only mechanised the production process, but also brought disparate manufacturing activities together. The net outcome was significant increases in productivity. The most notable downside of these past industrial revolutions was that they led to a jump in unemployment as manual labour was replaced by machines – a condition known as technological unemployment.[6] But overall, living standards improved over time as more value-added work was created. As we enter the age of the Fourth Industrial Revolution, the question of whether this shift will have more or less similar consequences becomes more pressing.

Even as we speak, the Fourth Industrial Revolution is coalescing thanks to an expansive array of disruptive technologies like artificial intelligence (AI), Internet-of-Things (IoT) and autonomous vehicles (AVs).[7] Some of these technologies, such as AI, are still decades out. Others including AVs are now being tested in pilot programs while IoT products are already rolling off assembly lines. The point here is not really when each of these technologies will become mainstream, but rather when they will converge and reinforce each other.[8] Take for example IoT and AI. The day when the two technologies finally meet, our everyday household appliances will not only interface with each other, like they do now, but will actually be able to foresee our preferences and tastes even before we realise we had them. Sounds far-fetched, but this sci-fi moment might just be around the corner and merely hints at a future that is both exciting and disconcerting all at once.

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3 Schwab, 6–7.

4 Rifkin, Jeremy. “The 2016 World Economic Forum Misfires with its Fourth Industrial Revolution Theme.” *The Huffington Post*, January 14, 2016. www.huffingtonpost.com/jeremy-rifkin/the-2016-world-economic-f_b_8975326.html.

5 Schwab, 7.

6 Rifkin, Jeremy., and Larry Hathaway. “Mastering the Fourth Industrial Revolution.” *The Project Syndicate,* January 21, 2016. www.project-syndicate.org/commentary/fourth-industrial-revolution-innnovation-by-larry-hatheway-2016-01.

7 Schwab, 1.

8 Schwab, 8.

Table 1: Key features of the 1st, 2nd, 3rd & 4th Industrial Revolutions

First Industrial Revolution (18th century)	Second Industrial Revolution (19th century)	Third Industrial Revolution (20th century)	Fourth Industrial Revolution (21st century)
Steam power	Electricity	Electronics	Extreme automation & hyper-connectivity

Source: Schwab, 2016.

While there is still some disagreement over whether the Fourth Industrial Revolution is truly distinct from the Third Industrial Revolution (or merely an extension of it), what is undebatable is that it will be disruptive.[9] Already around the world, newcomers to the taxi business no longer have to own an entire fleet of cabs to compete with incumbents. Through the use of smartphones and mobile e-hailing apps, these newcomers are unsettling the old business model and giving incumbents a run for their money – oftentimes without owning a single cab. And the disruption is not just limited to one or two industries. Entire regions are starting to reel from this profound shift. The city of Detroit is a case in point. Long-standing industrial powerhouse – thanks to automotive giants like General Motors and Ford – the "Motor City" has much of its economic clout overshadowed by Silicon Valley where incidentally, much of the work on technologies associated with the Fourth Industrial Revolution is being done. In all fairness, this shift would not be considered disruptive if Silicon Valley had not created considerably fewer jobs than Detroit did in its heyday.[10] These are but two examples of how the Fourth Industrial Revolution is unsettling long-standing institutions; more significantly, they hint at the kind of social, economic, political and security implications that are likely to surface in the coming years.

Then the critical question is: what might some of these repercussions be for Singapore in particular?

9 Rifkin.

10 Elliot, Larry. "Fourth Industrial Revolution brings promise and peril for humanity." *The Guardian,* January 24, 2016. www.theguardian.com/business/economics-blog/2016/jan/24/4th-industrial-revolution-brings-promise-and-peril-for-humanity-technology-davos.

Potential Implications for Singapore

Using a research methodology that included field visits, stakeholder interviews and document analysis, this policy report has identified a number of possible repercussions for Singapore from the Fourth Industrial Revolution. These unwanted consequences are presented next alongside the disruptive technology they are associated with.

AI & Robotics – loosely defined as human-like intelligence exhibited by machines, AI has come a long way since 1956 when the term was first coined. The world witnessed firsthand the coming-of-age of the technology when an AI program named AlphaGo defeated a Go board game champion from South Korea in March 2016. Since then, the question of whether AI poses an existential threat to humankind has emerged on numerous occasions with luminaries like physicist Stephen Hawking and industrialist Elon Musk urging caution.[11] Will AI wipe us out? The short answer is "no" – at least not for many decades out and only if researchers can answer age-old questions on human learning, consciousness and reasoning. If anything, the real danger with AI is when it comes together with advance robotics resulting in a situation whereby a large number of jobs are either replaced or eliminated by these super-intelligent machines. Bear in mind that the first three industrial revolutions led to the substitution of manual labor by machines. But, they also brought about increases in productivity and higher economic growth. More jobs were in turn created and standards of living improved overall. What might presumably be different this time with the convergence of AI and robotics is that the number of jobs lost could be substantial and more importantly, subsequent job growth might be minimal because the new jobs created when the economy grows would also be filled by AI-enabled robotics.[12] Estimates vary but one gloomy report has suggested that as many as seven million jobs around the world could be lost when these super-intelligent machines come online.[13]

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11 Cellan-Jones, Rory. "Stephen Hawking warns artificial intelligence could end mankind." *BBC*, December 2, 2014. www.bbc.com/news/technology-30290540.

12 Susskind, Richard and Daniel Susskind. *The Future of Professions: How Technology will transform the Work of Human Experts.* United Kingdom: Oxford University Press, 2016.

13 Treanor, Jill. "Women to lose out in technology revolution as robotics threatens jobs, warns WEF." *The Guardian,* January 18, 2016. www.theguardian.com/business/2016/jan/18/women-to-lose-out-in-jobs-revolution-wef-warns.

Figure 1: Robotic pharmacists in action at Tan Tock Seng Hospital
Credit: Michelle Yap, MHA

How would Singapore fare in this dystopian future? Jobs would surely be lost but compared to those economies that are heavily dependent on cheap labour, Singapore is expected to perform much better. If anything, Singapore might even benefit from AI-enabled robotics since the country suffers from persistent labour shortages. Furthermore, as the country undergoes rapid demographic ageing, AI-enabled robotics would not only augment its ageing workforce, but even ensure that the city-state remains competitive globally. Still, it is conceivable that AI-enabled robotics will led to some job losses and technological unemployment that is persistent and entrenched can stir instability. Income inequality could also widen because only a select few with the rare combination of talent, verve and luck will be successful. Further hampering the government's efforts to re-stock the local population through immigration as Singapore's population declines, xenophobia might rear its ugly head as citizens blame foreigners for their unemployment. These frightening outcomes are not hyperboles; indeed, we only need to see what is happening right now in some parts of the Western world to conclude that these grim scenarios are all too real. Fortunately, the convergence of AI and robotics is unlikely to materialise for many decades to come, making it an intermediate, if not long-term, threat. This means that policymakers still have time on their side. That however, may not be the case with IoT.

IoT – a catchall phrase for the vast assortment of Internet-enabled sensors, devices and systems in use today, IoT is set to explode in the coming years with the anticipated number of IoT products surging from 8.4 billion right now to over 20.4 billion by 2020.[14] Ranging from fitness trackers, medical devices, household appliances, mobile gadgets and even automobiles, IoT is expected to deliver a myriad of benefits such as energy conservation, increased automation and greater efficiency. But as appealing as this technology may sound, IoT's future is at present clouded by major cybersecurity concerns. To be more precise, the large number of IoT products currently in use might be dangerously susceptible to hacking. One reason is that many of these Internet-enabled systems are resource-constrained so they do not come with firewalls, encryption and antivirus applications baked in. Cybersecurity is a huge challenge in the IoT age because according to estimates from Hewlett Packard, a staggering 70 per cent of IoT products currently in use are susceptible to hacking.[15] IoT has major security implications for Singapore since the technology forms the backbone of the Smart Nation initiative – a major government project to transform the city-state into a tech-driven nation where cutting-edge technology is used to improve the lives of citizens. As more IoT devices enter the mainstream, the danger is that hackers could exploit digital weaknesses in IoT products and work their way into corporate or even government networks as employees bring their infected gadgets to work.[16] It just so happens that IoT products tend to collect a vast amount of personal data – not just plain personal identifiable information like names, birth dates and contact details but revealing information like energy consumption patterns, geo-location data and lifestyle habits. If this data stream were to fall into the hands of criminals, it is conceivable that it might be used to hatch more elaborate and believable scams. As it is, the number of fraud in Singapore involving e-commerce jumped 30.5 per cent

14 van der Meulen, Rob. "Gartner Says 8.4 Billion Connected "Things" Will Be in Use in 2017, Up 31 Percent From 2016." *Gartner*, February 7, 2017. www.gartner.com/newsroom/id/3598917.

15 HP. "HP Study Reveals 70 Percent of Internet of Things Devices Vulnerable to Attack." Accessed July 29, 2014. www8.hp.com/sg/en/hp-news/press-release.html?id=1744676#.WX26-4iGPIU.

16 Goodman, Marc. *Future Crimes – Inside the Digital Underground and the battle for our Connected World.* New York: Anchor Books, 2015.

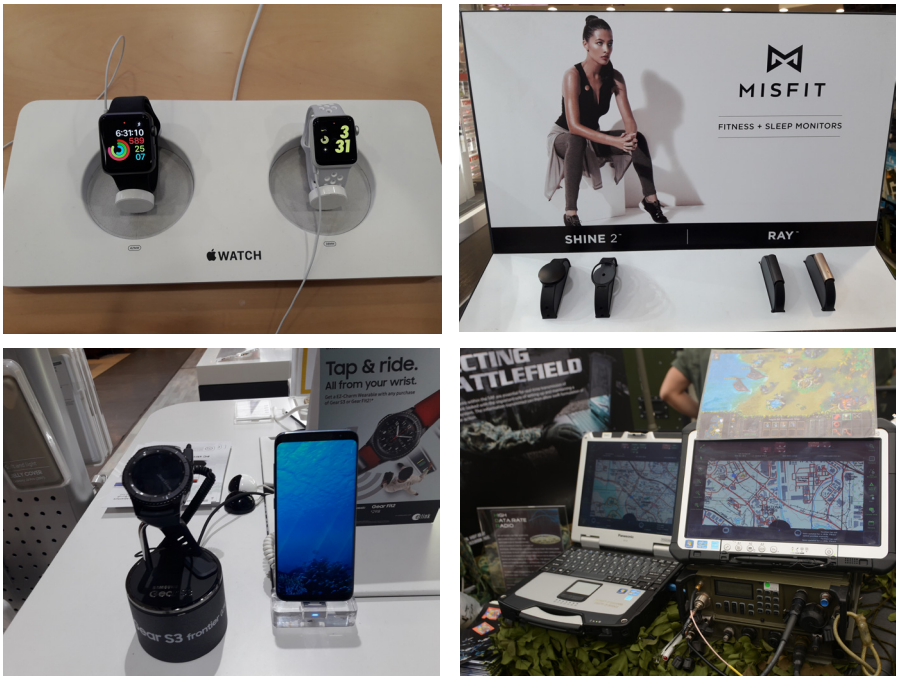

Figure 2: IoT Everyware
Credit: Tan Teck Boon and Wu Shang-su, RSIS

between 2014 and 2015 even as other crimes fell.[17] Whether the number of Internet scams will increase as more insecure IoT devices enter the mainstream remains to be seen but one thing is certain – there will be more digital pathways for malicious actors to exploit. In addition, the datafication of our most intimate personal information by IoT devices also has major privacy ramifications. For example, outfitting a residence with an IoT security cam that allows the owner to see what is happening in the house via smartphones might make a lot of sense when the owner is away but it also means that cybercriminals will be able to watch him or her in the house if the camera system had been compromised. Similarly, having a smart TV that is voice-activated might seem like a neat idea except that hackers may be able to listen in on the owner's private conversations thanks to the

17 Othman, Liyana. "Singapore crime up 4% in 2015, driven by cybercrime." *Channel News Asia*, February 12, 2015. www.channelnewsasia.com/news/singapore/singapore-s-crime-up-4-in/2509028.html.

TV's built-in microphone. As IoT devices proliferate, the big question to ask is whether existing data protection laws are adequate and if not, how should they be strengthened or updated. Unlike AI, IoT is already here so policymakers need to act fast before its fallouts completely overwhelm any anticipated benefits.

3D printing – also known as additive manufacturing, is set to bring about profound shifts in manufacturing and retail. By layering raw materials like plastic, metal and ceramic, 3D printers are now "printing" a whole range of physical objects. From cookie-cutter dinner plates to fashion accessories, to highly-complex fuel nozzles used in jet engines, 3D printing has essentially democratised the manufacturing process.[18] As a case in point, a teenager in Jakarta can now purchase the digital drawing of a bracelet from a designer in New York and then print out her purchase at home. For the designer in New York, 3D printing opens up previously inaccessible markets for her products; for the teenager in Jakarta, the technology offers a quick and inexpensive way to get hold of the latest fashion accessories. Putting an end to the global supply chain, it is not difficult to envisage a whole range of physical objects being traded this way. However, this deep shift in manufacturing and retail is also expected to create a host of economic and security issues. For now, 3D printers are unable to manufacture objects made of both plastics and metal (although the plastic and metal parts that go into these objects can certainly be printed separately and then assembled together).[19] Now, imagine the day when we can print out almost anything on-demand in the comfort of our homes. We no longer have to visit the store to replace the broken plate or cup because we can simply print another one out. But this convenience will also mean massive disruption for many traditional businesses. Manufacturers and retailers that cannot adjust to this radical change in fabrication and consumption pattern will falter and their workers will be laid off. At issue here is whether 3D printing will lead to the creation of more value-added jobs – defined as activities that generate outputs considered more valuable

18 GE Global Research. "3D Printing Creates New Parts for Aircraft Engines." www.geglobalresearch.com/innovation/3d-printing-creates-new-parts-aircraft-engines.

19 Allen, Nick, "Why 3D Printing Is Overhyped (I Should Know, I Do It For a Living)." GIZMODO, May 17, 2013. https://gizmodo.com/why-3d-printing-is-overhyped-i-should-know-i-do-it-fo-508176750. Curran, Chris, "The role materials play in powering the 3-D printing revolution." PWC, August 22, 2016. http://usblogs.pwc.com/emerging-technology/the-role-materials-play-in-powering-the-3d-printing-revolution/

Figure 3: The rise of 3D printing technology
Credit: Tan Teck Boon, RSIS

than the inputs used. If 3D printing opens up new markets for our designers and those laid off can, in due course, find more productive work, then the net outcome will be positive. However, if 3D printing leads to rampant unemployment, factory shutdowns and a sharp reduction in cross-border trade, then the technology is undoubtedly disruptive. On the security front, it is abundantly clear by now that the technology can be used to fabricate firearms.[20] Singapore, a country with very strict regulations on private gun-ownership, will find it increasingly difficult to enforce firearms laws now that digital designs for gun parts such as the lower receiver can be downloaded over the Internet and printed out at wish. The danger is that criminals and even terrorists can gain access to firearms this way. With Islamic State (IS) propaganda urging its converts to launch attacks wherever they might be, 3D printing can provide them with the means to inflict mass casualties in countries where guns are banned. Furthermore, it has emerged recently that cybercriminals might be able to insert hidden flaws and defects into 3D printed products. Now that 3D printed parts are being used in jet engines, this form of cyber-sabotage is not only potentially catastrophic

20 Percy, Jonathan. "When Guns and Drugs are Democratized: Potential Technical Solutions to Counter the Negative Consequences of Three Dimensional Printing." *Homeland Security Affairs*, December 2016. Accessed March 15, 2017. www.hsaj.org/articles/13226.

but particularly insidious to boot.[21] No longer will terrorists have to breach tight airport security and hijack aircrafts in order to kill large numbers of civilians like what the 9/11 hijackers did. As 3D printing becomes more widely used in precision manufacturing, they can simply find a way to insert undetectable defects into 3D printed jet engine parts. The psychological impact would be overwhelming if aircrafts start breaking up in mid-flight. By extension, any other critical infrastructures that use 3D printed parts can also be sabotaged in a similar fashion. To date, there is no viable solution to this problem.

AVs – with just 14 minor accidents after close to two million miles on the road, Google's self-driving cars have demonstrated that AVs can be as safe as, if not safer than vehicles driven by humans.[22] Despite a recent deadly accident involving Tesla Motor's semi-autonomous Model S sedan, there is little doubt that we will soon be seeing more AVs on our roads.[23] To be sure, the technology is still in its infancy and major technical issues remain before AVs can be certified ready for the road.[24] But then again, AVs do not drink and drive, are indefatigable and certainly do not slow down to ogle at road accidents. If widely deployed, AVs are expected to cut down on the number of road accidents every year, which in turn will save many lives. In Singapore alone, there were 141 fatalities and 10,582 injuries from road accidents in 2016; AVs, if ever introduced onto our roads, can be expected to cut these figures further.[25] Nonetheless, AVs can also be expected to give rise to a whole host of issues for Singapore. One possibility is that the deployment of AVs will eliminate large number of jobs in the transport sector. The introduction of autonomous car-share vehicles

21 E. Zeltman, Steven, Nikhil Gupta, Nektarios G. Tsoutsos, Michail Maniatakos, Jeyavijayan Rajendran and Ramesh Karri. "Manufacturing and Security Challenges in 3D Printing." *Journal of Minerals, Metals and Materials Society,* 68 (2016): 1872–1881.

22 Osborne, Charlie. "Google's autonomous car injuries: Blame the human." *ZDNet*, July 17, 2015. www.zdnet.com/article/googles-autonomous-car-injuries-blame-the-human/.

23 Yadron, Danny and Dan Tynan. "Tesla driver dies in first fatal crash while using autopilot mode." *The Guardian*, July 1, 2016. www.theguardian.com/technology/2016/jun/30/tesla-autopilot-death-self-driving-car-elon-musk.

24 Boudette, Neal . "5 Things That Give Self-Driving Cars Headaches." *The New York Times*, June 6, 2016. www.nytimes.com/interactive/2016/06/06/automobiles/autonomous-cars-problems.html.

25 Singapore Department of Statistics. "Road Traffic Accident Casualties, Annual." Accessed January 3, 2017. www.tablebuilder.singstat.gov.sg/publicfacing/createDataTable.action?refId=5513.

Figure 4: A driverless shuttle bus in operation
Credit: Tan Teck Boon, RSIS

for example, is bound to hit the taxi industry hard.[26] Besides being safer, self-driving taxis are also cheaper to ride in than regular taxis since driver compensation can make up as much as 50 per cent of the fares.[27] So it is not inconceivable that many cabbies could lose their livelihood when AVs hit our roads in full force. Drivers of buses, trucks and delivery vehicles could likewise face a similar fate. But careful assessment of the situation reveals that the outlook for Singaporeans, especially those working in the transport sector, is unlikely to be as grim as it appears. This is because the positive externalities (e.g., fewer road accident casualties, less congested roads, lower taxi fares and so on) brought on by AVs are likely to generate higher economic growth which in turn, will create more value-added jobs. Standards of living should rise, even if all other things remain equal. The real concern with AVs, one might argue, is cyber-sabotage, because many of these vehicles are manufactured without digital security in mind. In other words, AVs might be vulnerable to hacking and manipulation by cybercriminals. Indeed, researchers in the United States have already

26 LeBeau, Phil. "Ford will have a fully autonomous vehicle on the street in less than 5 years." *CNBC*, August 16, 2016. www.cnbc.com/2016/08/16/ford-will-have-a-fully-autonomous-vehicle-on-the-streets-in-less-than-five-years.html.

27 Abdullah, Zhaki. "Self-driving cars safe, says firm developing such vehicles here." *The Straits Times*, August 21, 2016. www.straitstimes.com/singapore/transport/self-driving-cars-safe-say-firms-developing-such-vehicles-here.

Figure 5: A UAV Jammer on display at INTERPOL World 2017
Credit: Tan Teck Boon, RSIS

demonstrated that they can breach a Jeep Cherokee's onboard computer system, take control of the vehicle and crash it at will.[28] This problem was evidently serious enough to prompt the US Federal Bureau of Investigation (FBI) to issue an alert warning Americans to take the cybersecurity of their vehicles seriously.[29] Since AVs are outfitted with a diverse array of electronic sensors, computer systems, cameras and software, it is not difficult to envisage them being hacked *en masse* by malicious actors to kill large number of people, or simply just to paralyse the transportation system. Needless to say, the repercussions will be catastrophic. Whether we like it or not, AVs will hit our roads within the next decade.[30] That at least gives policymakers some time to prepare for its arrival. Drones, on the other hand, are already here.

Drones – like AVs, are expected to benefit us in many ways. Whether flying autonomous or under remote control, they are now being used to survey natural disasters like tornadoes, volcanoes and forest fires. Researchers

28 Greenberg, Andy. "Hackers remotely kill a jeep on the highway — with me in it." *WIRED*, July 21, 2015. www.wired.com/2015/07/hackers-remotely-kill-jeep-highway/.
29 Greenberg, Andy. "The FBI warns that car hacking is a real risk." *WIRED*, March 17, 2016. www.wired.com/2016/03/fbi-warns-car-hacking-real-risk/.
30 Abrams, Rachel. "Self-driving cars may get here before we are ready." *The New York Times*, January 21, 2016. www.nytimes.com/2016/01/22/business/dealbook/davos-self-driving-cars-may-get-here-before-were-ready.html.

are also using these aerial unmanned vehicles to collect images from war zones and map caves inaccessible to humans. Some drones are so sophisticated that they can peer through dense vegetation with their sensors to build up images of what lies beneath the thick growth.[31] But perhaps the best known example of civilian use of drones is Amazon's Prime Air – a drone delivery system that promises to dispatch a small package to its buyer within 30 minutes of placing an order. Imagine receiving your prescription drugs or groceries within 30 minutes after placing the orders online from an octocopter drone that lands in your balcony or backyard. That might sound like a scene from a sci-fi movie except that it is already happening in some cities. There is no question that drones, when deployed for research and commercial purposes, can be a force for good even though the technology has traditionally been associated with warfare. But drones are also fast becoming a problem for authorities. They have intruded into restricted airspaces around airports and whether such intrusions were deliberate or not, they still pose a grave threat to aircrafts and their passengers. Terrorists could conceivably fly a drone into the engine of a commercial airliner during takeoff or landing in an attempt to crash it. This is not something theoretical because IS militants had been observed using drones to attack government forces in Iraq and Syria.[32] Furthermore, to avoid police interdiction, smugglers have been using drones to move contrabands and in at least one instance in the United Kingdom, have used them to sneak narcotics and mobile phones into prisons.[33] It has also been reported that North Korea is using drones to spy on South Korea by flying them across the heavily guarded demilitarised zone (DMZ) separating the two countries.[34] Unlike larger unmanned aerial vehicles (UAVs) used by the US military, the North Korean drones were small and so cannot be locked on by missiles to shoot them down. Clearly, drones have vital security implications not just for South Korea but for countries around the world looking for a way to stop them. If anything, hostile states no longer need expensive satellites or spy aircrafts to snoop

31 Bosworth, Mark. "Tree mapping drone start-up has sky high ambitions." *BBC*, May 28, 2014. www.bbc.com/news/technology-27485418.

32 The Straits Times. "Documents give peek into ISIS' lethal drones." Accessed February 2, 2017. www.straitstimes.com/world/documents-give-peek-into-isis-lethal-drones.

33 BBC. "Footage shows drones delivering drugs to prisoners." Accessed February 12, 2017. http://www.bbc.com/news/uk-36302136.

34 Gady, Franz-Stefan. "North Korea flew a spy drone over the DMZ." *The Diplomat*, September 4, 2015. thediplomat.com/2015/09/north-korea-flew-a-spy-drone-across-the-dmz/.

on other countries; drones now offer a cheap and effective means of doing so. Since some of these high-tech drones are outfitted with GPS sensors and thus, can be controlled from anywhere in the world via the Internet, it is not inconceivable that they would be used far from their home base for espionage and surveillance purposes. The coming-of-age of drone technology surely has significant security implications for Singapore. Be it smuggling, terrorism or espionage, drones pose a major challenge for the authorities. While various drone countermeasures – like using birds of prey and even drones to stop other drones – are being developed around the world, no reliable method currently exists to stop them. Apart from security implications, drones are also likely to impact businesses and alter consumption patterns. Specifically, innovative businesses that utilise the technology to reach out to consumers will benefit whereas traditional businesses that shun the technology are likely to suffer. Over time, these innovative businesses will gain market shares and traditional businesses – typically small enterprises – might disappear, leaving consumers with fewer choices. While it might be unbelievably convenient to shop online and have the orders dropped right at our doorsteps by drones, are we prepared to see small neighbourhood businesses vanish altogether? Is it even wise to count on one or two mammoth monopolies to meet our basic needs like food? These are some thorny issues that are likely to surface as drones start to pack our skies.

Coping with an Uncertain Future

Whether Singapore can successfully navigate through the Fourth Industrial Revolution hinges critically on its ability to cope with the disruptive consequences summarised in Table 2. There is no simple answer to how the country can be future-ready. Given how dependent Singapore is on international trade and the global economy, there is no question that it will be very much exposed and vulnerable to the disruptive forces unleashed by the Fourth Industrial Revolution. The small size of the country also means that it has limited fiscal resources to meet the challenges. There is no space here to discuss at length all the possible remedial steps that can be taken but three key observations are worth mentioning here.

To begin with, the idea of a universal basic income has recently emerged as a seductive idea to help workers soon-to-be displaced by disruptive technologies. In essence, a universal basic income is a subsistence salary

given out to all citizens regardless of need.[35] When humans are supplanted by intelligent machines, this cash payment is supposed to provide some form of relief for him or her, which in turn will help sustain the demand for goods and services. So in theory, a universal basic income will also prevent the economic system from going into a tailspin when technological unemployment surges.

Table 2: Potential implications of the Fourth Industrial Revolution

	Social implications	Economic implications	Political implications	Security implications
AI & Robotics Long-term concern	Income inequality	Technological unemployment	Rise of xenophobia Stirs instability	Citizens subscribe to alternative views
IoT Immediate to medium term concern	Erosion of privacy		Sensitive data migrated overseas	Cybersecurity Increase in online scams
3D Printing Immediate to medium-term concern		Disruption of traditional businesses Technological unemployment		Weapons proliferation Cyber-sabotage Terrorism
AVs Medium-term concern		Disruption of existing business models Technological unemployment		Cyber-sabotage
Drones Immediate to medium-term concern		Disruption of traditional businesses Rise of monopolies	Dependence on one or two sources for necessities.	Espionage Terrorism Trafficking

35 McAfee, Andrew and Erik Brynjolfsson. "Human Work in the Robotic Future." *Foreign Affairs* July/August (2016): 139–150.

As intriguing as the idea may sound, a quick calculation will reveal that this Utopian vision is untenable. According to the latest data from the Singapore government, there are well over 1.26 million residential households in Singapore in 2016.[36] Assuming the government hands out a $1,000 subsistence salary to each household every month, more than $15 billion is needed annually. Considering that the government generated a $5.18 billion budget surplus in 2016 – after a $4.05 billion budget deficit in 2015 – it is hard to imagine how a universal basic income can be possible without a substantial increase in taxes or borrowing. In that sense, the country will be better off with a more modest but realistic program to help citizens that can no longer find work. And considering that it takes time to set policies, it is definitely not too early to start looking into what this support net would look like eventually.

Even though the government may not be in the fiscal position to introduce a universal basic income, its role should not be undermined in the years ahead. As we enter the Fourth Industrial Revolution, the center of gravity is likely to shift in the direction of high-tech companies. The government's influence on the other hand, will increasingly be over-shadowed by a small group of powerful tech companies. From the standpoint of good governance, that can create a serious problem. Businesses maximise profits – not the welfare of citizens. So if technological unemployment jumps in the years to come, businesses are neither obligated nor incentivised to help those displaced. In that case, only the state can be counted on to help the needy. To be fair, private enterprises do engage in charitable activities every now and then. But only the government has the commitment, policy tools and planning capabilities to stave off mass unemployment if it happens. At the same time, the government will also be needed to provide security. Whether it is shielding the country from foreign adversaries, terrorists or hackers, the government's role in keeping the country safe will actually become more important in the future as sophisticated technology that can be turned into high-tech weapons proliferate. Again, businesses have no real incentives to provide it since security is after all a public good, nor can they be fully entrusted in many ways, to do so.[37]

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36 Singapore Department of Statistics. "Latest Data." Accessed July 25, 2017. www.singstat.gov.sg/statistics/latest-data.

37 A public good is defined as a commodity or service that does not exclude non-paying individuals from using it. Apart from national security, other examples include clean air, public knowledge and street lighting. The non-exclusive nature of public goods means that a business will not be able to charge all users if it were to provide a public good.

While Singapore's diminutive size implies that it will face many challenges in the era of the Fourth Industrial Revolution, this size limitation makes the country nimble enough to react quickly to changing circumstances. Apart from giving innovative individuals more space to grow, the country can also use its size to its advantage. Indeed, being small gives it the flexibility to take advantage of fleeting opportunities and to quickly alter direction in an era of rapid and unpredictable change. Being able to move fast and change direction at a moment's notice allows the country to react swiftly to new developments and equally important, to promptly switch direction when a mistake has been made – a must since a small country like Singapore has an even smaller margin for error. In particular, nimbleness can also come from a public sector that not only makes quality but quick decisions. The need for good decisions is a given, and being able to make decisions without having to go through multiple layers of approval will ensure that the country can respond rapidly to fast-changing circumstances. The country would not be particularly nimble if, for instance, the public sector takes too long to free up a budget to deal with real-time contingencies. Some scholars have argued that fast decisions are typically associated with a less rigid decision-making structure.[38] Having said that, it is important to bear in mind that the entire decision-making process should not be completely decentralised for the simple reason that guidance from the top echelon is fundamental to ensure that core principles of good governance remain in place. As Singapore enters the era of the Fourth Industrial Revolution, how the public sector can be fine-tuned to make quick but quality decisions should be a matter worth paying attention to.

Conclusion

This policy report explored some of the disruptive impact the Fourth Industrial Revolution will have for Singapore. With far-reaching implications for the country's economy, social fabric, national security and even political institutions, the Fourth Industrial Revolution is expected to bring about an era of great uncertainty for the city-state. The country's small size also suggests that it will be particularly exposed to this profound shift.

38 Janssen, Marjin and Haiko van der Voort. "Adaptive governance: Towards a stable, accountable and responsive government." *Government Information Quarterly* 33 (2016): 1–5.

However, Singapore's small size also means that it can be nimble enough to seize opportunities that may arise in the future. It should be noted that the Fourth Industrial Revolution will have a positive side too. To that end, it is vital for the public sector to be able to make fast but quality decisions. Meanwhile, the role of the government also needs to be strengthened so that it will be able to deal with the disruptive aspects of the Fourth Industrial Revolution.

Fortunately, there is still time to prepare for the looming challenges. And the sooner policymakers make plans for this uncertain future, the better Singapore will be to cope with the challenges. Doing so is not only part and parcel of good governance, but will also put the country in a stronger position to take advantage of the opportunities that come with the Fourth Industrial Revolution.

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