# 10 Trends to Watch in 2018 & Beyond

> "The future is already here —
> it's just not very evenly distributed."
>
> – *William Gibson*

**THE FUTURE HUNTERS**
WEINER · EDRICH · BROWN

**OMIDYAR NETWORK**

Created in partnership by The Future Hunters and Omidyar Network.

**Erica Orange and Jared Weiner, The Future Hunters**

Erica Orange (EVP & Chief Operating Officer) and Jared Weiner (EVP & Chief Strategy Officer) of The Future Hunters evaluate emerging social, technological, economic and political trends – and identify the strategic implications (the "So what?") of those trends for several of the most influential Fortune 500 companies, trade associations and public sector clients. Erica and Jared frequently speak to a wide range of global audiences about trends that are shaping the landscape today, and have keynoted several large industry conferences. Erica has authored numerous thought pieces on cutting-edge, future-focused topics. She also currently serves, and has served, as an advisory board member for several organizations. Erica originally hails from Rochester, NY. Jared is the former Chairman of the Board of the World Future Society, the world's preeminent futurist industry group. He also sat for several years on American Express OPEN's Digital Advisory Board. Jared received his M.B.A. from the Simon Graduate School of Business at the University of Rochester.

**Eshanthi Ranasinghe, Omidyar Network**

Eshanthi Ranasinghe is a manager on the Intellectual Capital team at Omidyar Network where she advances strategy and research across the firm's initiatives, incubates new areas of impact, and leads the firm's work on future sensing and foresight. Prior to Omidyar Network, she worked on social ventures throughout South Asia, and in management consulting at Boston Consulting Group. She attended the University of Michigan where she received an MBA and an MS from the School of Natural Resources and Environment, with a focus in sustainable systems. She attended undergrad at the University of North Carolina at Chapel Hill.

*Illustrations by Johan Thörnqvist*

# 10 Trends to Watch in 2018 & Beyond

**1** The "Moonshot" Economy – "Moonshots" signal a seismic shift from the innovation we see today to an entirely new era of uninhibited imagination across all industries, changing the how and who in leading innovation

**2** Risk in the White Space – Technology and its impact on society are changing so rapidly, that the calculation and identification of risk is becoming almost prohibitively difficult. Not only are things changing too quickly for risk assessment to ever catch up, but much more of the risk could be considered unpredictable and intangible – not tying back to any clearly liable entity

**3** The "Affectional Economy" – A technological revolution is allowing advanced machines to read, recognize, decode, process, and even mirror human emotion, to enhance their ability to interact with and understand us

**4** Rise of Neotribalism – Humans originally evolved to live in a tribal society, but growth in international travel, communication, and education created a sense of global identity. In 2017 we saw tribalism reemerge, platforms used to connect also used to disconnect. Trumpism, Macronism, are humanity's divisions becoming more intractable?

**5** The Industrial Internet of Things (IIOT) – Powerful enterprise counterpart to the consumer Internet of Things, IIoT is transforming manufacturing and the mindset such firms need to succeed

**6** "Cybrids": The Younger Global Generation – Gen Z have a fully symbiotic relationship with the digital world around them; this symbiosis will profoundly affect their cognition, perception, emotions, relationships, values and attitudes, learning capabilities, consumer behavior, and future career

**7** Moving from Green to Blue – The future of sustainability is having a net-positive impact on the ecosystem by putting more back than was taken

**8** 3D & 4D Printing as Forces for Social Good and Humanitarian Efforts – 3D printing offers an affordable, sustainable, on-demand manufacturing for immediate, local, and underserved needs; 4D printing adds the dimension of time, leveraging "intelligent" materials that can self-assemble, change shape, and self-repair

**9** Nation, Inc. – The role of institutions is changing and the line between the nation and the corporation is blurring – countries will need to provide jobs or job equivalents, corporations are shaping public policy; where will the roles of these institutions, and the balance between them, fall?

**10** Infrastructure of the Future – Competitive cities, countries, regions, and companies will depend on an entirely different set of infrastructure needs, e.g., smart sensor networks to sustainable urban farming

> "For a long time the future has belonged to people who have not had to struggle, and I think that will still be true. But as more and more systems collapse, currency, energy, the ability to get water, the ability to work, the future will increasingly belong to those who know how to hustle, and those people are not the people who are producing those purely optimistic futures" – *Madeline Ashby*

# The "Moonshot" Economy

Entrepreneurs and large Silicon Valley firms have been increasingly betting on "moonshots" – enormous projects difficult (or impossible) to achieve, but which would have a huge impact on the global economy if successful. Moonshots signal a seismic shift from the innovation we see today to an entirely new era of uninhibited imagination across all industries – the "moonshot economy." The hyperloop. Asteroid mining. Space tourism. Autonomous vehicles. DNA data storage and quartz "Superman memory crystal." Mind-reading technology. 4D printing. "Assisted colonization" for endangered species and "de-extinction" using CRISPR gene-editing. Feeding the planet through techniques like vertical urban agriculture. Clean water for all. New and seemingly implausible innovations that might once have seemed like the purview of science fiction minds, can now be pursued single-mindedly – taking the concept of "leapfrog" innovation to another level.

Peter Diamandis founded the XPRIZE with the Ansari prize for Suborbital Spaceflight, finally won in 2004, and arguably kicked off the modern era of moonshots and private space enterprise. This trend of moonshot activity has been developing for many years. Many "science fiction" ideas have now reached a tipping point – transitioning from theoretical concepts to real prototypes … and real results, promulgating moonshot models and approaches further, to more companies, organizations, and some governments.

Alphabet has its own "moonshot factory" with X; Musk's companies SpaceX and Neuralink are pursuing moonshots in space exploration and human-machine integration technology; and Facebook's secretive and unassumingly named R&D division, Building 8, is working on creating a silent speech system where your smartphone would directly read your brain and technology that could read language through your skin. While many governments have deprioritized space exploration, private sector is pushing into areas like space travel and new energy sources. Musk announced earlier this year that spaceship technology could power super-fast airliners and landing humans on Mars will take place in five years – by 2022. By more effectively combining AI and human intelligence, we could set hybrid computational systems to work on our biggest planetary issues.

The moonshot economy could lead to a major shift in how innovation occurs – lofty goals, more flexibility in timeline and budget, and, apparently, an openness to failure. Perhaps most controversially, this also represents a shift in who drives innovation – with influence wielded by a concentrated group of billionaire entrepreneurs and philanthropists, as opposed to startups, research institutions, and government. Unequal wealth concentration and income distribution is becoming one of the world's most pressing issues. We see more billionaires with bloated bank accounts and tech firms with bloated valuations. We might see these enormous fortunes applied toward addressing world problems – but what happens when the world's billionaires, rather than governments or public institutions, fund the global future? Who is their citizenry? What does this mean for ownership and with regard to increasing concentration of wealth? Who is accountable when something goes wrong? Should there be a difference between moonshots as profit-making investments versus solving global, public issues? How will society regulate and assess impact, and how should we think about rules to "govern" them? If large tech companies, often helmed by visionary entrepreneurs, become public, will their risk appetite for moonshots decrease? How will investors respond? How will leaders calculate risk?

# Risk in the White Space

Technology and its impact on society are changing so rapidly, that the calculation and identification of risk is becoming almost prohibitively difficult. Not only are things changing too quickly for risk assessment to ever catch up, but much of the risk could be considered risk in the white space: risk where it may not have been predictable beforehand and/or is intangible, amorphous, and not tying back to any clearly liable entity.

There has long been talk of "the Precautionary Principle," the idea that before initiating something – particularly in the scientific realm, the originator should consider all possible negative first-, second-, and third-order consequences. Not only has the Precautionary Principle not been followed by many of those bringing new concepts to the marketplace, but the rapid growth of risk in the white space is making that principle look less practical and more unattainable.

This observation is driven in part by the convergence of two things – the nature of technology, ubiquitous, interconnected, simplifying, opaque, transformative, fast; and the nature of people and culture – biased, broken, complex, contextual, and slow. Technology is becoming integrated into, affecting and affected by, everything. Everything that is technological and tangible (e.g., infrastructure) is generally more predictable. But everything that is technological and intangible (e.g., resulting from culture, society, biases, system effects, and externalities, etc.) is more unpredictable.

Further exacerbating this is that technology is oftentimes built by a homogeneous group of people for a heterogeneous world. Many unintended consequences arise because technology designers struggle to predict the way their technology will be used and misused in other contexts or cultures, by people different from them, as WhatsApp did when its platform was used to record and disseminate rape videos in India. Platforms are especially easy to manipulate because they are distributed, self-moderated, and enforce no accountability. This will only become exacerbated as network interconnectedness increases, while culture, education, and human rights remain far behind. Social media, fake news, and the decline of democracy is just one example of cracks exposed in the surface. What are we not yet seeing?

Other real-world examples of technological risk in the white space include:

- **Smart Toys & Digital Assistants:** "Smart" toys are increasingly able to spy on kids and their families. Who bears the risk if smart toys or other home software (e.g., digital assistants) update themselves to begin spying?

- **Autonomous Vehicles:** Establishing liability proved very murky when a driver using Tesla's self-driving Autopilot feature died in an accident. But, when it comes to technologies like autonomous vehicles, risk in the white space goes well beyond liability, and encompasses serious ethical considerations as well. For example, how will engineers program a vehicle to determine who should die in an accident? Some driverless cars could soon let the "driver"/ passenger determine who survives in a crash.

- **Artificial Humans:** As robots becomes more human-like, and regulatory bodies grapple with giving them human rights (e.g., as in the EU, Saudi Arabia, and Japan), the lines between risk and ethics will blur. The risks surrounding potential robotic citizenship are manifold. What are the risks that could occur if humans feel like their humanity is being threatened (see Neotribalism)? Who is responsible if a humanoid robot commits a crime? Are engineers responsible for trying to mitigate that risk? Identifying the risk "bearer" will become increasingly difficult to discern as the lines become more blurred between humans and technology.

In the future, risk and liability issues will become more diffuse and difficult to determine. Where else could "risk in the white space" emerge? We experience it already in areas that have similar non-linear tipping points, like the environment. Climate change could spur millions of extra crimes in coming years. And the exponential increase of involuntary migration because of climate change will lead to more refugee crises. And, as the climate warms, sea ice and permafrost melt, and oil and mining companies drill formerly off-limit areas in the Arctic, ancient human viruses may be released. Scientists are only beginning to consider the societal implications of this previously unforeseen risk – and others like it.



RISK IN THE WHITE SPACE
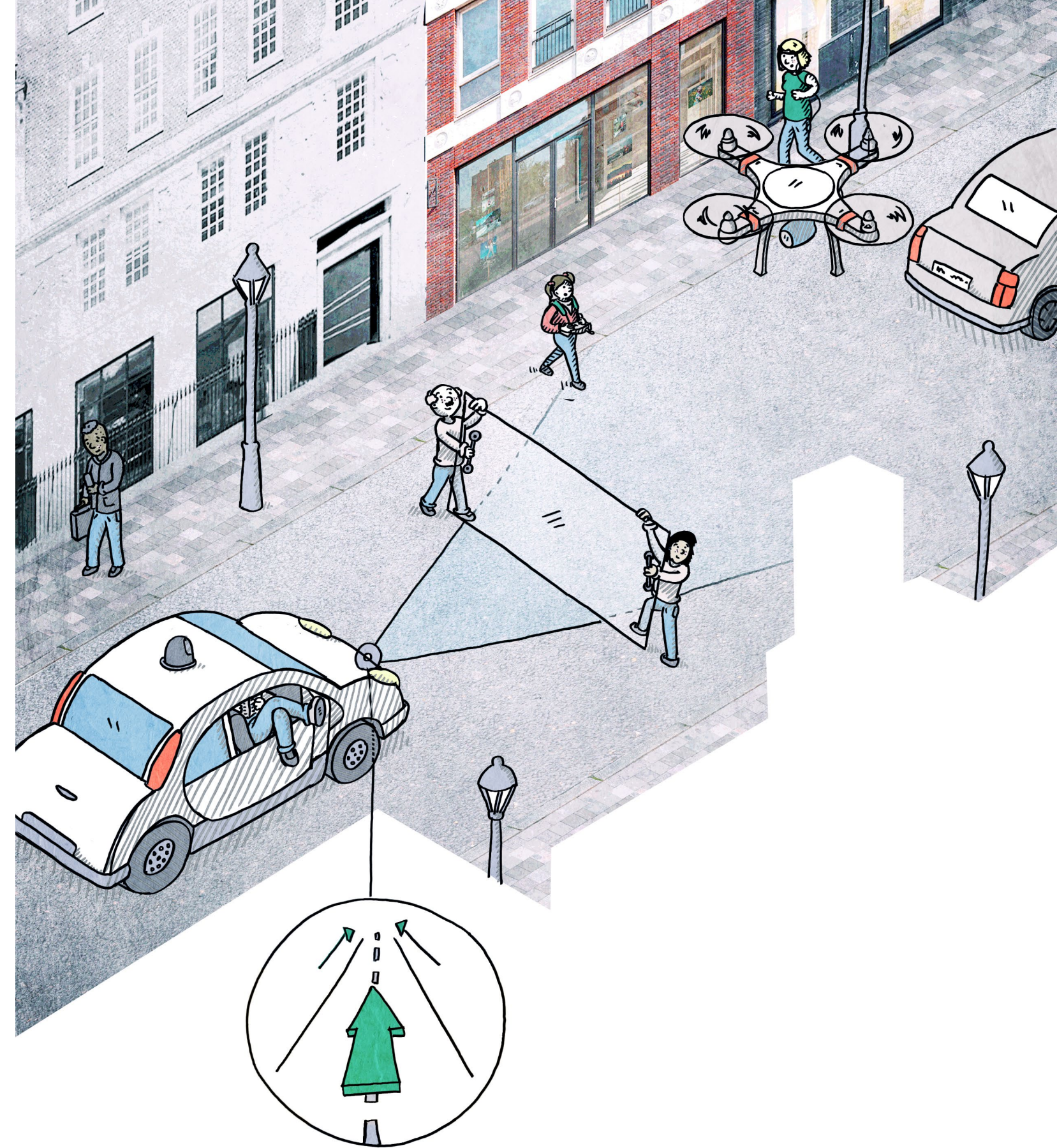
# 3 The "Affectional Economy"

A revolution is redefining the business of emotion: Advanced machines are beginning to read, recognize, decode, process, and even mirror human emotion. We are entering the "affectional economy" – an economy propelled by the rapid rise of affective computing and machine-based emotional reasoning. Through affective computing, we are not only building the digital equivalent of human emotional intelligence, but we are quickly reaching a new level of emotional transparency. This is driven, in part, by the rise of embedded products that leverage the IoT, artificial intelligence (AI), machine learning, and natural language processing.

Computational efficiency is increasingly giving rise to computational empathy. This is leading to what scientists refer to as artificial general intelligence (AGI) – AI that has some personality and even emotion that allows it to interact naturally with humans and develop motivations to solve problems in creative ways. It's not just that computers can express feelings, it's when and how they do so. While research on empathic robots is still in its infancy, scientists are already using machine-learning algorithms, natural language processing, sentiment analysis, and artificial neural networks to build robots that can understand and interpret human emotion. A market research firm forecast the global affective computing market will grow from $9.3 billion in 2015 to $42.5 billion by 2020. It is expected to grow at a compound annual growth rate of 33.85% during the forecast period of 2017 to 2024. As we interact more with voice- and gesture-controlled machines, we may expect them to recognize emotions such as humor and sarcasm. Honda's new concept car, for instance, has an emotional, AI-based component that interprets its driver's emotions. And Toyota's humanoid Kirobo Mini can keep its driver company by carrying out conversations, and identify people's facial expressions so it can respond accordingly.

Emotional AI is also increasingly capable of recognizing more complex cognitive states, such as fatigue, attention, interest, confusion, and distraction. Algorithms can already accurately read people's emotions from their facial expressions or speech patterns, and a computer can unmask hidden bias by scrutinizing people's body language for signs of prejudice. And research now reveals that as machines get closer to acquiring human-like language abilities, they are also absorbing the deeply ingrained biases (e.g., race and gender) in patterns of language use. Add to this that subconscious biases of engineers are unknowingly seeping into the design of algorithms and AI.

As we increasingly defer to AI to monitor, visualize, and define emotional experiences for us, many questions arise. Even if robots become more skilled at expressing a fuller range of human emotion, do we risk homogenizing expressions of social feeling? Does this threaten our ability to relate to one another? Will we value emotional relationships with robots as much as, or more than, emotional relationships with humans? In Japan, robotic proxies (and increasingly holograms) are being used as household companions, particularly for the elderly. A major product trend at CES 2018 was pet robot dogs and cats. Will we become better at masking our emotions if we knew that we were constantly being watched and analyzed? Will emotional robots change the kinds of human skills and abilities we begin to reward? What happens when human, and thus algorithmic, bias comes into play?
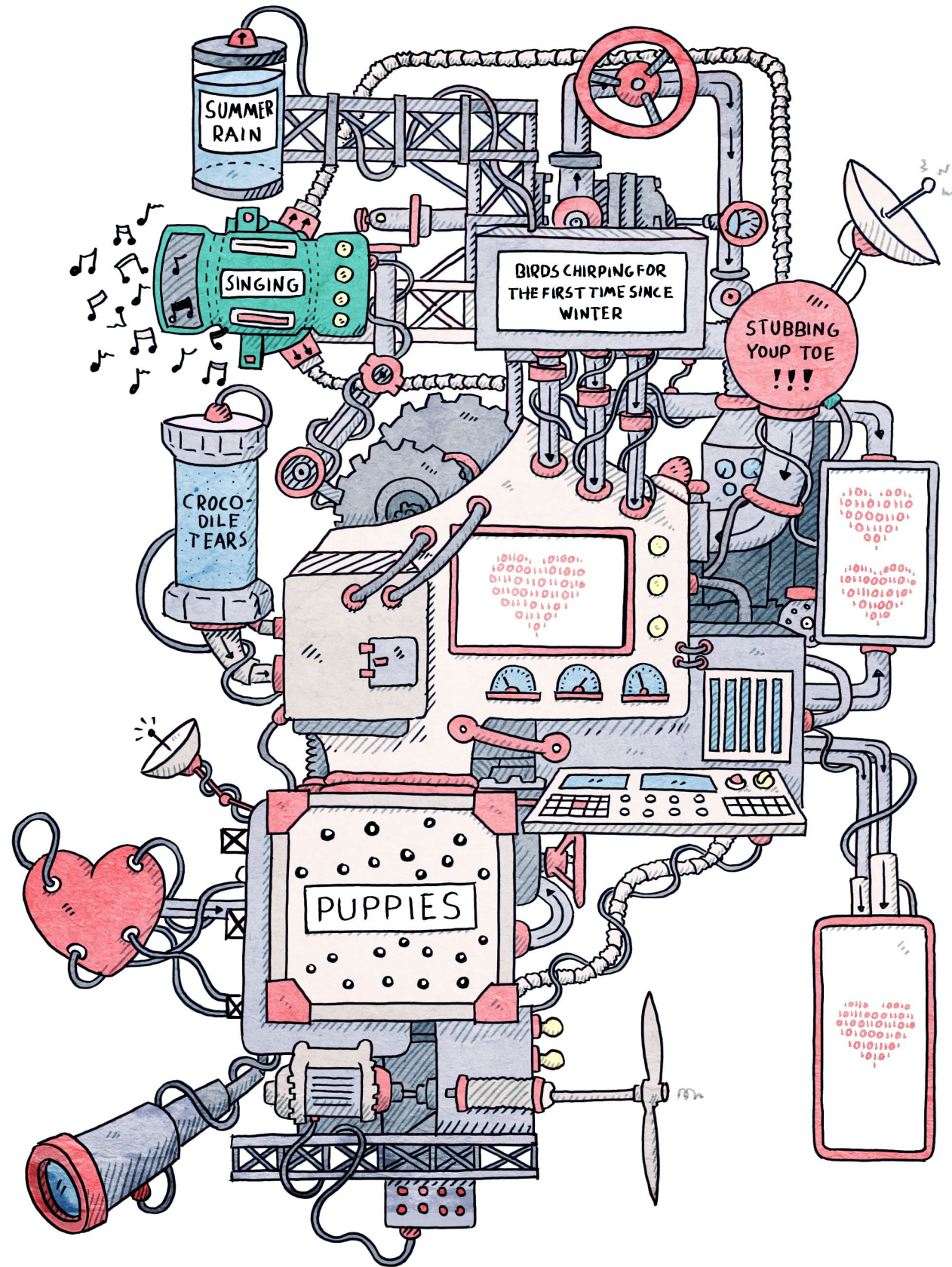
# 4 Rise of Neotribalism

Neotribalism is a sociological concept which suggests that humans evolved to live in a tribal society and thus will naturally form social networks constituting new "tribes." Despite globalization and vast technological progress, we continue to engage in in-group vs. out-group categorization. Instincts to demarcate self and other persist. But the revitalization of tribalism is making humanity's divisions even more intractable.

The affinity for authoritarian leadership is an example of geopolitical neotribalism – driven by a desire for order, a sense of loss of power, and a fear of outsiders. This with collective narcissism – when someone exhibits an exaggerated belief in the superiority of their in-group, but feels doubtful about their group's prestige and therefore craves recognition from others, is thought to be directing the global spiral into populist nationalism. Brexit and Trump provided cautionary tales, as identity politics – the tendency for people of a certain religion, race, or social background to form exclusive political alliances, reigned. The impact of this has had rapid effect – the EU is considering handing back some powers to national governments. The recent Dutch and French elections avoided a serious rupture, but still showed how identity politics has the power to divide. Further exacerbating left-right divides, a growing movement, known as Europhilia, is partly a backlash against the recent wave of nationalism. Neotribalism can also be felt in the resurgence of religious fundamentalism, one reason Christians are fleeing the Middle East, making the region less diverse.

Socioeconomic neotribalism is also emerging. For instance, mass automation could create a world where the rich get even richer. Capital liberated from labor means that without wages, robotic capital could enable elites to secede from society. Platform companies have come to control not just their own marketplaces, but have ended up controlling something closer to an entire economy. They aspire to monopoly, and arguably have rehabilitated the concept. In many ways, the personal liberties the tech industry meant to proliferate have been occupied and undermined by the very forces it planned to topple.

We are also beginning to see segmenting across demographic, religious, generational, and ethnic lines. In the US., for instance, we've witnessed the decline of the white male working-class which has led to not just downward mobility but increased racial and gender-related resentment, the disappearance of a distinct working-class culture and the marginalization of their views. This is also reflected in the Middle East, where a lack of work or income is resulting in a "crisis of masculinity." A growing sense of weakness is leading to heightened chauvinism and patriarchal attitudes. Will this usher in a return to more traditional gender roles in some cultures?

Neotribalism can be dramatically exacerbated by new platform technologies. The Alt Right gained its foothold in young, white males through videogame chat platforms. Social media has created opportunities for both cultural cross-pollination and for enclosing ourselves in ideological echo chambers, as a powerful global tool and global weapon. Social media provides a platform to express individualized sentiments and tastes, but too often herd mentality and conformity seem to rule. Recent experiments show that the behavior of others has a more profound effect on the use of aggressive language than anonymity does. Algorithms are struggling to distinguish between content that is truly offensive and language that is not offensive in context.

The larger story about neotribalism is not about traditionalism vs cultural openness, but about how the tone of division is becoming much more aggressive, anxiety-fueled, and protectionist. Are we moving closer toward social de-globalization? Are we inching back to a medieval-like era when humans were fiercely loyal to their own tribes rather than to larger societal interests? Or will technological progress help catapult us past these differences? What is next for neotribalism? It could eventually come to encapsulate a tribal divide between us (humans) vs. them (non-humans/AI/robots). Will this threaten our own identities, cultures, and morals? Will humanity coalesce around a common purpose? Or will we continue to segment ourselves?

# 5 The Industrial Internet of Things (IIoT)

The Industrial Internet of Things (IIoT) will be the powerful enterprise counterpart to the consumer Internet of Things (IoT). It is transforming manufacturing and the mindset firms need to succeed. The number of wirelessly connected products in existence (excluding smartphones or computers) is projected to rise to 21 billion by 2020. Bain predicts B2B IoT segments will generate more than $300B annually by 2020, including about $85B in the industrial sector. Discreet manufacturing, transportation/logistics and utilities will lead all industries in IoT spending by 2020, averaging $40B each.

Several of the world's leading enterprises are already successfully leveraging the IIoT in tandem with cloud-based analytics to drive efficiencies. Amazon's fulfillment warehouses make use of armies of Wi-Fi-connected Kiva robots. Airbus has launched a digital manufacturing initiative, Factory of the Future, to streamline operations and bolster production capacity. The company has integrated sensors into tools and machines on the shop floor and given workers wearable technology designed to reduce errors and strengthen workplace safety. Boeing has deployed IIoT technology to drive efficiency throughout factories and supply chains. Caterpillar is using the IIoT and augmented reality (AR) to give machine operators an at-a-glance view of everything from fuel levels to when air filters need replacing. Hitachi has developed an IIoT production model that it claims has slashed production lead times by half within its Omika Works division, which manufactures infrastructure. Danish shipping giant Maersk has embraced the IIoT to keep track of its assets and optimize fuel consumption and the routes of its ships. And Shell links its high-tech wells with fiber-optic cable that allows remote employees to monitor operations.

And while the IIoT will disrupt the back-end of supply chains that consumers rarely see, it will also disrupt the front-end of supply chains that consumers will see. Amazon Go's new smart convenience store format is an example of this. It leverages IIoT technology, including advanced sensor networks, to eliminate checkout lines and, ultimately, save consumers considerable time.

One of the biggest challenges facing the IIoT is interoperability – smart objects will have to be programmed to synch on the same platform to communicate. Yet it's likely that a handful of global giants will develop competing platforms that dominate this space, instead of one all-encompassing platform. A second major challenge will be security. Xage Security recently launched as the self-proclaimed "first and only" blockchain-protected security platform for the IIoT.

Within this context, however, it is important to understand that smart systems, robotics, sensors, software, and AI – hardware – will not be working alone. Smart technology will increasingly work symbiotically with humans – wetware – to achieve even greater operational efficiencies. Industrial employees are learning to work side-by-side with the latest generation of robotic systems. Collaborative robots, dubbed "cobots," have the potential to revolutionize production. It is estimated that the cobot market could grow from just over $100 million in 2015 to $3 billion by 2020. Cobots can also increase human productivity. BMW researchers found that robot-human teams were 85% more productive than either alone. And new microfactories that allow for rapid prototyping allow humans to drive innovation while robots fill lower-skilled roles.

In the near future, will the IIoT increasingly merge with complementary technologies like AR and cloud computing to form an even richer ecosystem? Data is the powerful weapon behind the IIoT. How will humans process this information? Will it be automated? And, ultimately, how will best-practice companies use this data to optimize insights? Or to enhance productivity? While still relatively nascent, we are beginning to see some of the world's top companies integrate and innovate around the Industrial Internet of Things.

# "Cybrids": The Younger Global Generation

**6**

"Millennial" has become a global buzzword. But behind them is Generation Z, a rapidly rising cohort that is not only coming into their own, but is markedly different from millennials – from social media preferences to their appetite for risk to their buying behaviors and spending power. Gen Z is loosely defined as those born after 1995, the tipping point when the internet became a commercially ubiquitous technology. People often categorize today's youth as "digital natives" – the first wave of kids who have grown up surrounded by digital technology. But one could argue they are not just digital natives, or "iGen-ers", as Jean Twenge calls them, but cybrids – cyber hybrids, with a fully symbiotic relationship with the digital world around them. For those in this generation, this symbiosis will profoundly affect their cognition, perception, emotions, relationships, values and attitudes, learning capabilities, consumer behaviors, and future careers.

Cybrids are expected to reach 2.56 billion individuals globally by 2020. Within the US., they will reach 84.7 million by 2020, making up 24.7% of the American population. According to the US. Census (March 2015), Gen Z is also the most ethnically diverse in history, representing the last generation to be majority non-Hispanic white (52.9%). And the impact of Gen Z extends well beyond the US. By 2020, they will make up 40% of consumers in the US., Europe, and BRIC countries, and 10% in the rest of the world. Globally, there are 1.8 billion people between the ages of 10-24 – about a quarter of the world's population – and over half the world's population is under 30. India, Nigeria, the Philippines, Pakistan, Egypt, Bangladesh, and South Africa all have Gen Z populations exceeding 30% of overall population. As the world's most demographically diverse generation, they also represent an underleveraged source of promoting cross-cultural dialogue and collaboration.

No longitudinal studies have been done on the neural mapping of a generation exposed to up to 10 hours daily of multimedia screens since infancy. This is the first generation in history to have different neural wiring than their predecessors. Their brains are wired for the fast and continuous delivery of digital content – content they have been exposed to since birth. Young brains constantly form new connections, and this is happening at an accelerated rate. Smartphones and other modern, digital technologies may also change the way Gen Z experience boredom. Mobile devices offer instant stimulation, but researchers speculate that they may leave some even more bored when they are unplugged. What will we learn in coming years about just how dramatically the structure of Gen Z brains has evolved? And how will a generation forming different brains assimilate – or better yet, change, the Industrial-era structures of yesterday (e.g., the educational system and traditional workplace)?

For the youngest of Gen Z – those under the age of 5, artificial intelligence + ambient intelligence will amplify the real world to such an extent that it will affect their behaviors. For instance, children who spend time with a robotic companion appear to pick up elements of its behavior. New experiments suggest that when kids play with a robot that's a "real go-getter," the child acquires some of its can-do attitude. And as robots become new role models for children, some parents have complained that Amazon's Alexa is training their children to be rude. Children tend to anthropomorphize technology, including digital assistants. More interactions and playful experiences are centered around assistants like Alexa, thereby shaping kids' behavior. A larger question will be whether this stymies children's ability to learn how to interact with real people. Is this "kiddie AI" revolution to their benefit or detriment? Will these digital interactions supplant human-based ones? Hacking will also be of heightened concern. Lego Life, for example, is a social network designed to enable children to express themselves while exchanging ideas in a friendly environment. But despite attempts to create privacy and security fail safes, these platforms and internet-connected toys are still highly vulnerable to attacks, thereby exacerbating spying concerns.

In the face of this, a powerful countertrend among Gen Z is also emerging. Almost two-thirds of schoolkids in a recent study said they wouldn't mind if social media had never been invented. Many respondents said that social media was having a negative impact on their emotional wellbeing. And smartphones may be leading to an increase in teen depression, suicide, and suicide attempts. Gen Z will straddle, and learn to move between, two seemingly disparate realities – one technophilic, the other Luddite-like. They will embrace both realities in different aspects of their lives.



"CYBRIDS": THE YOUNGER GLOBAL GENERATION

# 7 Moving from Green to Blue

Green-to-blue describes a continuum from <u>do</u>ing green to <u>be</u>ing green to, ultimately, being <u>blue</u>. Doing green is the basic model of sustainability; a baseline expectation. Being green is the current aspiration for sustainability, and it entails having as close to a net-zero impact on the ecosystem as possible, throughout the entire value chain. Being blue could be considered the future of sustainability. It entails having a net-positive impact on the ecosystem by putting more back than was taken.

Cities are just beginning to get more comfortable with the concept of being blue. Repurposed industrial buildings, reclaimed brownfields and vertical urban farms are all reshaping aging landscapes into beacons of future urban sustainability. The Food and Agriculture Organization of the United Nations (FAO) reports that 800 million people worldwide grow vegetables or fruits or raise animals in cities, producing 15 to 20 percent of the world's food. They estimate that by 2020, Africa, Asia, and Latin America will be home to some 75% of all urban dwellers, and to eight of the anticipated nine mega cities with populations in excess of 20 million. By 2030, some two-thirds of the world's people will be living in cities, according to UN projections.

We are also seeing the development of "living" buildings/architecture. Using microorganisms, like yeasts and bacteria, and modifying their DNA, synthetic biologists can grow a wide range of resources. Living Architecture is developing construction bricks composed of biofilm that can harness solar energy, wastewater, and air pollution, and turn them into usable resources. The living bricks fit together to create "bioreactor walls" that can be programmed to perform all sorts of functions, creating buildings that become "large-scale living organisms." And DARPA's Engineering Living Materials program wants to replace current building materials with new materials that can grow into predetermined shapes, repair themselves if damaged, and even adapt or alter themselves to the environment. Entire buildings could be grown from scratch, using little material. Future buildings could self-heal after a natural disaster to change shape to accommodate the climate, morph to suit individual needs, and assemble and reassemble for migrant populations.

Ultimately, being blue is not just about what William McDonough calls "cradle-to-cradle design," but about Recirculative Design – a paradigm that incorporates regenerative and nature-inspired design + environmental circularity + zero waste & toxicity + rapid technological and scientific innovation. This framework represents an overhaul in how products are designed, built, sold, consumed, and disposed of. An example is the World's Advanced Saving Project (WASP) which unveiled the world's largest 3D printer which can build full-size buildings out of mud and clay for nearly zero cost.

**MOVING FROM GREEN TO BLUE**
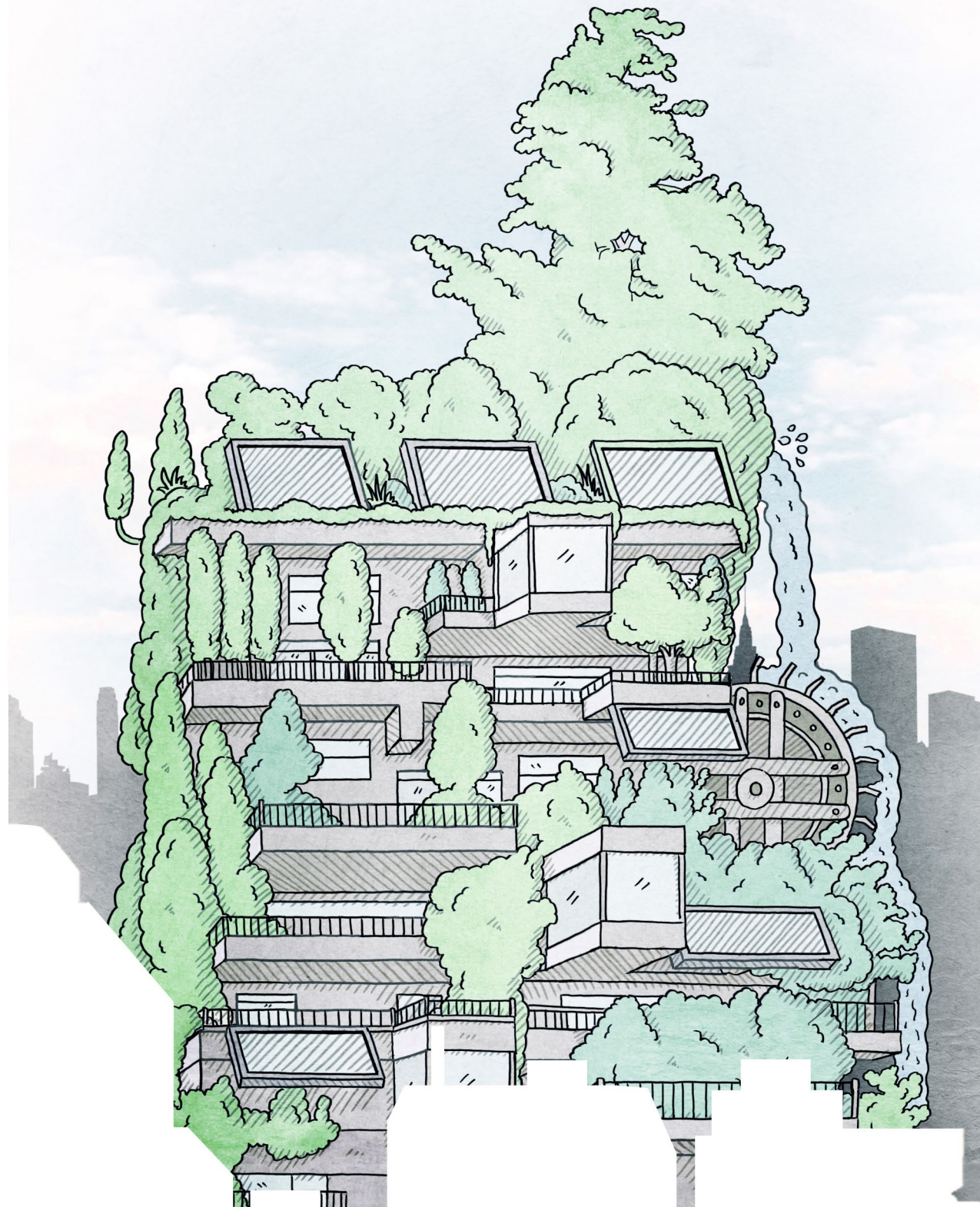
# 3D & 4D Printing as Forces for Social Good and Humanitarian Efforts

3D printing, otherwise known as additive manufacturing, has long been heralded as the next potential industrial revolution. Like the Internet of Things, however, the most powerful applications in the near-term will not be in the consumer space, but in the industrial/enterprise space. While consumer desktop 3D printers today can print basic household items and trinkets, the technology is being advanced to print far more complex items like physical structures, which holds the promise of upending the construction industry, and addressing inevitable housing crises in the future. It is also evolving to print clothing, food, and even replacement human organs – which, taken in combination, have the potential to revolutionize humanitarian efforts. Imagine dropping 3D printers into remote and underserved areas and/ or warzones, as a method of allowing local populations to "print" food, medicines, and medical devices, and other important supplies, in real-time. The World Health Organization estimates there are about 30 million people who require prosthetic limbs, braces, or other mobility devices – the majority of whom are in developing or crisis-torn areas – yet fewer than 20% have them. This could represent an entirely new model of philanthropy.

And the visionary possibilities of 3D printing are not limited to the planet. The technology might also be pivotal in helping billionaires turn their outer space moonshots into reality. Imagine a near future when private space enterprises can extract available substrates on, say, the lunar or Martian surfaces, to 3D print necessary items or make repairs, on-demand and in real time.

More practically, today, 3D printing offers an affordable, sustainable, on-demand solution to meet the immediate needs of local or underserved communities in areas like agriculture, health, and waste management. For example, engineers are developing tiny 3D-printed computers that could revolutionize data collection for farmers in developing countries. Separately, a doctor working in the Gaza strip has developed a 3D printed, 30-cent stethoscope. The plan is for Gazans to build and manufacture them themselves. And UK charity Techfortrade is trying to make 3D printing affordable for developing countries by creating software that is able to take e-waste components and use them to build 3D printers.

The concept of 4D printing takes the potential even further. In 4D printing, the 4th dimension is time. Some of the leading research on 4D printing has come directly out of MIT's Self Assembly Lab. The technology leverages "intelligent" materials that can self-assemble, change shape, and self-repair in response to changing environmental conditions. For example, 4D printed garments or armor could have thermal properties that change in response to warmer or cooler temperatures, in real time – something which could have tremendous military applications, especially for those operating in more demanding environments. In the healthcare arena, 4D-printed medical devices like biomedical splints could save lives when implanted into the body to change shape along with the changing (e.g., expanding or compressing) contours of the patient. Similarly, Chinese researchers are developing 4D-printed breast implants for cancer patients. And, in conflict or disaster zones, one of the greatest potential applications of 4D printing technology could be self-healing roads that use smart materials like heat-conductive asphalt. Gartner named 4D printing among its three "megatrends" to watch over the next five to 10 years.

3D printing and, to a greater extent, 4D printing are fairly nascent; but, they hold the promise of revolutionizing medicine, construction, and humanitarian efforts. How will these technologies change production, inventory, and supply chains – will they render current inefficiencies obsolete? Could real-time, on-demand printing help mitigate inputs to climate change by reducing the need for the transportation (e.g., trucking, rail)? How could 3D and 4D printing be used in combination with other novel technologies (e.g., synthetic biology, drones) for even greater impact? 3D and 4D printing in a way democratizes construction and manufacturing, and that could mean major shifts in demand, supply. What are the downsides? Copyright infringement? 3D/4D printed weapons? How can they be minimized without restricting positive impact?



3D & 4D PRINTING AS FORCES FOR SOCIAL GOOD AND HUMANITARIAN EFFORTS
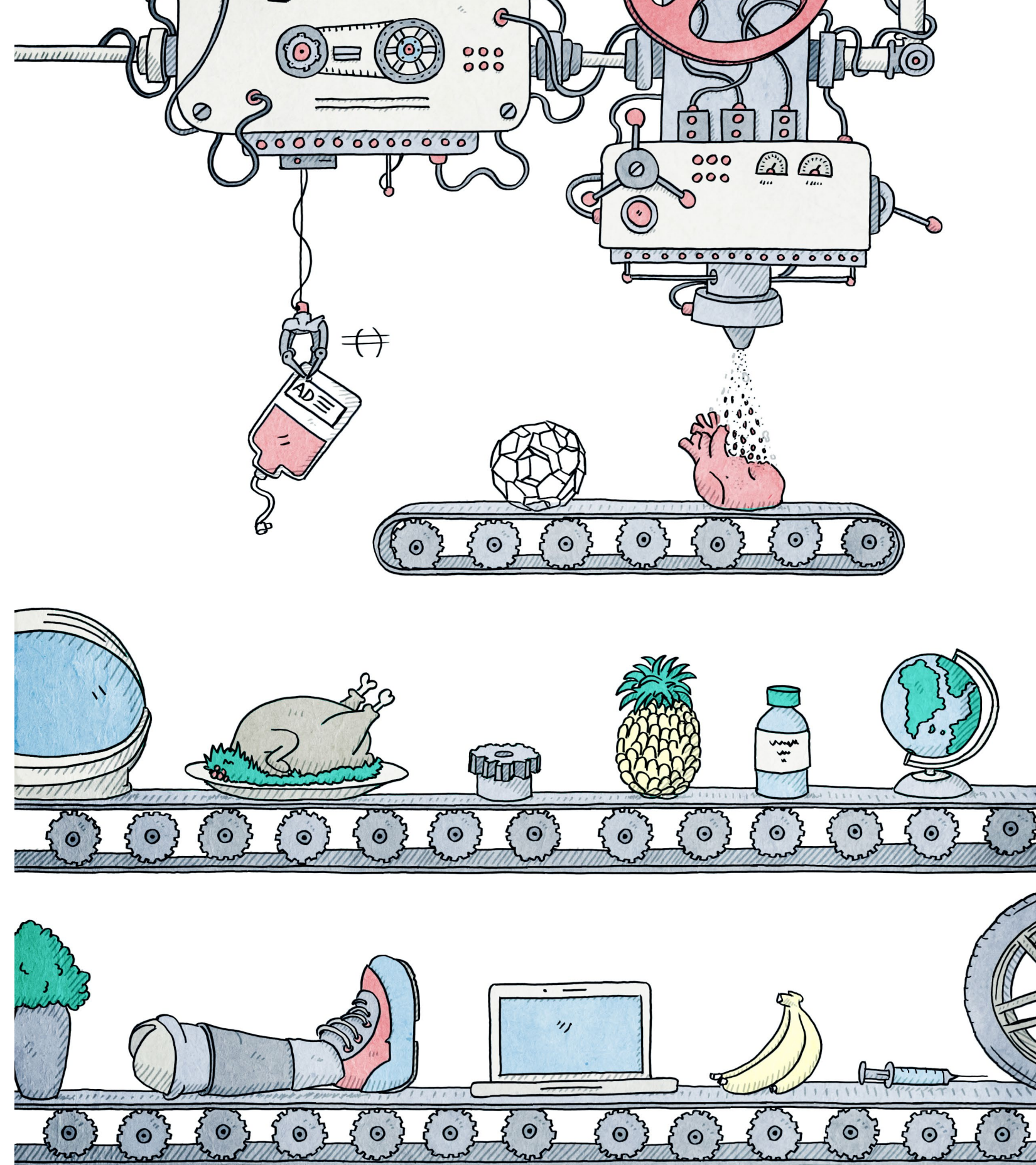
# Nation, Inc

The role of institutions is changing around the world. Government, corporation, news and media, faith and religion, technology platforms (arguably its own institution), family, friends, and community. We've seen them rise and fall, change and bleed into one another. It's too early to tell where they are heading, and the answer will likely vary across regions. But one trend is apparent – the blurring of lines between the role of government versus that of corporations. We've seen governments acting like corporations, corporations acting like governments.

Governments acting more like corporations. A major driver of this blurring is the changing nature of work. As smart machines relieve humans of tedious tasks, traditional paths to economic viability are vanishing. Despite new fields for employment, job losses are threatening the future stability of nations, as the displacement of people by efficiencies (e.g., cheaper labor, technological advances) provoke global sociopolitical disruptions. The latest MGI report estimates that about half of all paid work activities (amounting to $15 trillion in wages) can be automated with current technology, leading to job loss or deterioration in available work. But as job creation slows down, increasingly, nations, acting more like corporations, are intervening to fill the void.

As available jobs decrease, in the developing world, the size of the global work age population is expected to increase by half a billion people by 2030. In Latin American nations like Chile and Brazil, government-backed programs that foster entrepreneurship are a reflection of concerted public policy. African nations, amid a depressed job market, are desperate to employ their youth populations. The same is true in India. India is expected to add over 280 million people to the job market by 2050, but job creation is at an eight-year low. The rise of Nation, Inc. will call for a radical reshaping of work and labor, which will demand a new set of policies to protect the vulnerable while reaping technological gains. A report from the UN Conference on Trade and Development advises developing countries to embrace the digital revolution by changing educational policies and supporting macroeconomic, industrial, and social policies.

In some places, this is not entirely new. Nation, Inc. is evident in China, where the balance between state and business has long favored the state. President Xi Jinping has built authoritarian leadership around a large, direct state role in the economy. One example is Xiongan, a government-funded high-tech innovation center designed to resuscitate poor areas and transform urban centers. Xiongan is the world's most modern, sustainable city created by fiat. President Xi is betting on the Communist government, more than markets, to steer China's economic future. Is this model the future for countries struggling with job loss and looking for an alternative to capitalism?

Corporations acting more like governments, particularly in influence of public policy. For example, tech giants are taking more activist positions, and their platforms are impacting ingrained institutions – both for the better (e.g., lobbying for improved LGBT rights, improving public health, advocating for UBI, though better is arguable) and for the worse (e.g., weakening democracy, suppressing competition, and destroying jobs), the latter leading to techlash. In fact, Amazon, Google, Apple, Microsoft, and Facebook (and arguably Tencent and Alibaba) are collectively more powerful than many governments, and wield tremendous influence over the global economy. This influence is already being challenged by regulators in many markets, and that will only increase.

The role and nature of our institutions is shifting. Many countries will need to provide jobs or job equivalents. This could lead to more government debt expansions, private/public partnerships, and loosened regulations to elevate jobs to highest priority. For example, China wants to build, through a $3.5 trillion Silk Road Economic Belt – a network of highways, railways, power stations, and industrial parks stretching to Europe. Or it could mean a more protectionist kind of capitalism. We may see a new model for public/private partnerships unfold, perhaps signaling a pivotal shift and radical remake of the balance between state and market.



NATION, INC

# Infrastructure of the Future
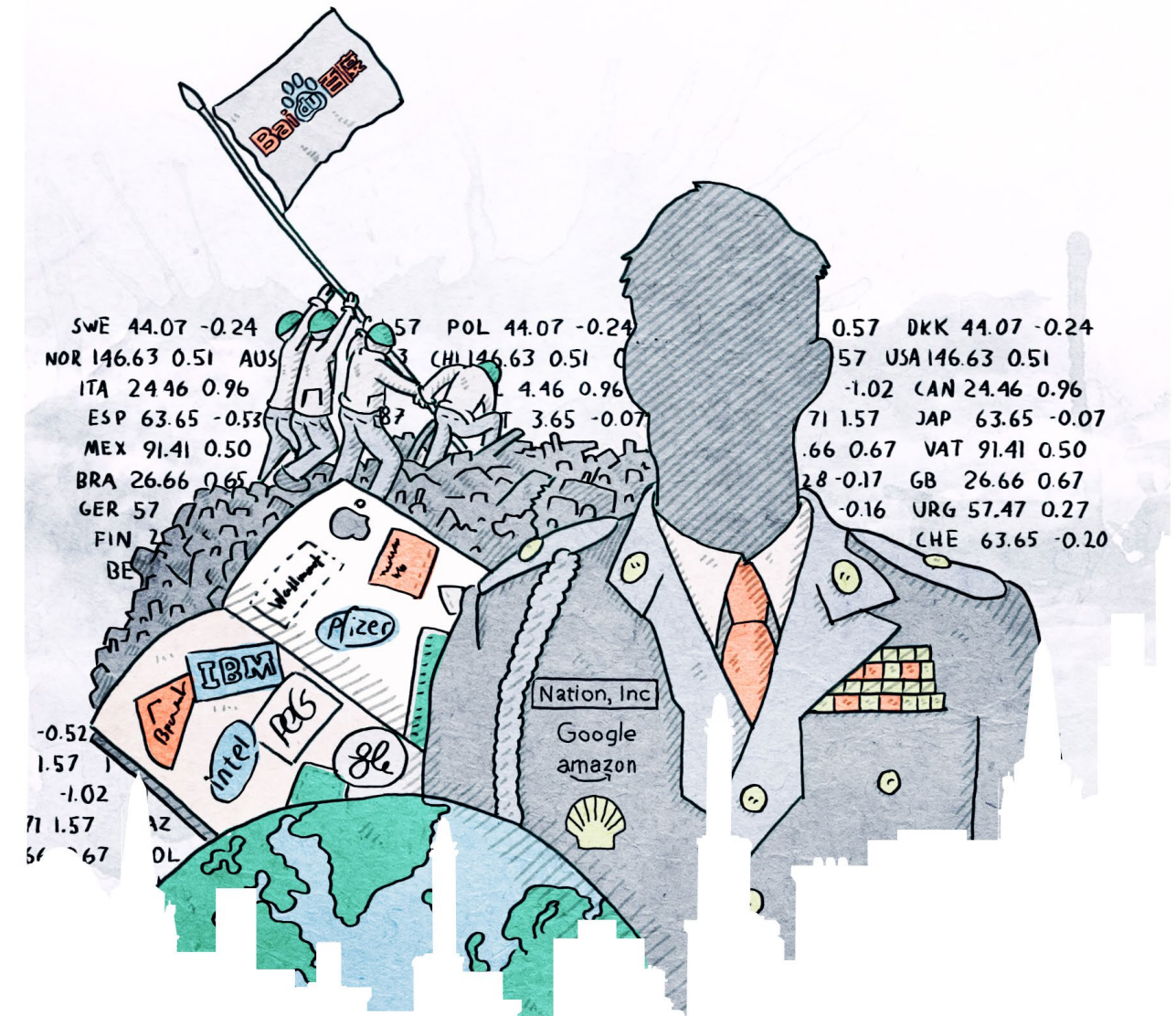
Infrastructure has long been defined in an industrial-era context, using a soon-to-be-outdated model for development. An entirely different approach to building for future competitiveness of cities, countries, regions, and companies is needed, taking into account new characteristics:

**"Smart" Sensor Networks:** Fifty-four percent of humanity lives in cities, and almost all the world's projected population growth over the next three decades will be in cities. IBM, Cisco, Hitachi, Siemens, and others have taken aim at this market, using technology to tackle urban challenges of transportation, parking, traffic, weather, energy, water management, and policing. Cities already spend a billion dollars a year on these systems, and that's expected to exceed $12 billion a year in the next 10 years. In India, where the urban population is predicted to increase from 31 percent of the total to 38 percent by 2026, PM Narendra Modi plans to invest $1.2 billion in 100 new and retrofitted smart cities. We may first see several smaller-scale pilot projects prove out the utility of these systems – including, for example, how San Diego is currently experimenting with a network of smart street lights. Ultimately, the end game here may go beyond smart cities, and be about truly responsive cities.

**Support Platforms for Startups:** The location of startups is a key indicator of entrepreneurship, innovation, and economic growth – not just a large volume of startups, but a series of very successful ones. Currently, successful startups are highly concentrated in a small number of the world's largest cities in North America, Western Europe, and East Asia. But, in the future, the balance could well change. Scanning the world, we see this happening in Lagos, Nairobi, the Balkans, Colombia, and Myanmar. And, through democratizing technologies like social media, historically repressed populations are empowered toward entrepreneurship in unexpected places.

**Internet "From Above":** There are currently ~3 billion people connected to the internet, mostly through mobiles and cellular networks. Yet, most people still do not have internet access. And, of those who do, most are on slow connections. The solution to getting fast internet to the next 4 billion people may be an aerial internet. If internet connectivity improves, India would become a vast marketplace for online companies. As it stands, India struggles with the lack of traditional infrastructure that would make it easier to connect the country. If internet connectivity becomes a basic human right, will the aerial internet be a form of disaster relief? What about for war-torn areas?

**Hyper-Efficient/Sustainable Urban Farming:** Food insecurity is one of the most existential threats to populations throughout the developed world. Addressing this issue, even in part, with solutions like vertical urban farming will go a long way toward improving health outcomes and alleviating poverty. Japan has converted dozens of abandoned electronics warehouses into farms. The indoor farming effort produces 10,000 heads of lettuce per day with 40% less power, 80% less food waste and 99% less water usage than outdoor fields. A similar facility is under construction in Hong Kong, with Mongolia, Russia, and China on the list for near-future builds.

**Drone Networks:** One of the exciting features of the new infrastructure model, is that much of the advancement will take place in underdeveloped markets where innovation is a need, versus a nice to have. As an example, East Africa is leading the way in drone-based deliveries. In early 2018, Tanzania's government will begin using drones to deliver medical supplies to remote areas. The government expects to save lives thanks to faster delivery times. And Rwanda has already completed 1,400 similar deliveries. What's next – drones from the sea?

**A Thriving Collaborative Economy:** The rise of the collaborative economy has led to debates over regulatory and labor issues, but this new economic model is growing into a global movement. India is leading the way in home-grown sharing outside the US., with ride- and car-sharing (Zipgo, Zoomcar, and Myles join ride-sharing apps like Ola), P2P lending (Faircent), clothing sharing (Swishlist, RentItBae), and coworking space (CoWrks, Awfis). A thriving collaborative economy values access over ownership; cities, regions, and nations will need to adapt legal and regulatory frameworks to match, and ensure they benefit and support all parties – customers, owners, workers, aggregators, intermediaries, and tech.

**Remittances & Open Mobile Payment/Savings Platforms:** Economic migration has become so widespread that global remittances are now worth more than twice as much as foreign aid. There is a $26 billion remittance industry in the Philippines. Alibaba's Alipay has attracted 400 million people worldwide. The same is in full swing in Africa, a world leader. (You know this!) Next – how will alternative currencies help developing countries bypass traditional banking?

**Blockchain:** Could Blockchain be considered a new form of infrastructure? It could change how we tap into and measure the energy grid, as one example. That said, the tech is one piece of broader change that must be in place. On its own, blockchain's impact is limited, but if it pushes entities to cooperate and systems to change, employ more pragmatic, transparent, and privacy-protecting practices, its impact could be substantial.

To perform well on infrastructure competitiveness, the public sector can look to the private sector. For example, best-of-breed large companies have had incubators, accelerators, garages, and labs for years. Now these innovation units are becoming more common in the public sector. Denmark has MindLab, and Singapore has PS21 Office. The most popular idea is open innovation: Sitra, in Finland, and the South African Center for Public Service Innovation both invest in companies. In addition to entirely new types of infrastructure, cities and countries should plan to adapt existing infrastructure as well – as an example, autonomous vehicles will reorient cities. Future competitiveness will ultimately be driven by a multi-pronged approach to building 21st century infrastructure, not just maintaining that left over from the industrial age.

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