The Future is Now

Q4 2018

Quarterly Emerging Trends Report

ASIAN PRODUCTIVITY ORGANIZATION

The Future is Now, Quarterly Emerging Trends Report (Q4 2018)

First edition published in Japan
by the Asian Productivity Organization
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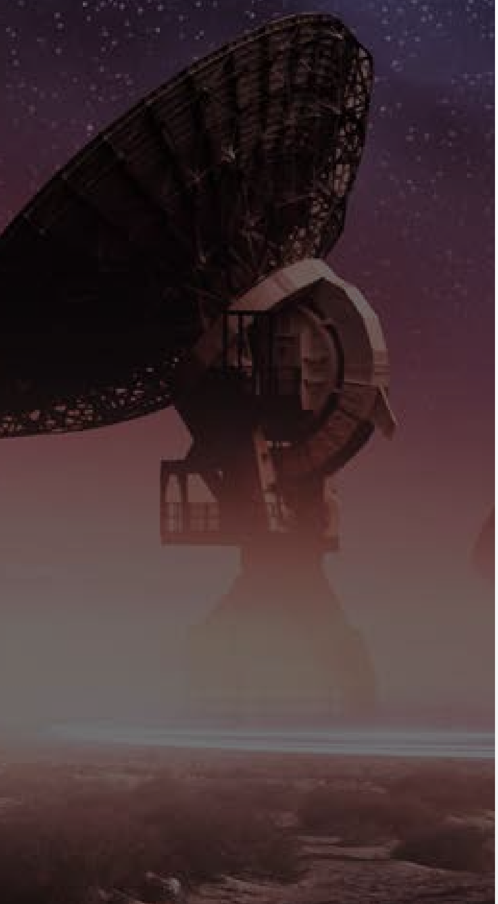
FOREWORD

The future,

especially the far future,
is not predictable,
so what is the value in
making guesses about
what will happen?

Foresight helps to
break habits,
challenge assumptions,
and open the space
for strategic
conversations about
fundamental issues.



There are a few tendencies that plague those attempting to forecast "the future." First, predictions are often clouded by advocacy, envisioning overly optimistic outcomes. Second, organizations rely on extrapolating into the future using only the recent past or, inversely, to assert confidently that we are on the verge of a great transformational discontinuity. Third, bureaucracy and organizational politics can disincentivize thinking about the unthinkable.

With The Future is Now series, the Asian Productivity Organization (APO) hopes to help its member countries counterbalance these tendencies. The emerging trends covered in this report are not known to be uniformly positive or negative; they pose both risks and opportunities for member countries. Their impacts, while potentially transformative, are uncertain. Also, unlike many organizations that must focus their efforts on the day-to-day or medium term, the APO Futures Team is dedicated to exploring the "black swans" and "black elephants" that may be lurking out of view.

In this fourth quarter emerging trends report, you will find new strategic issues that have been coming to light in recent years. The issues explored in this report may not come to pass, but reflecting on them can help ensure that your current strategy and business model are "future-ready." The direction and pace of these issues are not yet known, but policymakers, businesspeople, and ordinary citizens can begin to think through them and act to prepare for possible disruptions.

Is humanity's ultimate destiny to build cities among the stars? Will we build advanced systems to monitor planetary health? Is our technological progress truly inevitable? These are some of the questions explored in this latest report. The Futures Team covers the essentials, the status of each trend, and discusses implications and possible responses that member countries could make.

The Futures Team continues to use our AI-driven platform and a range of other foresight tools to regularly scan for trends, drivers, and uncertainties that may affect APO member countries. Some of these trends end up being covered in this series of reports, while others are used as the foundation for research projects and future-oriented initiatives.

In recent months, we have been exploring ways to build a regional network of foresight practitioners and experts across our member governments. While strategic foresight and scenario planning were developed in North America and Europe, these techniques have been adapted and advanced in the Asia-Pacific. In the coming years, the APO looks forward to expanding the community of foresight users in the region and sharing a unique "Asian-Pacific style" of foresight.

I hope that you find The Future is Now both challenging and interesting. While it might not foretell the future, I hope that it will help you and your organization to think the unthinkable. In this coming year, the Futures Team will also be working on a new way to present the strategic emerging issues and trends which they uncover. We hope you will continue supporting the upcoming 2019 reports as well.

Dr. Santhi Kanoktanaporn
Secretary-General
Asian Productivity Organization
January 2019

EXECUTIVE SUMMARY

NEWSPACE

In recent years, there have been emerging signals of a new Space Age. From Washington, DC, to Beijing, Moscow to Tokyo, billionaires, privateers, and political leaders are vying to send up satellites, mine asteroids, and colonize Mars. Space-based services, like satellite-enabled navigation, are already central to modern civilization and their paid growth will make them even more important over the coming century and beyond.

DASHBOARD EARTH

Anthropogenic climate change, dwindling fisheries, urban pollution, and ozone depletion are just a few of the emerging environmental challenges that countries face. Given the complex interdependencies and uncertainties relating to the environment, it is difficult to holistically understand the state of the planet. As a result, scientists and policymakers are developing new frameworks and technologies to monitor the stability and resilience of the Earth at the system level.

RADICAL RESKILLING

The future landscape of employment is uncertain given the risk of automation and disruptive new technologies. What is nearly certain, however, is that the task profiles performed by workers will change. As the skills needed in the labor market are set to change rapidly in the coming decades, governments will need to rapidly reskill workers or face revolt. What are the emerging models of reskilling being experimented with today?

THE SECOND BLUE REVOLUTION

The global population is expected to reach 9 billion by 2050, and global meat consumption continues to rise. Both trends present a serious challenge to humanity. The "Blue Revolution" starting in the mid-1960s saw significant growth in worldwide aquaculture and helped to meet the challenge of feeding the world. However, the rise of aquaculture in Asia as a major source of food has also created serious health and environmental issues. Now, novel practices are being explored to produce seafood sustainably.

GLOBAL INNOVATION WINTER

Since the end of World War II, there have been many transformative technological innovations that have driven increases in productivity, growth, and human well-being. However, escalating political and security concerns may lead to a "global innovation winter," a reduction in the human and financial capital needed to drive the creation of next-generation emerging technology.

From Washington, DC, to Beijing, Moscow to Tokyo, billionaires, privateers, and political leaders are vying to send up satellites, mine asteroids, and colonize Mars.

In recent years, there have been emerging signals of a new Space Age, as governments and private companies show renewed interest in the profits, perils, and possibilities of outer space. These new players are filling a void left by First World governments that have slashed funding for space missions. Within this century, many commentators have suggested that there will be mainstream space tourism, asteroid mining, advanced satellite technology, and even the first colonies set up on Mars. By some estimates, the space industry is expected to be worth USD3T by 2050 [1].

In the next two to four years, there will be tens of thousands of commercial satellites providing electrooptical, infrared, radar, and hyperspectral thermal imagery that will map the globe in minutes, available for anyone to purchase. This geospatial data can be analyzed with advances in data analytics and artificial intelligence to detect environmental changes. As the services and benefits of this satellite network become tied to the day-to-day functioning of the global economy, it will increase the risks associated with military conflicts in space.

THE ESSENTIALS

This renewed focus on space and its possibilities is sometimes referred to as NewSpace or "alt.space," an umbrella term for the movement toward a globally emerging space-based economy and society [2]. Unlike in the classical Space Age, private players such as corporations and wealthy individuals are playing a larger role in driving this change forward. New aerospace companies often work independently of government and traditional contractors to develop faster, better, cheaper access to space and spaceflight technologies [3].

NewSpace encompasses a range of emerging technologies in various stages of development, from theory to near commercialization. Some of the major technologies include satellite constellations, cheaper rockets with greater launch cadence, asteroid mining, hypersonic space travel, and asteroid defense systems [4]. As a loose movement, there is a range of goals, from realizing a profit in a growth industry to more romantic notions of spreading human life across the stars [5].

SITUATION REPORT

"There is more going on right now in space than I've ever seen in my career."

– Robert M. Lightfoot, Jr., NASA Acting Administrator

NewSpace marks a potential turning point in the organization of space travel, technology, and humanity. The original 20th century Space Race was between Cold War superpowers, largely dominated by military and defense logic. While Great Power competition and security issues will still drive the development of space, in the 21st century there is a new set of players and drivers. Now, private entrepreneurs and companies are often driving innovation. Examples include SpaceX under Elon Musk, Blue Origin under Jeff Bezos, and Google's Larry Page backing of Planetary Resources [6]. The old guard of the space industry, such as the United Launch Alliance, are still leading players as well, focusing mainly on military launches. Government national space agencies still matter, with many developing nations moving forward quickly in building their space capabilities. PR China's space program overtook Russia's in 2016 as the second-largest one at an estimated USD4.9B [7].

Today, over 75% of space activity comes from the private sector, and new developments have made the commercial promise of space more tangible [8]. Lower-cost rocket launches, launch reusability, small satellites, and other technologies have changed the calculus of developing private space assets. Changing models of investment, from being a public-funded enterprise to attracting investment from asset owners and managers, are a large-scale shift. Public–private partnerships among governments and public and private companies may become increasingly common in the future.

WHY DOES THIS MATTER TO APO STAKEHOLDERS?

The global space economy is one of the fasting-growing sectors in the world, with an annual growth rate between 5% and 8% since 2012 [8]. Education, healthcare, weather prediction, aviation safety, navigation, storm warnings, mapmaking, global communications, global business, and thousands of industrial products are enriched by space applications.

Space-based services are already key resources of modern civilization, undergirding our navigation and communication capabilities. Potentially billions of dollars and thousands of lives are saved by satellite weather forecasting. Without satellites, we would be much more devastated by hurricanes; lack awareness of the ozone hole, El Niño, and

the full effects of global warming; and be far less capable of defending the world's communications, energy, and IT systems against solar flares or incoming asteroids. Rare lunar and asteroid materials and space-based solar power may be future resources to be extracted from space.

More countries are launching satellites and investing in space systems, given the lower costs and clear long-term benefits (Figure 1). With more satellites being launched every day, coupled with solar flares and growing amounts of space debris, the risks of these systems being disrupted are rising (Figure 2) [8]. There is now concern about this critical infrastructure being targeted by hostile agents. The USA, Russia, and PR China are developing antisatellite weapons and reorganizing their militaries to be more capable in space [9].

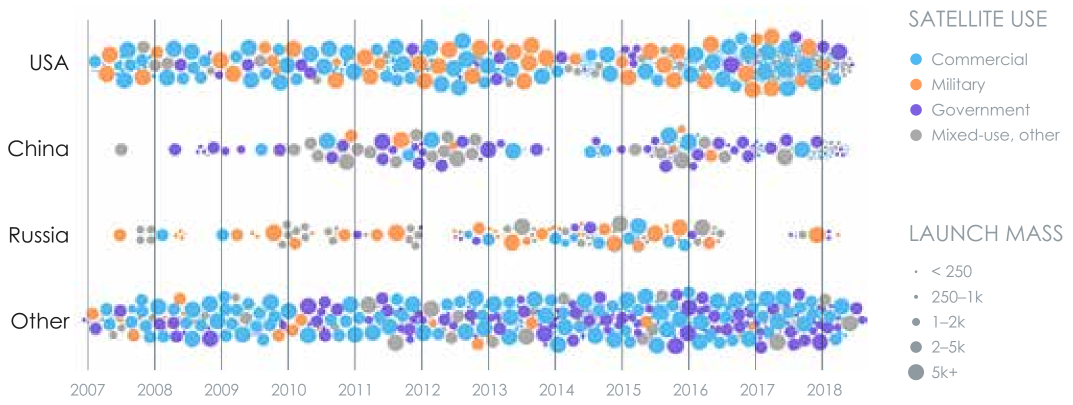
Ultimately, the total value of space is difficult to capture, and much of the major private investment is centered around the long-term promise of human settlements. The United Launch Alliance, SpaceX, and NASA have begun exploring building settlements in low-earth orbit, on the Moon, and on Mars (Figure 3).

WHAT CAN MEMBER COUNTRIES DO TO RESPOND TO THIS ISSUE?

- Member governments can act multilaterally to improve the current regulatory frameworks for space as a global commons, much like when they came together to develop the UN Convention on the Law of the Sea.
- With lowered barriers to entry and growing importance, member governments, even from developing countries, can begin bolstering or starting their space programs, working alongside fellow member countries such as India, Japan, and the ROK with existing space programs.
- Aside from national public programs, member countries can encourage and incentivize the development of a commercial space economy to complement their public investment.

FIGURE 1

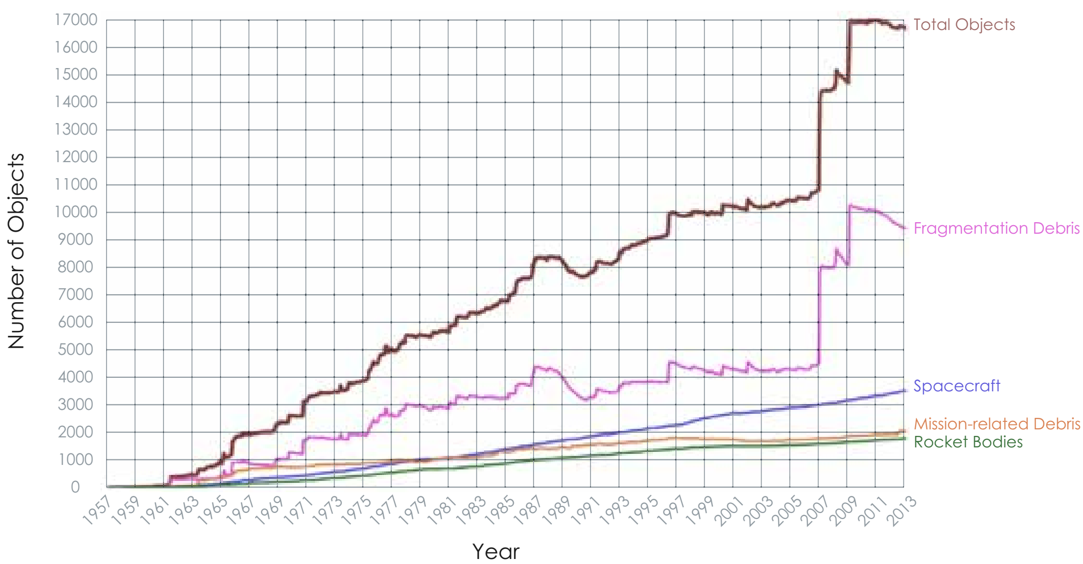
Satellite launches by primary use and operating nation



Source: Union of Concerned Scientists Satellite Database

FIGURE 2

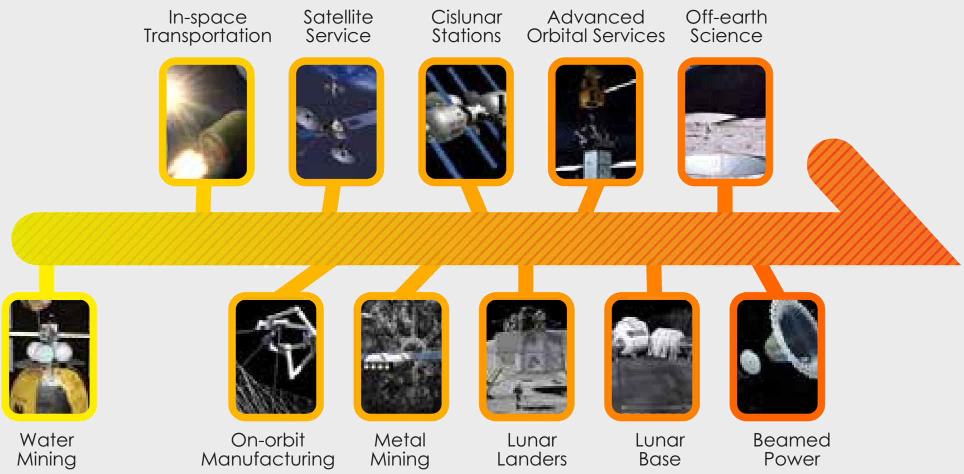
Evolution of debris in space by origin [10]



Source: National Aeronautics and Space Administration Orbital Debris Program Office

FIGURE 3

Need for activities of each vertical in the cislunar economy by time [11]



Source: Utrilla, C. M. E. Establishing a framework for studying the emerging cislunar economy; 2017. Acta Astronautica

DASHBOARD EARTH

Scientists and policymakers are developing new frameworks and technologies to monitor the stability and resilience of the Earth at the system level.

Anthropogenic climate change, dwindling fisheries, urban pollution, and ozone depletion are just a few of the emerging environmental challenges that countries face. Given all the complex interdependencies and uncertainties relating to the environment, it is difficult for policymakers, firms, and citizens to holistically understand the state of the planet.

What if there were open-access, detailed, up-to-the-minute data on ecosystem functions available to citizens and policymakers across the globe? A unified system that reflects the environmental conditions of the Earth, enabling rapid responses and long-term planning to promote human welfare and sustainable development worldwide? This is the goal of organizations and teams looking to leverage new and old technologies and develop a comprehensive monitoring system for our planet.

THE ESSENTIALS

In 2009, Stock Resilience Centre Director Johan Rockstrom and Australian National University's Will Steffen led a group of 27 internationally renowned scientists in identifying the processes that regulate the Earth's systems [12]. The outcome of this effort was the Planetary Boundaries Framework, which captures quantitatively the global boundaries within which humanity could thrive for generations to come (Figure 1). Crossing these boundaries would increase the risk of large-scale or irreversible environmental changes.

Boundaries are not thresholds or tipping points, which are the values at which small incremental changes produce large consequences, because it is difficult to identify those points. Boundaries act as a likely range where a threshold may be located, defining a safe space for human development.

Nine processes were identified: climate change; biosphere integrity; land-system change; freshwater use; biogeochemical flows; ocean acidification; atmospheric aerosol loading; stratospheric ozone depletion; and novel entities (Table 1) [13]. Exceeding the safe operating space in any of these areas introduces environmental risk and uncertainty, possibly leading to severe disruptions in human society and economies.

SITUATION REPORT

"No single solution is enough to avoid transgressing planetary boundaries. But when they are implemented together, our research indicates it may be possible to feed the growing population sustainably."

–Dr. Marco Springmann, Oxford Martin Programme on the Future of Food, Oxford University

Since 2009, the Planetary Boundaries Framework has generated enormous interest in science, practice, and policy and it has been refined. Then-UN Secretary-General Ban Ki Moon endorsed the concept of Planetary Boundaries on 16 March 2012 [14].

Kate Raworth of Oxford University's Environmental Change Institute integrated this framework into her "doughnut" model for a sustainable economy [15]. By embedding thinking about the economy within the Earth's systems, this model offers an alternative perspective to the growth model of development. Recent research has indicated that three of the planetary boundaries, climate change, biosphere integrity, and biogeochemical flows, have already been exceeded [16].

On the planetary scale, new satellite technologies like those offered by Planet Labs make it easier to understand the state of the environment in real time and produce precise data (Figure 2) [17]. Platforms like Wild.me and Zooinverse allow people to quickly identify plants and animals to better monitor biosphere integrity [18]. The Earth Institute at Columbia University maps settlement patterns and land use, connecting environmental and social indicators [19]. However, these multiple layers of data, from the local to the global level, can be difficult to integrate. It is also complicated to use these data to make predictions about possible outcomes.

WHY DOES THIS MATTER TO APO STAKEHOLDERS?

The plethora of environmental challenges linked to human activity since the Industrial Revolution have already had adverse consequences for communities around the world. To make sense of these changes, and to track progress in developing appropriate responses, it is useful to a have unified, comprehensive framework available to the public, firms, and policymakers. The idea of a "Dashboard Earth," building on frameworks like Planetary Boundaries and new technology, may be critical in directing our efforts to develop sustainably.

Combining scientific frameworks, artificial intelligence, and big data in creative ways, it is possible to bring together individuals and organizations to tackle disparate ecological issues. New data generated by ordinary people and emerging technology, as well as existing environmental information, can be visualized and communicated widely. This depends on integrating the data at different scales.

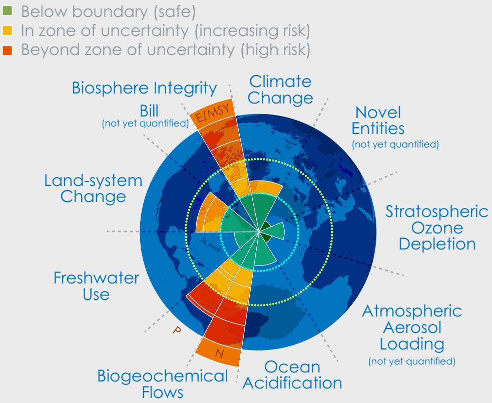
Acceptance of planetary boundaries enables more effective coordination between scientists, businesspeople, and policymakers in responding to and managing environmental challenges. The widespread dissemination of these concepts and data also allows citizens to hold their national governments accountable and track their performance at a system level.

WHAT CAN MEMBER COUNTRIES DO TO RESPOND TO THIS ISSUE?

- Countries must establish regional and international frameworks to understand and act on global environmental health.
- The quality of map-related data varies, and legal and system interoperability between data sets is lacking. Member countries can push for international open environmental data standards.
- Member countries can sponsor the use of both socially generated environmental data and satellite data to monitor environmental health and performance, beyond relying on emissions and firm-level reporting.

FIGURE 1

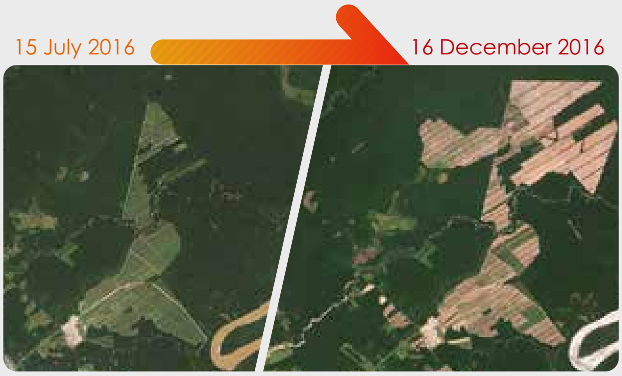
Nine planetary boundaries



Source: Steffen et al. Planetary boundaries: Guiding human development on a changing planet, Science

FIGURE 2

Planet Labs' satellite images of rapid deforestation near the Bolivian Andes, 15 July–16 December 2016



Source: Planet Labs Inc.

Table 1

Nine planetary boundaries

Earth system process	Control variable	Threshold avoided or influenced by slow variables	Planetary boundary (zone of uncertainty)
Climate change	• Atmospheric CO_2 concentration, ppm • Energy imbalance at Earth's surface, W m^2	• Loss of polar ice sheets • Regional climate disruptions • Loss of glacial freshwater supplies • Weakening of carbon sinks	• Atmospheric CO_2 concentration: 350 ppm (350–550 ppm) • Energy imbalance: +1 W m^2 (+1.0–1.5 W m^2)
Ocean acidification	• Carbonate ion concentration, average global surface ocean saturation state with respect to aragonite (Ωarag)	• Conversion of coral reefs to algal-dominated systems • Regional elimination of some aragonite- and high-magnesium calcite-forming marine biota • Slow variables affecting marine carbon sinks	• Sustain ≥80% of the preindustrial aragonite saturation state of mean surface ocean, including natural diel and seasonal variability (≥70–80%)
Stratospheric ozone depletion	• Stratospheric O_3 concentration, DU	• Severe, irreversible UV-B radiation effects on human health and ecosystems	• <5% reduction from preindustrial level of 290 DU (5–10%)
Atmospheric aerosol loading	• Overall particulate concentration in the atmosphere on a regional basis	• Disruption of monsoon systems • Human health effects • Interacts with climate change and freshwater boundaries	• To be determined
Nitrogen and phosphorus inputs to the biosphere and oceans	• P: inflow of phosphorus to ocean increases compared to natural background weathering • N: amount of N_2 removed from atmosphere for human use, MT N yr^{-1}	• P: avoid a major oceanic anoxic event (including regional) with impacts on marine ecosystems • N: slow variable affecting overall resilience of ecosystems via acidification of terrestrial ecosystems and eutrophication of coastal and freshwater systems	• P: <10 × (10–100×) • N: Limit industrial and agricultural fixation of N^2 to 35 MT N yr^{-1}, which is ~25% of the total amount of N^2 fixed per annum naturally by terrestrial ecosystems (25–35%)
Global freshwater use	• Consumptive blue water use, • km^3 yr^{-1}	• Could affect regional climate patterns (e.g., monsoon behavior) • Primarily slow variable affecting moisture feedback, biomass production, and carbon uptake by terrestrial systems and reducing biodiversity	• <4,000 km^3 yr^{-1} • (4,000–6,000 km^3 yr^{-1})
Land-system change	• Percentage of global land cover converted to cropland	• Trigger of irreversible and widespread conversion of biomass to undesired states. Primarily acts as a slow variable affecting carbon storage and resilience via changes in biodiversity and landscape heterogeneity	• ≤15% of global ice-free land surface converted to cropland (15–20%)
Biodiversity loss	• Extinction rate, extinctions per million species per year (E/MSY)	• Slow variable affecting ecosystem functioning at continental and ocean basin scales • Impact on many other boundaries like C storage, fresh water, N and P cycles, land systems • Massive loss of biodiversity unacceptable for ethical reasons	• <10 E/MSY (10–100 E/MSY)
Chemical pollution	• For example, emissions, concentrations, or effects on ecosystem and Earth system functioning of persistent organic pollutants (POPs), plastics, endocrine disruptors, heavy metals, and nuclear waste	• Thresholds leading to unacceptable impacts on human health and ecosystem functioning possible but largely unknown. May act as a slow variable undermining resilience and increase risk of crossing other thresholds	• To be determined

Source: Stockholm Resilience Centre

RADICAL **RESKILLING**

As the skills needed in the labor market are set to change rapidly in the coming decades, governments will need to reskill workers or face revolt.

Recent debates about the future of jobs center on the risks of automation and technological mass unemployment [20]. This ignores the possible effects of automation on job creation and other trends such as aging, urbanization, and the rise of the green economy. Ultimately, the future landscape of employment is uncertain and likely to vary considerably across regions. What is nearly certain, however, is that the task profiles to be performed by workers will change. Many organizations see it as necessary to try and anticipate these changes and develop reskilling initiatives. However, is such radical reskilling even possible or will national governments face widespread revolt? What are the emerging models of reskilling being experimented with today?

THE ESSENTIALS

Pathways to stable, meaningful work that provides a good income have become increasingly fractured and polarized, favoring those with certain skills or living in certain locations. Value creation in the global economy is based less on routine tasks, threatening employment for a large share of the current workforce. In the future, even those currently well employed may find technological and socioeconomic forces have rendered their skill sets outdated. Artificial intelligence, robotics, and other digital technologies are overturning the position of human expertise in the economy. Researchers suggest that those with "human skills" like empathy and those who can complement work done by machines will succeed in the future economy.

The key question is: how can we best anticipate and proactively manage the current labor market transition and shape a future of work which expands opportunities for all? While traditional education and expansion of social safety nets are two pillars, many also see reskilling and lifelong learning as crucial elements [21]. There are urgent calls to step up workforce reskilling, but what kinds of jobs could affected workers actually reskill for? Is it realistic to expect displaced coalminers to become software engineers?

SITUATION REPORT

"The emphasis needs to be placed on skills. We will have to spend the money to educate our people—not just the children, but also the people getting misplaced mid-career—so that they can find new jobs."

–Satya Nadella, CEO of Microsoft

By 2030, according to a McKinsey Global Institute report, as many as 375 million workers, or around 14% of the global workforce, may need to switch occupational categories due to tech-related disruptions [22]. The magnitude of this challenge is similar to the large-scale shift from agricultural work to manufacturing in the early 20th century in North America and Europe.

Today, organizations are exploring different models of reskilling to meet talent shortages and mitigate future unemployment. While digitization and algorithmic analysis are often portrayed as threats to employment, organizations like the World Economic Forum and BCG are using digital data to map job transition pathways and reskilling opportunities [23]. Figure 1 shows one sample pathway for an assembly line worker.

Examples include the Singapore government's Institute for Adult Learning, which plays a pivotal role in developing adult educators for a range of industries and conducts research on the impact of skills on work and productivity [24]. By blending classroom and work-based learning and developing clear professional standards for continuing education educators, workers are able to find quality instruction when seeking to reskill or upskill.

The Danish government also has a skill anticipation system that compiles accessible, detailed information on labor trends and skill demands for 850 occupations [25]. Using quantitative forecasting, sector studies, employer surveys, and foresight, individuals can gain a better understanding of labor market dynamics to plan their livelihoods. Manpower Group has helped redundant workers transition to new careers in Europe, PR China, and India by developing entrepreneurial, IT, and other in-demand skills. For instance, in Italy, Manpower Group partnered with companies, local governments, and universities to retrain adults from declining sectors for roles like computer-assisted design engineers, aerodynamics engineers, and human resources specialists. This model has been expanded across Europe and the USA.

Analysts suggest a shift to on-demand learning, where platforms like Udemy, edX, and others offer targeted microcredentials as a more agile substitute for traditional ones and two-year graduate courses [26]. For in-demand skills like coding, these microcredentials are becoming increasingly valued by employers.

WHY DOES THIS MATTER TO APO STAKEHOLDERS?

Given the changing nature of work and employment, productivity and competitiveness will be linked to whether people's skills are well suited to the future economy. New technologies can enhance productivity, but unless people have the appropriate skills, the full value of the gains will be left on the table (Figure 2).

In lieu of reasonable investments in reskilling, citizens in APO member countries will face disruptions in their livelihoods. Member governments may face overstretched budgets from rising welfare costs, social unrest, and even political upheaval. Researchers found declining employment to be associated with rising political instability [27].

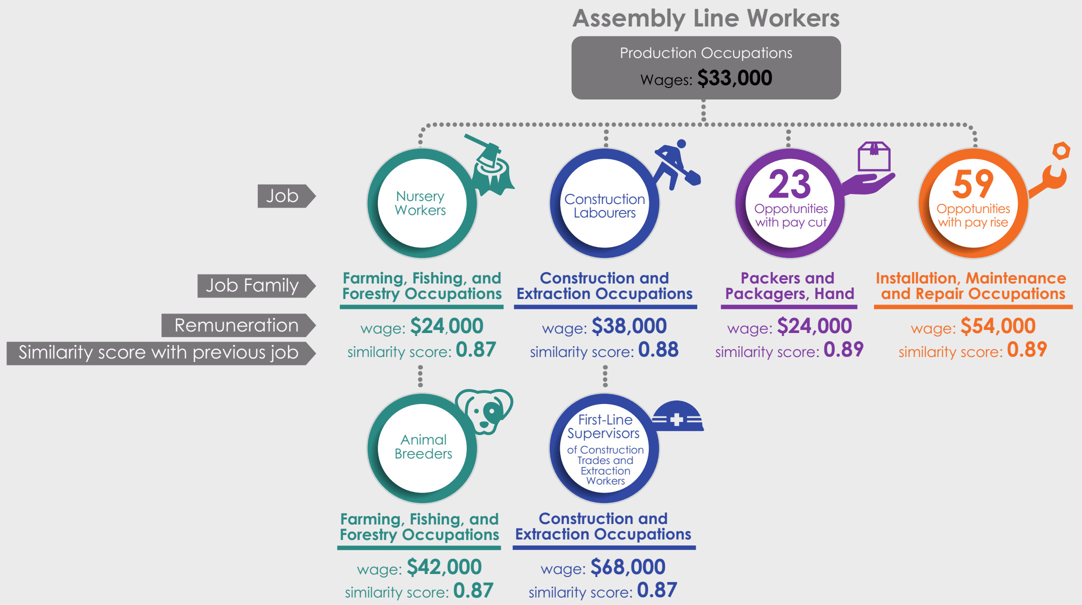
Many APO member countries, from the least developed to the most advanced, face significant risks from automation and changing employment patterns. The kinds of reskilling programs and models they will need vary, which is why it is crucial not to rely on "best practices" but to see which emerging models of reskilling and lifelong learning can be best adapted to each context (Figure 3).

WHAT CAN MEMBER COUNTRIES DO TO RESPOND TO THIS ISSUE?

- Member governments can make investments in reskilling programs and skill anticipation systems, like those implemented in Singapore and Denmark but adapted to the local context.
- People need to take temporary time out from work for retraining and exploring job transition, so public and private financial support is needed. Agile social protection and insurance will help workers avoid destabilizing income shocks.
- Member governments can recognize and promote microcredentials and new methods of training and education combining offline and online models to promote flexible upskilling and reskilling.

FIGURE 1

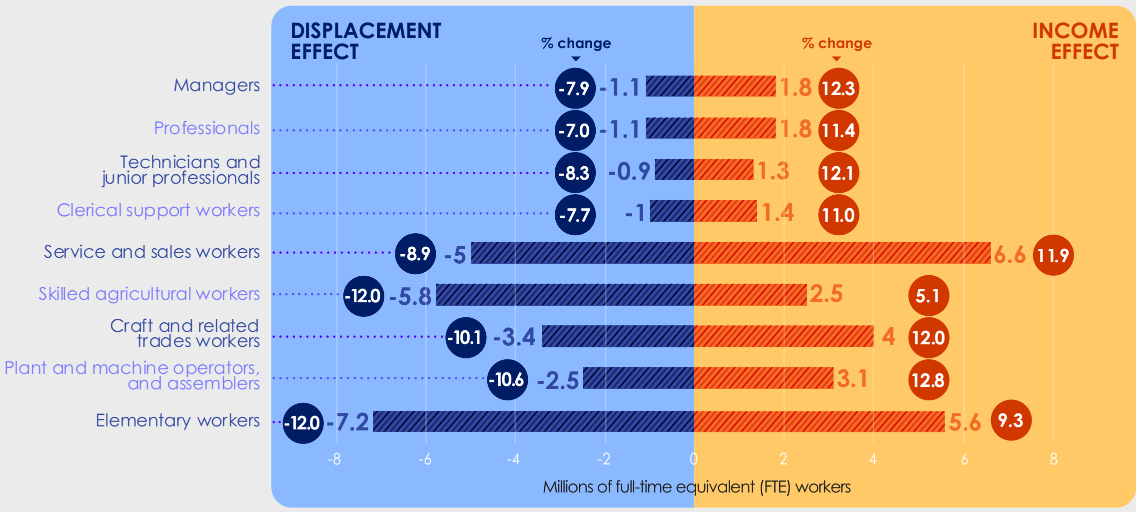
Examples of reskilling pathways for assembly line workers



Source: World Economic Forum. Towards a reskilling revolution: A future of jobs for all, 2018

FIGURE 2

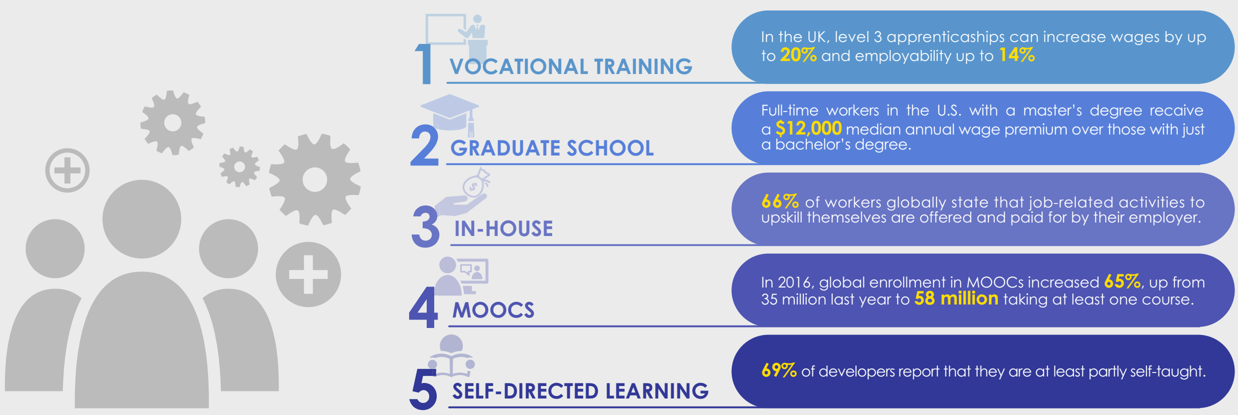
Positive and negative impacts of increased technology adoption by occupation type in ASEAN+6, number of workers (axis), percentage of workforce (labels)



Source: Cisco. Technology and the future of ASEAN jobs, 2018

FIGURE 3

Five ways workers can learn new skills on the job



Source: 1) City & Guilds Group 2) Bureau of Labor Statistics 3) Global Report Randstad Workmonitor Q3. 2017 4) The Economist 5) Quartz

THE SECOND BLUE REVOLUTION

The rise of aquaculture in Asia as a major source of food has also created serious health and environmental issues. Now, novel practices are being explored to produce seafood sustainably.

The global population is expected to reach 9 billion by 2050, and global meat consumption continues to rise. Both trends present a serious challenge to humanity. Agriculture, and the meat industry specifically, is among the greatest contributors to global warming [28]. The Blue Revolution started in the mid-1960s saw the intense growth of worldwide aquaculture and helped to meet the challenge of feeding the world. Today, the world produces more farmed fish than beef. However, this trend introduced similar externalities as the Green Revolution: habitat destruction; water pollution; and food safety scares. Now, there is a movement toward a Second Blue Revolution, mirroring the calls for a Second Green Revolution in agriculture. Can the aquaculture industry achieve long-term sustainability? If so, how?

THE ESSENTIALS

Compared with other kinds of protein production, seafood is more efficient to produce than pork and beef. Fish require fewer inputs to yield the same amount of protein. It takes roughly a pound (0.454 kg) of feed to produce a pound of farmed fish, compared with two pounds (0.907 kg) of feed per pound of chicken, three pounds (1.361 kg) for pork, and around seven pounds (3.175 kg) for beef (Figure 1) [29].

As global meat consumption continues to rise, it makes sense for a sizable share of protein requirements to come from the sea. The increasing demand for seafood has led to a rapid expansion of fish farming in Asia, where 90% of farmed fish is now produced (Figure 2). This expansion, however, has come with significant environmental consequences. The FAO reported that nearly one-third of global fish stocks are harvested at an unsustainable level [30]. During the 1980s, vast swaths of tropical mangroves, critical for coastal protection, were bulldozed to build shrimp farms. Aquaculture pollution, a mix of nitrogen, phosphorus, and dead fish, is now a widespread danger in Asia.

While intensifying aquaculture is necessary to meet rising demand, the ecological risks posed by contemporary fish farming create serious challenges as well. Producers, researchers, and other actors involved in the Second Blue Revolution look to make fish farming cleaner while still producing at the volume needed to meet future demand.

SITUATION REPORT

"But you can't just go volume, volume, volume. We're going quality, diversity, and sustainability.'"

–Dr. Stephen Cross, co-Director of the Coastal Aquaculture Research and Training Network at the University of Victoria, British Columbia

Different producers are exploring new ways of farming fish sustainably yet still commercially viable. While no single model of aquaculture has emerged, there are promising experiments across the globe. The first set of challenges concerns where to farm fish. Traditional net-based and pond aquaculture allows waste, pathogens, and parasites to flow directly into the environment [31].

Experts generally suggest two approaches moving forward: land-based recirculating systems; and offshore aquaculture. In the first approach, fish farms are moved from the ocean and ponds to recirculating systems consisting of indoor tanks regulated by heaters, aerators, and filters. Some producers have begun creating large-scale indoor aquaculture facilities able to remove most of the waste from water using these systems. Norway-based firm Nordic Aquafarms is building a USD500M indoor salmon farm to produce 30,000 tons of fish, roughly 8% of US consumption, annually [32]. The second approach is to move fish farms farther out to sea. Offshore systems use deeper waters and strong currents to funnel excess nutrients and waste away from sensitive coastal ecosystems, avoiding the need for mechanical pumps and filters (Figure 3). While it is sometimes difficult to manage these farms, it is easier to produce fish at scale than on land. Both systems remain niches rather than the norm.

These cleaner approaches to aquaculture still face obstacles, especially regarding energy use. Land-based systems must use a lot of electricity to filter and disperse waste, while offshore operations require diesel fuel for transport and maintenance.

The other major challenge concerns what to feed the fish. In general, fish farmers have become more efficient. The amount of forage fish used per pound (0.454 kg) of output has fallen by about 80% in 15 years [33]. Many omnivorous fish, like tilapia, can be farmed using vegetarian feed. Scientists are also adopting biotechnologies to produce sustainable fish feed [34]. Replacing fish oil is trickier because it contains omega-3 fatty acids produced by algae which are passed up the food chain in higher concentrations. Some companies are extracting omega-3 from algae; others are genetically modifying canola oil to produce high levels of omega-3 fatty acids directly.

WHY DOES THIS MATTER TO APO STAKEHOLDERS?

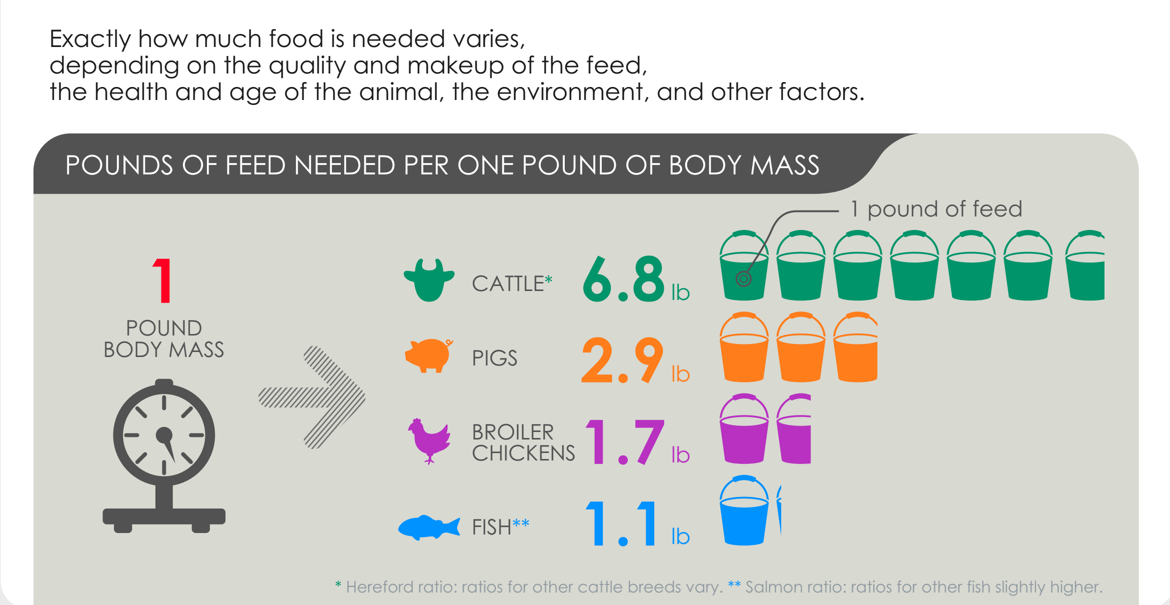
The Asia-Pacific is the producer of the vast majority of the world's seafood. Because of this, these countries are the most directly impacted by the negative side effects of intensive aquaculture. While productivity has increased in the past few decades, these gains have come at the cost of long-term sustainability. Wild catch cannot be harvested sustainably at current rates, and aquaculture also produces a range of ecological risks. For the world to meet the future food demand, it is essential to explore new ways of farming fish at scale which minimize negative environmental and health impacts.

WHAT CAN MEMBER COUNTRIES DO TO RESPOND TO THIS ISSUE?

- Member governments can engage in the emerging regional platforms that help coordinate the collective management of fisheries and aquaculture development, such as the Network of Aquaculture Centers in the Asia-Pacific. These facilitate knowledge sharing, capacity development, and monitoring of country compliance [35].
- Member governments can support the adoption of disruptive technologies and emerging practices such as land-based aquaculture or bioengineered feed, which may allow more sustainable farming. The risks and scalability of these practices should be investigated before full implementation.
- Member governments and private businesses can cooperate to create highly visible branding and certification of sustainable aquaculture and raise mass awareness of some of the dangers of traditional fish farming. This can distinguish sustainably farmed fish as higher-value products for the socially conscious consumer.

FIGURE 1

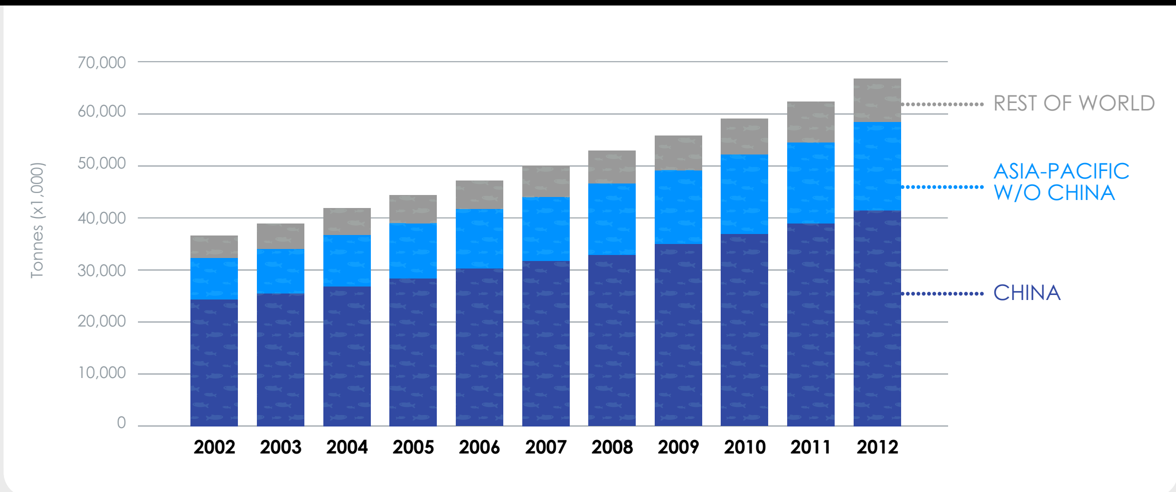
Pounds of feed required to produce equivalent pounds of meat (1 pound = 0.454 kg) [33]



Source: Bourne, J. K. How to farm a better fish. 2015. National Geographic

FIGURE 2

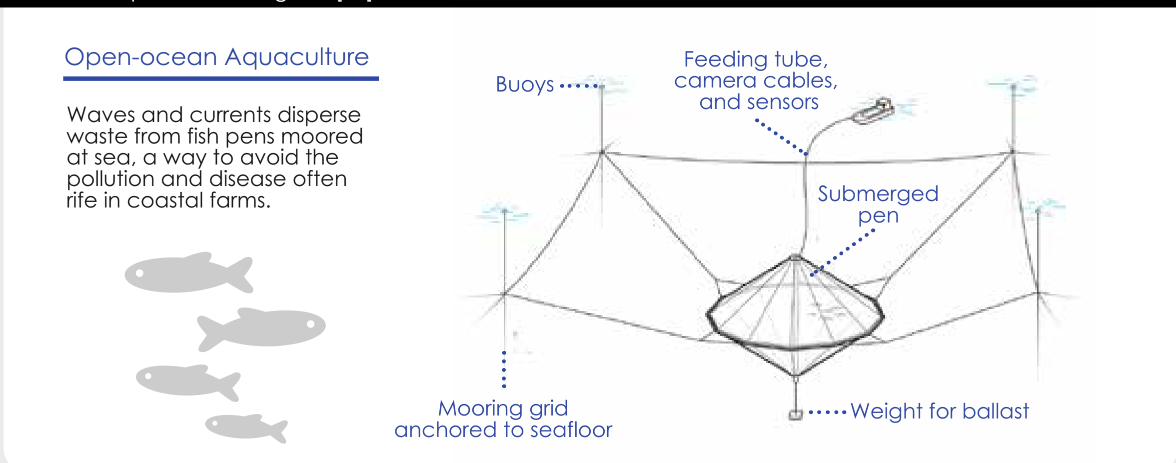
Trends in global aquaculture production (volume), excluding aquatic plants, 2002–2012 [36]



Source: Food and Agriculture Organization. Regional overview of aquaculture trends in the Asia-Pacific Region 2014

FIGURE 3

Open-ocean aquaculture diagram [33]



Source: Bourne, J. K. How to farm a better fish. 2015. National Geographic

GLOBAL INNOVATION WINTER

Escalating political and security concerns may lead to a "global innovation winter," a reduction in the human and financial capital needed to drive the creation of next-generation emerging technology.

It is uncontroversial to believe that we live in a golden age of technological, medical, and scientific progress. Accelerating technological advances seem so inevitable that they have become a reliable feature of modern life. For example, when the National Science Foundation connected five computers in 1986, the transfer rate was 56 kilobits per second [37]. Now, standard fiberoptic cables transfer information at 1,000 megabits per second, nearly 18,000 times faster than in 1986. However, it is not a forgone conclusion that this rate of innovation will continue unabated. Technological progress is driven by a globalized network of firms, researchers, and investors and if these networks are disrupted or severed, progress may halt.

THE ESSENTIALS

Since the end of World War II, there have been many transformative technological innovations: electronics; nuclear power; television; antibiotics; space travel; computers; and the birth of the Internet [38]. In computing specifically, the constant innovation has been typified by Moore's law, the doubling of transistors per square inch on integrated circuits [39].

However, in recent years, technological competition has grown political. There is a race for breakthrough technology as US and Chinese tech giants are attempting to master AI, among other investment-intensive technologies [40]. There has been a splintering of cyberspace, with many countries creating barriers to cross-border data flows and tougher cybersecurity laws. Wariness over surveillance and growing outrage over tech giants' abuse of users' personal information have led to more serious digital regulatory efforts [41]. While there may be benefits to these developments, governments might risk stifling tech development through disproportionate responses to these issues.

SITUATION REPORT

"The biggest story of the last fifteen years, both nationally and globally, is the growing likelihood that a cyclical model of history will be a better predictor than a model of ongoing progress."

–Tyler Cowen, Professor of Economics, George Mason University

Three political drivers increase the possibility of a global-level innovation winter. First, security concerns are leading to reduce exposure to foreign suppliers in areas key to national interest. For example, efforts to increase scrutiny of Chinese students and workers in STEM fields reduce the flow of creative talent into the USA [42]. They also limit the flow of engineers and entrepreneurs with US experience back to PR China. Similar efforts to block foreign investment in US companies have all but halted Chinese investment in US technology startups [43].

Second, concerns about privacy and data protection are leading some governments to tightly regulate citizens' personal data. Digital regulation is increasing as governments around the world face a public backlash over privacy and growing concerns over foreign influence operations via social media [44]. While Europe has taken a lead in this, countries like Brazil and India have adopted or are considering legislation that draws on Europe's tough data rules. Data localization is already firmly entrenched in places in certain countries, and these trends can impair collaboration and innovation.

Third, economic concerns have led to countries putting up barriers to protect their emerging tech champions against foreign firms. This forces firms to shift portions of their supply chains, relocating assembly lines and warehouses to locales without the same base of skilled labor and strong logistics. Decreased competition may result in reduced pressure to innovate.

Broadly, these drivers raise the risk of a halt in global technological innovation by increasing the costs of cross-border data transfers, sourcing of inputs from the most cost-effective suppliers, regulatory compliance, and limitations in talent mobility. The production of technology like the iPhone, an emblem of tech globalization, would be under threat from these movements (Figure 1). These trends, while insignificant in isolation, can be significant when coupled with growing concerns among some economists and tech experts that progress will face technical barriers in coming years.

The technology roadmap for Moore's law maintained by the world's major chip makers is being scrapped, and experts like Horst Simon, deputy director of Lawrence Berkeley National Laboratory, report a "kind of stagnation" in computing power [45]. This presents challenges as the expectation of continuous increases in computing power acted as a coordinating device among many industry players. There are also concerns that today's innovations are mostly trivial, consumer-driven improvements in IT and that breakthroughs from post-World War II to the 1970s had far more significant impacts on society [46]. Technical difficulties, coinciding with deteriorating conditions for innovation, may seriously slow the anticipated convergence of AI, big data, and other breakthrough technologies.

WHY DOES THIS MATTER TO APO STAKEHOLDERS?

Concerns about privacy, security, and the protection of national industry are understandable as developments in recent years have created serious tensions in the trilateral relationships among states, tech companies, and citizens. The potential consequence of strong policy and regulatory responses to these issues is that it will critically slow technological innovation in key areas. Technologies like big data, AI, and smart devices have the potential to radically boost productivity

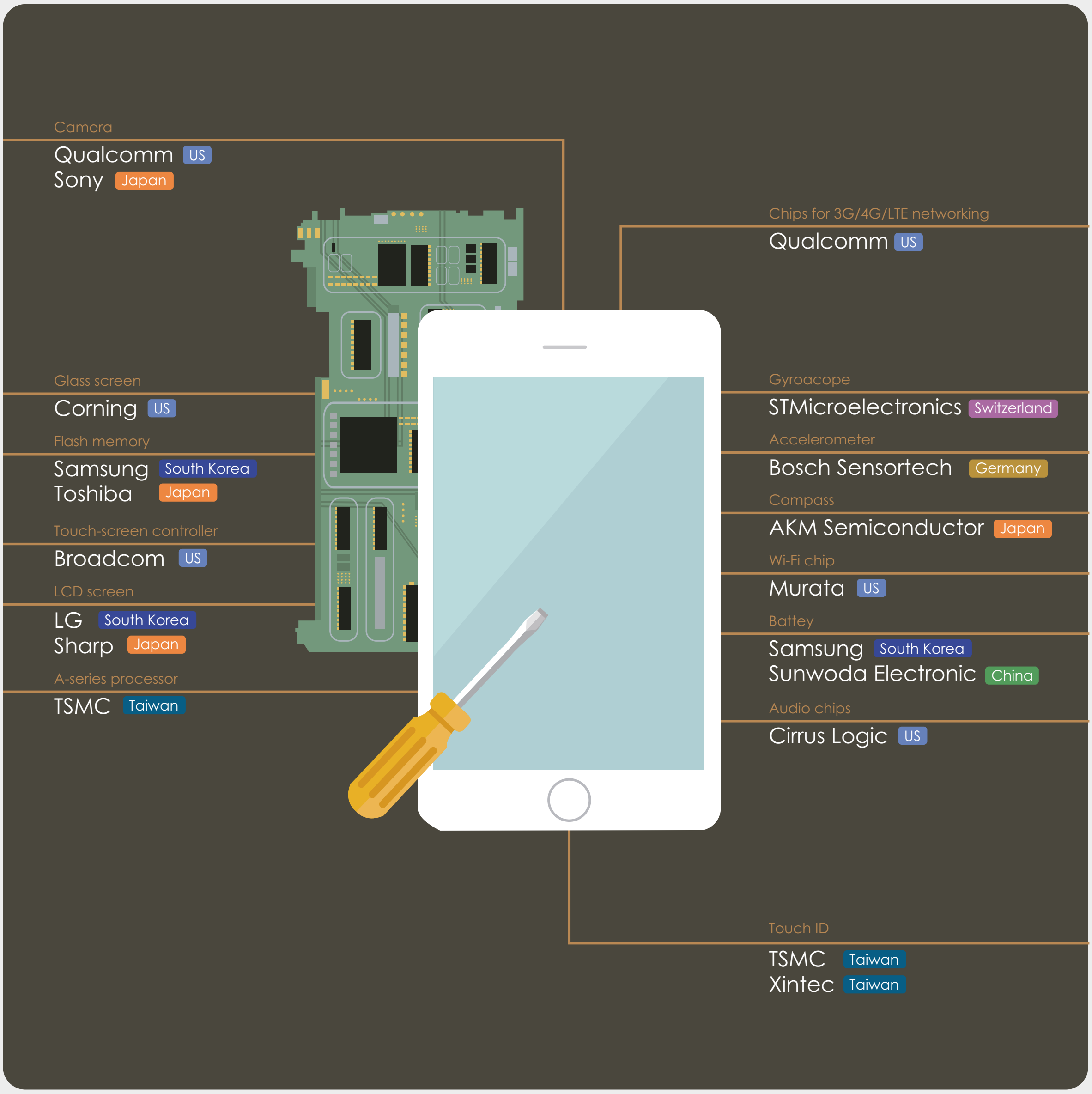
and economic growth. However, the pace and diffusion of progress in these areas are likely to be hampered by sharp reductions in human and financial capital.

Technological progress, with its attendant increase in productivity, has been a major driver of economic growth and human development since the Industrial Revolution [47]. While it is likely that this trend will continue, policymakers and other actors from APO member countries should be vigilant about the risk of an innovation winter and its possible causes. Global scientific cooperation, knowledge sharing, and international free trade regimes can be considered global public goods. If these are not maintained, then the dynamic of accelerating technological development could stop suddenly, with tremendous consequences. Companies and innovators around the world would suffer if international R&D and manufacturing were to shut down because of unmanageable geopolitical tensions.

WHAT CAN MEMBER COUNTRIES DO TO RESPOND TO THIS ISSUE?

- Member governments can develop their own knowledge assets of research, networks, software, and human capital that drive innovation-based growth. These can be further developed through international collaboration in research facilities and firms.
- Member governments can act in concert as a regional bloc to maintain global trade regimes, joint scientific research, and the movement of human capital across borders. This type of coordination carries more political and economic weight than nations acting unilaterally.
- Multilateral diplomacy can be used to develop stronger norms against the use of certain technologies for negative political purposes, such as using botnets and fake news in mass persuasion campaigns. This prevents the escalation of cyberwarfare and cybersecurity actions that may stymie innovation.

FIGURE 1
Manufacturers and countries of origin of Apple iPhone subcomponents



Source: Eurasia Group Global Risk Report 2019

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SUSTAINABLE PRODUCTIVITY

THE NEW FRONTIER FOR PRODUCTIVITY

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