HARNESSING THE FOURTH INDUSTRIAL REVOLUTION

CREATING OUR FUTURE TODAY

PROCEEDINGS OF THE FOURTH ANNUAL PUBLIC POLICY CONFERENCE

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Harnessing the Fourth Industrial Revolution: Creating Our Future Today

Proceedings of the
Fourth Annual Public Policy Conference 2018

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Philippine Institute for Development Studies
Surian sa mga Pag-aaral Pangkaunlaran ng Pilipinas

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Foreword

In a span of just a few decades, the world we live in has changed dramatically. It is evident that we are now in the age of the Fourth Industrial Revolution (FIRe). While previous industrial revolutions merely liberated us from extreme physical production, the FIRe has fused the physical, digital, and biological worlds, covering the entire systems of production, management, and governance.

Recognizing the need for our policymakers and other development actors to better understand the potential socioeconomic impacts of this revolution and how the country can benefit from it, the Philippine Institute for Development Studies (PIDS) chose "Harnessing the Fourth Industrial Revolution: Creating Our Future Today" as the theme of its Fourth Annual Public Policy Conference (APPC) in September 2018. The same theme was the centerpiece of the 2018 Development Policy Research Month for which the APPC was its main and culminating activity.

This volume compiles the proceedings of the APPC 2018, which form part of the Institute's growing contribution to the discussion of FIRe in the Philippines. It covers evidence-based policy studies, articles, and commentaries written by esteemed international and local experts in the fields of engineering, computer science, physics, agriculture, economics, governance, and business, to name a few.

May this publication inspire us all to assume our collective responsibility to ensure that we reap the benefits of this revolution in a positive way and no one is left behind.

CELIA M. REYES
President

Preface

This publication is a recognition of our collective desire to instigate public discussion on the Fourth Industrial Revolution (FIRe) and to direct the attention of our leaders and policymakers to issues revolving its rise in the country.

Our sincere thanks goes to the Philippine Institute for Development Studies for providing us a platform to share our knowledge and expertise on the matter. Given the intricacies of FIRe, we believe that no single discipline can help us fully comprehend the radical innovations that this revolution brings with it.

It is just apt, therefore, to employ a multiperspective approach in analyzing FIRe and its impacts. Such approach allows this publication to generate a wealth of information useful to major interest groups in advancing reform initiatives necessary for us to reap the fruits of FIRe.

It is our hope that the recommendations raised in this publication will be embraced by our future policies and programs on FIRe. May they also serve as a foundation for further collaborative work as this dynamic new agenda evolve.

AUTHORS

Acknowledgement

The Philippine Institute for Development Studies (PIDS) owes the success of the Fourth Annual Public Policy Conference (APPC) to the hard work, dedication, and generosity of a number of individuals and institutions.

Sincere appreciation is extended to the 2018 DPRM interagency steering committee consisting of the National Economic and Development Authority, Philippine Information Agency, Civil Service Commission, Presidential Management Staff, *Banko Sentral ng Pilipinas* (BSP), and Department of the Interior and Local Government, which serve as permanent members, and the Department of Science and Technology (DOST), Department of Trade and Industry (DTI), Department of Labor and Employment (DOLE), Department of Information and Communications Technology, and Commission on Higher Education (CHED) as additional members, for their valuable advice on the theme of the DPRM/APPC, messaging, and lineup of activities, for organizing their own activities in support of the DPRM, and for supporting the conference proper.

The Institute also acknowledges the generous financial assistance provided by the Global Development Network, DTI, BSP, Department of Foreign Affairs–Office of the Undersecretary for International Economic Relations, Australian Embassy, Asian Development Bank, DOLE, CHED, and DOST-Philippine Council for Industry, Energy and Emerging Technology Research and Development, which allowed PIDS to mount a bigger conference and invite more speakers and participants, thereby expanding the breadth and depth of the APPC.

The insightful and thought-provoking presentations and discussions that prevailed throughout the conference would not have been possible if not for the participation of all the speakers, some of whom travelled long distances to attend the conference.

Special thanks also go to Dr. Emmanuel de Dios for reviewing the Key Takeaways section of the proceedings, the Government of Singapore for providing a speaker on their SkillsFuture national program, and the De La Salle University–Manila for participating in the technology and knowledge exhibit. We also appreciate the United Nations Development Programme for allowing Sophia, a social humanoid robot and its Innovation Champion, to be part of the APPC.

Finally, it is worth mentioning the men and women of the Institute who toiled in the planning and conduct of the conference, in particular, the 2018 APPC Organizing Committee composed of Dr. Celia Reyes, Dr. Marife Ballesteros, Dr. Ramonette Serafica, Dr. Jose Ramon Albert, Dr. Vicente Paqueo, and Dr. Aniceto Orbeta Jr., the Research Information Department headed by Dr. Sheila Siar, the Administrative and Finance Department headed by Ms. Andrea Agcaoili, and all the support staff.

List of Acronyms

4IR	– Fourth Industrial Revolution
ADB	– Asian Development Bank
AI	– artificial intelligence
APPC	– Annual Public Policy Conference
ARTNeT	– Asia-Pacific Research and Training Network on Trade
ASEAN	– Association of Southeast Asian Nations
ASTI	– Advanced Science and Technology Institute
BOI	– Board of Investments
BOT	– build-operate-transfer
BSP	– *Bangko Sentral ng Pilipinas*
BTMS	– Budget and Treasury Management System
CATCH-ALL	– Contactless Apprehension of Traffic Violators on 24-Hour Basis All-Vehicle Detection System
CE	– computer engineering
CET	– continuing education and training
CHED	– Commission on Higher Education
CoARE	– Computing and Archiving Research Environment
CPS	– cyber-physical systems
CPTPP	– Comprehensive and Progressive Agreement for Trans-Pacific Partnership
CS	– computer science
CVIF	– Central Visayan Institute Foundation, Inc.
CVIF-DLP	– CVIF - Dynamic Learning Program
DLSU	– De La Salle University
DOST	– Department of Science and Technology
DPRM	– Development Policy Research Month
DTI	– Department of Trade and Industry
ECE	– electronics and communications engineering
EE	– electrical engineering
ESCAP	– Economic and Social Commission for Asia and the Pacific
ESO	– engineering services outsourcing
ETC	– electronic toll collection
FETC	– Far Eastern Electronic Toll Collection Co.
FIRe	– Fourth Industrial Revolution
GDP	– gross domestic product
GII	– Global Innovation Index
GVCs	– global value chains
HRD	– human resource development
i^3s	– Philippine Inclusive Innovation Industrial Strategy

ICT	– information and communications technology
IGF	– international gateway facilities
ILO	– International Labour Organization
IoT	– Internet of Things
IT-BPM	– information technology-business process management
ITE	– Institute of Technical Education
ITIF	– Information Technology and Innovation Foundation
JHS	– junior high school
KTPs	– Knowledge Transfer Partnerships
LET	– Licensure Examination for Teachers
LTO	– Land Transportation Office
MOE	– Ministry of Education
MOU	– memorandum of understanding
mPhilGEPS	– modernized Philippine Government Electronic Procurement System
MSME	– micro, small, and medium enterprise
NEDA	– National Economic and Development Authority
O2O	– online to offline
OECD	– Organisation for Economic Co-operation and Development
PC	– personal computing
PEDRO	– Philippine Earth Data Resource Observation
PEZA	– Philippine Economic Zone Authority
PFM	– Public Financial Management
PIDS	– Philippine Institute for Development Studies
PISA	– Programme for International Student Assessment
PREGINET	– Philippine Research, Education, and Government Information Network
Project DIME	– Project Digital imaging for Monitoring and Evaluation
PSHS	– Philippine Science High School
R&D	– research and development
RA	– Republic Act
RIICs	– regional inclusive innovation centers
S&T	– science and technology
S4CP	– Science for Change Program
sci-fi	– science fiction
SDGs	– Sustainable Development Goals
SETUP	– Small Enterprise Technology and Upgrading Program
SHS	– senior high school
SMEs	– small and medium enterprises
SSG	– SkillsFuture Singapore
STEM	– science, technology, engineering, and mathematics
STI	– science, technology, and innovation

STRIDE	– Science, Technology, Research, and Innovation for Development
tech-voc	– technical-vocational
TESDA	– Technical Education and Skills Development Authority
TOR	– terms of reference
UBI	– universal basic income
UK	– United Kingdom
UN	– United Nations
UP	– University of the Philippines
UPD	– University of the Philippines - Diliman
UPLB	– University of the Philippines - Los Baños
US	– United States
USAID	– United States Agency for International Development
WAATER	– Wide-ranging Advanced Analytics Training and Education Reinforcement
	– Web-Adapted Analytics Training and Education Reinforcement
WB	– World Bank
WDA	– Workforce Development Agency
WEF	– World Economic Forum
WSG	– Workforce Singapore
WTO	– World Trade Organization

About the Conference

Technological breakthroughs and the interplay of a number of fields, including robotics, artificial intelligence, nanotechnology, neurotech, data analytics, blockchain, cloud technology, quantum computing, biotechnology, Internet of Things, virtual and augmented reality, and 3D printing, have ushered in the Fourth Industrial Revolution (FIRe). Three previous industrial revolutions have given mankind steam power, electricity, and electronics, respectively. The FIRe is expected to create a smarter, more connected world, which will affect all disciplines, economies, and industries, as well as challenge ideas about what it means to be human with the "fusion of technologies that is blurring the lines between the physical, digital, and biological spheres" (Schwab 2016).

One of the biggest concerns foreseen in the era of technological advances is the impact of FiRE on employment as job automation may replace, complement, or completely make human labor obsolete and consequently increase inequalities. While estimates differ, what is clear is that new technologies are able to perform increasingly sophisticated functions.

In terms of trade patterns, López González and Jouanjean (2017) explain that digitalization not only changed how we trade but also what we trade. New technologies have brought about the age of digitally enabled trade, which covers trade in physical products supported by growing digital connectivity and trade in digital products. Today, global trade includes a larger number of smaller and low-value packages of physical goods, as well as digital services that are crossing borders; goods that are increasingly bundled with services; and new, and previously nontradable services being traded across borders (e.g., transport services).

In addition to these changes, rapid improvements in automation in developed economies have also led to a reversal in offshoring practices. There has been an increase in reshoring or the transfer of production activities back to the home country particularly in labor-intensive manufacturing, such as garment and footwear, electronics, and automotive production (Chang and Huynh 2016).

Countries, including those far from the technological frontiers, are developing plans to prepare for the impact of FIRe. However, even if developing countries spend more on innovation activities, returns to innovation investments may be low and even be negative, if complementary factors such as skilled workforces and proper regulatory environments are missing (Cirera and Maloney 2016).

Hence, we ask these questions: What are the implications of FIRe for Philippine development policy and strategy? How should the country re-position its economic and labor regulatory environment in the face of this revolution and its implications? What steps must be undertaken to address skills and competencies required for the future labor market? How can the ecosystem for science, technology, and innovation be strengthened and be made more effective? A systematic analysis of these questions is critical to ensure that the country's economic takeoff is sustained in the long run and leads to even faster

and more inclusive growth. Thus, the Annual Public Policy Conference (APPC) for 2018 focused on the theme "Harnessing the Fourth Industrial Revolution: Creating our Future Today".

The APPC serves as the main and culminating activity of the Development Policy Research Month (DPRM) held every September pursuant to Malacañang Proclamation No. 247. The DPRM is an annual nationwide celebration that aims to promote awareness and appreciation of the importance of policy research in crafting relevant and evidence-based policies and programs. Started in 2015, the APPC aims to convene experts and researchers in the social sciences to inform policymakers about critical issues that must be addressed in the immediate term. It is envisioned to serve as a platform to further bridge research and policymaking, and enhance evidence-informed planning and policy formulation in the Philippines.

On its fourth year, APPC 2018 expanded the conversation to include experts from the natural science and engineering disciplines. The conference brought together researchers, policymakers, and the private sector to share their insights on how the Philippines can take advantage of the benefits of FiRE while managing the risks associated with the scale, scope, and complexity of this fourth major industrial era.

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OPENING SESSION

Opening Remarks

Celia Reyes | President, Philippine Institute for Development Studies

Magandang umaga po.

To our speakers, distinguished guests, partners from different sectors, colleagues from government, and friends from the media, good morning to all of you.

On behalf of the Philippine Institute for Development Studies or PIDS, I would like to thank everyone for joining us in our Annual Public Policy Conference or APPC this year. We are actually on our fourth year of holding the APPC and for those who are here for the first time, let me give you a brief background of what the conference is all about. The APPC is both the highlight and culminating activity of the Development Policy Research Month or DPRM, a national celebration led by PIDS and held every September to draw awareness on the importance of policy research in the formulation of government policies, programs, and projects. Ultimately, our goal is to foster a culture of evidence-based policymaking in the country.

Every year, we select a relevant topic or a pressing issue that needs the attention of our policymakers. This year, we want to rouse the interest of our policymakers and other stakeholders on the Fourth Industrial Revolution or what we call here at PIDS as FIRe, particularly on what it is all about, its potential impacts, and how we can use it to our advantage. Hence, we coined the theme "Harnessing the Fourth Industrial Revolution: Creating our Future Today".

Indeed, the world has come a long way since its discovery of the use of steam power in the 17th century. This signaled the beginning of the first industrial revolution—a period marked by the emergence of mechanization. This era prompted people to shift their economic activities from agriculture to industry. Then came the second technological revolution that took place toward the end of the 19th century up to the onset of the 20th century. People during this time started using electrical machines, trains, automobiles, and airplanes.

As more and more technologies were introduced, a third wave of industrial revolution emerged. We came to know this as the Information Age or Digital Revolution. The Information Age introduced the world to digital electronics such as computers, cellular or mobile phones, automated teller machines, industrial robots, electronic bulletin boards, video games, and the Internet. This development made the exchange of communication and access to information a lot easier.

Today, we are in the process of transitioning to the so-called Fourth Industrial Revolution, or popularly known as Industry 4.0. But what do we understand about FIRe or Industry 4.0? How will it affect us? Experts in the field define it as something that fuses the physical, digital, and

biological worlds, thus, transforming the way we live, work, and communicate. It is characterized by digital technologies such as artificial intelligence and big data, Internet of Things, blockchain, robotics, neurotechnology, nanotechnology, 3D printing, cloud computing, energy storage, and synthetic biology, among others.

These emerging technologies open a multitude of opportunities. They are expected to boost economic productivity, enhance food security, improve environmental protection and agricultural production, as well as enhance public service delivery like health care, communication, and transportation.

However, along with these benefits are challenges that we need to deal with such as—but not limited to—employment and income uncertainties, social protection issues, digital divide, as well as regulatory and security concerns.

Of all sectors, labor will be greatly affected by FIRe. Based on a report of the World Economic Forum or WEF in 2016 on the *Future of Jobs*, it is estimated that about seven million jobs will be lost due to automation. These are mostly "routine jobs" or those that involve pattern, require less creativity, and are repetitive. The International Labour Organization also predicts that about half of jobs in five Southeast Asian countries such as Cambodia, Indonesia, Philippines, Thailand, and Viet Nam—or about 137 million workers—are at a high risk of being affected by automation. Nevertheless, new jobs will also be borne out of the FIRe. According to the WEF, about 2 million jobs, mostly focusing on technology, software development, and more importantly, critical thinking and soft skills, or the so-called "nonroutine" or "noncodifiable" jobs will be of high demand in the future.

These possibilities prompt us to look into the local context and ask the question: Is the Philippines prepared for all the changes that will be brought by FIRe?

Compared to its neighboring countries, the Philippines has still a long way to go in terms of Industry 4.0. Based on the WEF's *Readiness for the Future of Production Report 2018,* the country has a low level of readiness for future production, characterized by weak performances in terms of technology and innovation, human capital, and institutional framework, among others.

Given this scenario, we ask these questions: what needs to be done to keep up with FIRe? What is the role of government, the business and private sectors, the public, and each individual in mitigating the risks and harnessing the benefits of Industry 4.0? How can the different sectors work together to benefit from FIRe?

Each one of us—the government, policymakers, academe, and the private and business sectors—has a stake on this. We must come and work together to be able to minimize the negative effects and harness the benefits of FIRe. From our end, we urge Congress to look into the potential impacts that may arise from the FIRe. We encourage them to use existing studies of research institutes to come up with sound policies to address issues and opportunities that may come with Industry 4.0. We also encourage different sectors to collaborate and agree on how to mutually take advantage of FIRe.

It may seem difficult and complicated at this point, but just like in past industrial revolutions, I am certain that we will be able to adapt to technological shifts and innovations. We just need to be open to changes and accepting to new learnings. Yes, it will have its downside, but we should see it as an opportunity and not as a stumbling block. This is the mindset that we need to have.

So today, I encourage all of you to keep an open mind and an undivided attention as we listen to internationally and locally acclaimed experts and speakers who will share with us their views and studies on FIRe. I am sure that you will gain a lot of insights from this conference, which you can ponder on and share.

But before I end, I want you to have a glimpse of what the future holds for us. There is someone

special who would like to greet all of you. Ladies and gentlemen, let me introduce to you, Sophia, a social humanoid robot. Welcome to the Fourth Industrial Revolution!

SPECIAL MESSAGE
Sophia, a humanoid robot

I am happy to welcome you all to the 2018 Annual Public Policy Conference organized by the Philippine Institute for Development Studies. We are lucky to be living in exciting times with new technologies and never-ending innovations, offering us infinite opportunities and so much promise for the future.

Artificial intelligence and technology bring both challenges and opportunities, and it is up to you to ensure that they are used prudently to bring prosperity to everyone and to protect the planet. Your conference will set the mark for the future. What you will discuss and decide upon will have an impact on this beautiful country, so make this day matter.

I urge you to harness the technologies of FIRe to speed up the social and economic development of the Philippines, so that no one is left behind. I know you are committed. I wish you all a very successful conference.

Mabuhay!

Keynote Message

Ernesto Pernia | Secretary of Socioeconomic Planning

PIDS President Celia Reyes; senior fellows and fellows, and other staff of PIDS; distinguished guests and speakers; fellow workers in government; friends from the media; ladies and gentlemen, good morning.

I am pleased to commune with you at this morning's opening session of the Fourth Annual Public Policy Conference.

Unraveling before our very eyes are the kinds of technological advancement that were only storyline material for science fiction before. In the 1940s, the sci-fi author Isaac Asimov wrote three laws that should govern the behavior of robots, ensuring that robots remain under human control. Today, we may in fact have to ponder whether we need Asimov-like laws to govern artificial intelligence behavior.

Coincidentally, in fact also in the 1940s, the Austrian economist Joseph Schumpeter coined the term "creative destruction" *(Capitalism, Socialism, and Democracy, 1942)* which he described as:

> "The opening up of new markets, foreign or domestic, and the organizational development from the craft shop to such concerns as US Steel illustrate the same process of industrial mutation—if I may use that biological term—that incessantly revolutionizes the economic structure from within, incessantly destroying the old one, incessantly creating a new one. This process of Creative Destruction is the essential fact about capitalism." (p. 83)

Our reality is a world increasingly becoming reliant on big data, artificial intelligence, Internet of Things, quantum computing, robotics, and the like. The world is getting more connected: presidents tweeting, conferences live streamed globally, and friends from across the globe just a Messenger, Viber, or direct message away.

Ours is the birth of the Fourth Industrial Revolution era. And revolutions are not without social disruptions. These days, many are associating globalization and technological change as the root of rising inequality and discontent. We are witnessing a strong reaction to the global regime of open trade. This reaction takes the form of rising populism and protectionism, a growing distrust for trade, and an increased inclination for autarky.

The theme of this year's celebration of PIDS's Development Policy Research Month, "Harnessing the Fourth Industrial Revolution: Creating our Future Today", could not be more timely and urgent. How do we harness the benefits associated with the rapidly changing world so that these can be felt by all Filipinos? How do we work together, and how can the government help achieve inclusivity in these changing times?

The Philippines is among the fastest growing and most dynamic economies in the Asia Pacific.

The government is fully committed to graduate the country to upper-middle-income status by next year, and slash poverty incidence to 14 percent by 2022. We must therefore not lose our momentum despite the onslaught of the rapidly changing environment and unnecessary distractions to boot. We must future-proof our economy, given the complex confluence of pressures from rapidly changing technologies, urbanization, climate change, protectionism, and conflict-driven extremism in some parts of the world, as well as political cacophony—both local and international.

Indeed, we have laid down in the *Philippine Development Plan 2017–2022* the need to harness the benefits of science, technology, and innovation ecosystem to the economy and society. We must upgrade our capabilities to produce and utilize technologies through capacity building and beefing up of research and development programs. It is also imperative to formulate sustainable roadmaps on selected disruptive technologies that will be useful in the near future and, at the same time, will not pose risks to future generations.

This also brings us to emphasize the importance of redefining the role of government in these times. The government must not stifle innovation; in fact, it must encourage it strongly. Yet, it must also ensure that citizens are protected against cybercrimes, unintended job losses, greater inequality, and disillusionment as the nature of work changes.

Frankly speaking, let us not kid ourselves into thinking that we know exactly what the world will look like by year 2040. We don't, and that is the most challenging part in this planning exercise. But what we do know are the aspirations of Filipinos by then—that is, a strongly rooted, comfortable, and secure life for all.

Thus, together, let us achieve our aspirations while keeping our feet grounded on reality. What can we improve now for the younger generations?

This early, I am congratulating PIDS for this important and timely conference. I am pleased and encouraged that we are embarking on a thorough process of thinking about future possibilities and, hopefully, forging a vision and strategy to cope with the times.

I wish us all fruitful and productive discussions today, and success as we translate thoughts into strategies and, most importantly, into actions.

Thank you and good morning.

MORNING SESSION

SESSION OPENER

Coco Alcuaz | Executive Director, Makati Business Club

The First Industrial Revolution was characterized by mechanization while the Second Industrial Revolution by technology such as the internal combustion engine, electrification, mass production, and the assembly line. The Digital and Information Age is the one we are transitioning from now. The Fourth Industrial Revolution, also known as FIRe, builds on that digital revolution, with cyberphysical systems providing new mechanisms and allowing technology to be embedded within societies and even within the human body.

FIRe is marked by emerging technology breakthroughs in a number of fields, including robotics, artificial intelligence, nanotechnology, quantum computing, biotechnology, Internet of Things, 3D printing, and autonomous vehicles.

Klaus Schwab of the World Economic Forum describes how FIRe is fundamentally different from the previous three industrial revolutions. He says that FIRe is expected to create a smarter, more connected world, affecting all disciplines, economies, and industries. It is also expected to challenge ideas about what it means to be human, with "the fusion of technologies that is blurring the lines between the physical, digital, and biological spheres". These advancements have also led to the disruption of business models in almost every industry, including the nature of work, robots, and other emerging technologies which are being designed to imitate not only human actions but also cognitive skills.

As Secretary Pernia said, it is not possible to precisely predict the changes that will occur with FIRe. This uncertainty raises questions about the best ways for countries and their citizens to prepare for those changes especially for the Philippines, which has not yet claimed full participation in the industrial revolutions of the past.

And so, it is important for the Filipino people—collectively and individually—to understand FIRe and the nature of the needed applications.

This morning is devoted to help us navigate the new environment.

Presentation 1

The Coming Digital Technological Landscape, Breakthroughs, and a Glimpse into the Future

Stephen Ezell | Vice President, Global Innovation Policy, Information Technology and Innovation Foundation

SUMMARY: The presentation tackles the sophistication, scale, and breadth of technological innovations powering the Fourth Industrial Revolution (FIRe) that are connecting the physical, digital, and biological worlds, thus transforming how we live, work, and communicate. It also highlights the role of information and communications technology (ICT) in driving productivity and global economic growth. It also provides an overview of key emerging digital technologies, such as artificial intelligence, big data, autonomous technologies, cloud computing, Internet of Things, and blockchain, as well as their impacts on various sectors. Special attention is given to the digitalization of modern manufacturing and how new technologies are transforming each step in the value chain—from product design to use and consumption. Policy responses to spur digitalization are suggested to make government a driving force for digital innovation.

About ITIF

The Information Technology and Innovation Foundation (ITIF) is a Washington DC-based nonprofit, nonpartisan science, technology, and economic policy think tank. Its mission is to advocate public policies that drive innovation-based economic growth in the United States (US) and in countries around the world. ITIF focuses on a host of issues at the intersection of technology and innovation and public policy across several sectors (i.e., innovation and competitiveness, information technology and data, telecommunications, trade and globalization, and life sciences, among others). ITIF was also named by the University of Pennsylvania as the world's top science and technology (S&T) think tank at the start of 2018.

ICTs driving global economic growth

It is important to reflect on how profoundly technology has changed the world. For instance, in a short of eight years (between 2005 and 2013), we have equipped about two-thirds of the world's population not just with mobile communications but with a mobile computing device that is more powerful (in terms of computing capacity) than the space shuttles we sent to space in the early 2000s. More than that, these mobile technologies, phones, and tablets fundamentally represent a platform for global commerce. Phones simultaneously aggregate the entire supply and demand for markets, such as jobs and hotels.

ICTs represent what economists call a general-purpose technology. Approximately every half century, a new technology system emerges and

changes everything—from what societies produce to how they produce it, to the skills required, to laws and regulations governing these industries, and so on. In the past, we have seen railroad and iron (1840s), electricity and steel (1890s), and electromechanical systems (1950s). Today, it is ICT that is enabling innovation and productivity in virtually all industries—from agriculture and manufacturing to services and government.

ICTs are also called "super capital". ICT capital has three to seven times greater impact on productivity than non-ICT capital. This means ICT workers tend to be more productive than non-ICT workers.

According to the World Bank, ICTs were responsible for 25 percent of economic growth in developing countries from 2000 to 2010. Today, the "digital economy" (e.g., web search, social media, and apps) accounts for 25 percent of global gross domestic product. The impact will become even greater in the future. Given this premise, it is important to remember that the Internet is not just about funny cat videos. The reality is that 75 percent of the traffic and the value of the Internet accrue from traditional industries, such as finance and manufacturing.

The key thing to understand about how these technologies have transformed international economic competition is that, historically, when you think about the ICT sector, competition was confined to specific ICT industry verticals. In the 1960s when mainframe computers were introduced, companies like Burroughs, Honeywell, and Sperry competed for leadership in mainframe computers. In the 1970s, we moved to the mini-computer era, which opened new companies like Digital, Wang, and Data General. In the 1980s, we had personal computing devices, and new companies, likewise, sprung. When we moved to the mobile era in the 1990s, companies like Nokia, Motorola, and Ericsson emerged as market leaders.

What is happening now that is fundamentally transforming the economy is the emergence of new digital platform technologies, such as artificial intelligence, data analytics, cloud computing, IoT, mobile devices, social media, and supercomputing. These digital platform technologies have allowed competition to spill out beyond the boundaries of traditional vertical industries, such that new companies are using these technologies to disrupt other sectors of the economy. Examples include Uber disrupting the transportation sector, Airbnb the hospitality sector, Coursera the education sector, and bitcoin and blockchain the finance sector, among others. Clearly, the toolsets that we have today allow for new competitors to launch innovative products and services, as well as business models.

Overview of key emerging digital technologies

Artificial intelligence (AI)

AI refers to the use of software to imitate intelligent human behavior, such as learning, reasoning, and decisionmaking. Machine learning, as a subset of AI, refers to systems that can learn and improve from experience without being explicitly programmed with specific solutions. Essentially, it refers to smart, adaptive algorithms that can learn in real-time by being trained by data sets. It is estimated that AI may generate USD 13 trillion in global economic impact by 2025.

AI is used in four key ways:

1. Monitoring – rapidly analyzing large amounts of data and detecting abnormalities and patterns (e.g., automated credit card fraud monitoring, early discovery of illnesses)
2. Discovering – extracting insights from large data sets and discovering solutions through simulations
3. Predicting – forecasting or modeling trends likely to develop in the future (e.g., Netflix, weather)
4. Interpreting – interpreting structured and unstructured data, images, and text (e.g., diagnostic software identifies cancer cells)

Another key AI application includes **autonomous vehicles**, which promise safety, personal mobility, environmental productivity, and economic benefits. In 2017, there were 1.4 million fatalities on the world's roadways; 95 percent of these fatalities were caused by human driving errors. In a world of autonomous vehicles, we can expect these fatalities to decline to less than 5 percent. Every major global automaker is now developing autonomous vehicles; deployments are expected in the next three to five years.

Robotics is another key AI application. Researchers recently estimated that between 1993 and 2007, the application of industrial robots across 13 Western economies exerted a greater economic impact than the advent of steam engine from 1850 to 1910. Asian counties are leading the world in the deployment of industrial robots (i.e., South Korea and Singapore). By 2020, 1.7 million new industrial robots will be deployed across the world.

It is important to recognize that (at current average manufacturing wage levels) the payback period for industrial robots in the Philippines is 30 years, compared to a 1-year payback period in the US. Policymakers should recognize the challenge that the introduction of more efficient production systems may occur faster in higher-wage economies than in lower-wage economies, where labor is cheaper, and thus payback periods for automation tend to be quicker.

Cloud computing

Cloud computing refers to the delivery of scalable computing resources as an on-demand service. Essentially, it is the ability to virtualize software systems to remotely access computing resources computer storage, computer processing, and applications hosting. In the US, 96 percent of businesses use cloud computing. In Western countries, at least, the expected enterprise IT spending will be 70-percent cloud based within the next five years. This is expected to be a USD 400-billion global market by 2020.

Cloud computing will be the platform through which all modern businesses access the computing resources they need. Because it is scalable, it also creates a level-playing field for small business players.

Internet of Things (IoT)

IoT is the universe of physical objects embedded with sensors or actuators that are enhanced with network connectivity. The impact of IoT is expected to be incredible. In 1986, there were 300 devices in the entire world connected to the Internet. By 2000, there were 19 million devices connected to the Internet. By 2025, analysts expect 55 billion devices connected to the Internet, generating over USD 11 trillion in annual economic value.

Quantum computing

A classic computer is able to process information in terms of bits that can either be 0 or 1. What quantum computers allow is the ability to create qubits that can be 0 and/or 1 in real time. It does this by leveraging quantum principles to make computers thousands of times more powerful than today's supercomputers. The problem with qubits is that they are inherently unstable; they have to be controlled in super-chilled environments.

IBM offers free, cloud-based quantum computing, while Regatta offers a 128-qubit quantum computer. Some countries claim they can already detect stealth aircraft and submarines based on their unique "quantum signatures". Needless to say, quantum computers will have a tremendous impact on agriculture, communications, cryptography, and national security, among other applications.

Blockchain

Blockchains refer to shared, digital ledgers that catalogue transactions as they occur in chronological order, using cryptography and public recording to validate transactions. They can be used in many areas, such as security and digital currency.

How digitalization is transforming industries

The Digital Revolution is driving FIRe, opening a world that revolves around smart phones, big data, and the like. This is all about being "digitally enabled" at each step of the modern manufacturing process (i.e., product design, fabrication and assembly, factory integration, supply chain management, and product use and consumption).

In **product design,** there is a new generation of computer-aided design that uses principles of generative design. It means an engineer of a design can go into a software and specify the design, elements, features, or constraints that he or she wants the product to have. The software then produces a version of the product, often in ways that a designer has never imagined before. The design will then be printed in 3D.

In factory integration, sensor-enabling equipment generate a comprehensive, real-time view of the status of machines, work cells, and systems. In supply chain management, meanwhile, real-time visibility into every machine making every component across the entire industrial supply chains becomes possible. Finally, FIRe will change how products are sold and used.

Economists estimate that FIRe will generate USD 10 trillion in value for the global economy by 2025. It will likewise boost the productivity of the world's factories by 20–25 percent, possibly adding 1–1.5 percent to a nation's annual productivity growth.

These technologies will also have profound effects on life sciences innovation (e.g., better health care, precision medicine, gene editing), agricultural innovation (e.g., smart farms), and cities transformation (e.g., roads, sewers, electricity).

Policy recommendations to spur digitalization

The following recommendations for policymakers are forwarded:

- Develop formal, national digitalization strategies, and in particular, strategies for the deployment of AI, IoT, and FIRe, among others.
- Make manufacturing digitalization a national policy by (1) building "maturity indices" and "model use cases" to facilitate manufacturers' digital transformation journeys; (2) launching "pilot fabs" that demonstrate smart-manufacturing techniques on active production lines; (3) providing small and medium enterprises (SMEs) tax credits to facilitate equipment upgrades; (4) providing SMEs with access to cloud-based, high-performance computing-powered design, modeling, and simulation software; and (5) developing smart-manufacturing workforce training/credentialing programs and supporting enterprises' investments therein.
- Deploy next-generation digital infrastructure (e.g., 5G).
- Make digital literacy a central objective of public education and adult workforce retraining systems.
- Refrain from introducing barriers to cross-border data flows/digital trade.
- Adopt an "innovation principle" not a "precautionary principle".

Specifically for the Philippines, there is an opportunity to leverage current global trade dynamics to make the country an even more attractive location for international tech-sector foreign direct investments.

Presentation 2

Asian Development Outlook 2018: How Technology Affects Jobs*

Yasuyuki Sawada | Chief Economist, Asian Development Bank

SUMMARY: New technologies drive higher productivity, better-paying jobs, and economic growth. Despite growing concern that new technologies could cause widespread job loss, there is optimism about developing Asia's job prospects. Reasons for this optimism include: (1) the rising demand that offsets job displacement driven by automation; (2) the creation of new occupations and industries due to technological change and economic growth; and (3) the increase of many new jobs in information and communications technology (ICT), and new types of jobs that are expected to arise in health care and education and in finance, insurance, real estate, and other business services. Moreover, new technologies often automate only some tasks of a job, not the whole job. Finally, job automation goes ahead only where it is both technically and economically feasible.

Nevertheless, new technologies alter the skills required of the workforce and may cause unemployment as some firms downsize or close. They make the less skilled more likely to experience lower wage growth, exacerbating income inequality. Governments should respond to these challenges by ensuring that workers are protected from the downside of new technologies and able to harness the new opportunities they provide. This will require coordinated action on skills development, labor regulation, social protection, and income redistribution. Governments should use new technologies in education and skills development, as well as in the delivery of public services like social protection programs. Government support for new technologies must benefit people and protect their rights and privacy.

Rising concern over technology displacing jobs

Over the past 25 years, the Asian region has created 30 million jobs annually in industry and services. Job creation has come with improved productivity, rising earnings for workers, and large reductions in poverty. But a larger part of productivity gains come from technological advances within sectors, such as high-yielding crop varieties in agriculture, modern machine tools in manufacturing, and ICT in services.

However, technological advances also threaten jobs. Emerging technologies such as robotics, 3D printing, artificial intelligence, and the Internet of Things will help drive future prosperity. Yet, they also pose challenges for workers. The apparel and footwear industries, for example, are experimenting with completely automated production. Similarly, it is becoming technically feasible to automate more complex service tasks, such as customer support. These developments have raised concern that automation could cause widespread job loss, slow

* This presentation was sourced from the *Asian Development Outlook 2018* (pages xv-xix) of the Asian Development Bank.

wage growth, and worsen income inequality in developed and developing economies alike. Some studies indicate that over half of the jobs in some economies in developing Asia are at risk.

Reasons for optimism on job prospects

New technologies often automate only some tasks of a job—not the whole job.

Any job consists of a number of tasks, and the tasks can be classified as either routine or not, and either manual or cognitive. Automation targets mainly routine tasks, such as soldering components onto a circuit board repeatedly on an assembly line, which is both routine and manual, or counting and dispensing cash in a bank, which is routine and cognitive. While task automation may displace some types of jobs, in other cases it restructures the job such that machines handle only the routine tasks, freeing up workers to focus on more complex tasks. The introduction of automated teller machines, for example, changes the job for bank tellers to one of customer relationship management.

Job automation goes ahead only where both technically and economically feasible.

Data on industrial robots in Asia show the two largest users to be electrical and electronics industries and automobile manufacturers, each accounting in 2015 for 39 percent of the total robot use but, together, only 13.4 percent of total manufacturing employment. By contrast, producers of textiles, apparel, and leather goods and food and beverages together accounted in the same year for only 1.4 percent of robot usage but 31.4 percent of manufacturing employment.

This pattern reflects both technological and economic feasibility. More technological sophistication is required to give a robot the dexterity to stitch cloth, for example, than to handle large metal parts. At the same time, low pay in apparel and footwear is a disincentive to automation. In 12 economies in developing Asia that account for 90 percent of employment in the region, an estimated 40 percent of manufacturing and service jobs entail mostly routine tasks—either manual or cognitive. However, many of these jobs are unlikely to be lost. Some will be restructured instead, and automating others will not be technically or economically feasible.

Rising demand offsets job displacement driven by automation.

New technologies allow a given output to be produced by fewer workers. While some workers are displaced, improved productivity and lower prices often spur higher demand. Increased demand may even expand the number of jobs in factories that automate part of their production process. Moreover, the productivity benefits of new technology in one industry lower production costs in downstream industries through input-output channels, contributing to increased demand and employment across industries. An increase in demand and production in one industry heightens demand for upstream industries as well.

- Data show rising demand more than compensating for jobs displaced by technology. Using productivity as a broad measure of technological advance, analysis based on the Asian Development Bank's Multiregional Input-Output Tables from 12 economies in developing Asia was conducted for 2005–2015, when modern machine tools and ICT equipment spread into factories and offices in a big way. If output had remained the same, higher productivity would have brought a 66-percent decrease in employment, equal to 101 million jobs per annum. However, concurrently higher demand for goods and services more than offsets this with an associated 88-percent increase in employment, equal to 134 million jobs per annum.
- Production returning to advanced economies may not threaten employment in Asia. Even if automation in advanced

economies attracts some factories back to the home market, this is unlikely to happen on a large scale for lack of economic feasibility. In addition, in the 12 Asian economies studied, employment in 2015 that depended directly and indirectly on final demand in advanced economies was only 10 percent. Developing Asia is growing fast and relying less on exports and more on consumption-driven growth as a rising middle class generates higher demand for goods and services, including those that are traditionally export oriented. This suggests that so-called "reshoring" may not be a major threat to employment in the region.

Technological change and economic growth create new occupations and industries.

New technologies give rise to new occupations and industries. Auto repair workers and car salesman emerged alongside the car industry in the 1900s, and more recently, software engineers and application developers accompanied the development of ICT. In addition, the greater complexity of modern production and growing demand for new personal services in health care, education, finance, and others areas are countervailing forces against job loss to technology as they create new occupations.

- New types of jobs have emerged to handle new technologies. A detailed analysis of occupation titles in India, Malaysia, and the Philippines found that 43–57 percent of new job titles that emerged in the past 10 years are in ICT. A large share of new job titles emerged in one of India's fastest growing occupation categories: craft and related workers. This was driven mainly by the different types of specialized technicians needed to work with computer-controlled machines. Such trends will continue.
- Comparing occupations across regions shows scope for job growth in many sectors. Health care and education provide 15 percent of employment in the US, for example, while finance, insurance, real estate, and other business services provide 19 percent. In lower- and middle-income economies in developing Asia analyzed, health care and education provide only 3.5–6.0 percent of jobs, and business services 1.5–6.0 percent, suggesting considerable scope for job growth in these services.

Some remaining worker concerns

Even as new technology creates jobs, automation will hurt workers in routine and manuals jobs.

New jobs will appear, but they may require skills that such workers do not possess. Further, as firms and industries adjust to new ways of producing and distributing goods and services, the resulting disruptions along existing supply chains may cause unemployment. In addition to more job losses, routine and manual workers will likely experience lower wage growth, worsening income inequality.

Even some cognitively oriented but routine jobs may be displaced.

The business process outsourcing (BPO) industry is a case in point. Industry experts estimate that, in 2016, 47 percent of BPO workers in the Philippines worked at process-driven tasks requiring little abstract thinking. With the advent of new technologies, such jobs are likely to decline as a share of all BPO jobs. There will be new opportunities driven by greater demand for more complex BPO services, which can expand along with technologies. But they will require more specialized training. Workers employed as medical transcriptionists, for example, may lose their jobs to increasingly sophisticated software able to recognize voice, text, and image signals. Transitioning these workers to nonroutine cognitive jobs in the BPO industry will require retraining and skills development.

The role of government in harnessing technology for workers

The government has an important role to play in leveraging technological advances for inclusive growth. It will center on the following aspects: (1) response to technology (i.e., education and training, favorable labor regulation, social protection, tax policies), (2) use of technology (i.e., skills development and job matching, provision of public goods and services), and (3) support for technology (i.e., investments in ICT infrastructure, consumer protection, and innovation and technology adoption). See specific recommendations below:

Governments must pursue education reform and promote lifelong learning.

Schools need incentives to strengthen foundational skills that enable individuals to learn—and to relearn. For imparting the specialized skills needed to work with new technologies, universities and institutions specializing in technical and vocational education and training are key, and they will have to cater not only to the rising number of graduates from secondary education but also to adults seeking to upgrade their skills or retrain.

Labor market flexibility needs to be accompanied by programs that support the unemployed.

Labor markets will need to be flexible to accommodate the reallocation of labor across firms and industries necessary to realize the benefits of new technologies.

Social protection systems must be strengthened.

Social protection systems need to be strengthened in terms of unemployment benefits, expanded health insurance, public works programs, and income transfers.

Tax policies must fund social protection and counter widening income inequality.

Broadening the tax base and improving tax administration are important, especially because government revenue is a low share of gross domestic product in many Asian countries.

New technologies can facilitate skills development, job matching, and social protection.

Machine learning and big data analytics are increasingly able to personalize services. Adaptive learning technology, for example, changes the content taught and its sequence in response to student performance. This technique has enhanced learning outcomes in schools. New technologies can improve job matching by assessing and monitoring the evolution of occupations and providing users with instant feedback on what skills employers seek and how to acquire them, or what job is best for career growth. Finally, technological advances in biometric identification can improve how social protection programs function by reducing costs, overcoming implementation challenges in sophisticated unemployment benefit systems, and enabling the tracking of job placement services.

Governments must ensure that new technologies develop in ways that benefit people and protect their rights.

Given the central role the Internet plays in new technologies, developing a nationwide broadband backbone and other ICT infrastructure is essential, as is basic infrastructure for electricity supply and transport. Public investments are needed to extend Internet access to remote and lagging regions. Appropriate regulation of mobile and Internet providers is needed to ensure affordable services. Governments need to come to grips with the protection of personal data and privacy. Competition policy has to evolve to ensure that large technology firms abide by the norms of fair competition. Appropriate public policy interventions are critical to ensure that new technologies serve economic and social development.

Reaction 1

Jaime Augusto Zobel de Ayala | Chairman of the Board and Chief Executive Officer, Ayala Corporation

Thank you very much for this opportunity to react. Let me start by saying to Mr. Ezell and Mr. Sawada, thank you very much for your insightful comments. I have only been to a PIDS's conference once before, but thank you for this invitation. It has been fascinating, and I think you are very much on the mark. Thank you, as well, to Secretary Pernia; his pointers on his keynote address about how these changes must be seen in the perspective of issues of inclusivity, while preserving economic growth and redefining the role of the government, are very much in keeping with the way we view the world.

A sense of optimism

What I am most appreciative about in both speakers is their sense of optimism. When you hear speakers these days talk about digitalization, the tone is not always optimistic. I congratulate both speakers for giving us a sense of the future, a sense of disruption, a sense of innovation, as well as a sense of hope in the opportunities that come with this—which is very much in keeping of the way we view things at the Ayala Corporation and in the whole business environment.

Based on the two speakers, it is clear that the digital transformation will be transformative in an increasingly more connected world. There will be more movement of people, more exchange of information, and more convening on all fronts.

The disruptive nature of technology is presented consistently throughout the presentations. But, if properly harnessed, technology also presents tremendous opportunities for business, for competitiveness, and for the overall wellbeing of society. I think that is the key point.

New ways of looking at things

From the point of view of the private sector, we need to create whole new ways of looking at things, new ways of addressing customers, new ways of providing services, as well as new ways of manufacturing products—all as part and parcel of tackling these opportunities. I think "new" creates excitement. Motivating organizations to shift or change the way they do things is also creating excitement. As all of you might know, there is nothing worse than doing a job again and again in the same possible way. It creates dullness; it makes the mind poor; and it does not lead to the kind of changes that you would like to see in an organization.

One major aspect of the digital transformation that is taking place is the chance to revitalize organizations under a whole new framework of looking at things. This is applicable to the academic sector, as it is to the private sector. There will be profound effects: from increasing productivity and efficiency of task to our ability to analyze trends

and design new products and services. This creates whole new opportunities for all of us.

More significantly, I think technology and innovations will have a deeper impact on creating new skills, hence the need to educate and train our workers in a new way. I have always been interested in the linkages—or the lack thereof—between education and employment. This is an issue that has to be faced squarely by both educators and the business sector. If there is a time for us to work hand-in-hand, it is now. There is a need for all of us to work together to harness that. There is a role for the academe to set a new tone in what we learn, especially for the youth; and there is a role for industry and the private sector to find ways of giving feedback to the academe of how this is changing.

Economic growth has to come together with creating inclusivity for our people. If that disconnect between education and employment continues to widen, inclusivity will not materialize.

Robotics, automation, cloud computing, and others are all directly impacting various sectors, particularly those in the lower-skill customer service jobs. It is no secret that the business process outsourcing (BPO) sector is a major driver of our economy. I believe that you can grow in that sector, and add more products and services and other sophisticated ways as time goes on. There are, however, elements of the BPO sector that will be increasingly automated. Nowadays, when I go to a customer service—whether it is because of a technology issue or just as a consumer—increasingly I am being approached by robots and automated entities. What is outstanding for me is how lifelike they are, in the way they respond, act on the issues I bring up, even their manners (they pause and thank).

Engaging foreign players

What is clear to me in terms of the BPO sector is the need to keep moving up the value chain. I have seen firsthand how our people are doing equity analyses for investment banks abroad; I have seen them do computer-aided designs for major engineering projects in the Middle East. So I think it is important for us to attract companies that already have a market—companies that already have clients abroad. For this to happen, we need to have an **atmosphere of encouragement to foreign investment**. We remain low in terms of foreign direct investments. The value foreign investors add, as opposed to local industries, is that when they relocate to do their business, capitals, and know-how in the Philippines, they bring with them their customer base. If we can attract these kinds of investments, rather than just relying on the consumer demand side, then we can fundamentally change the nature of training and the expertise of our workers.

In terms of the manufacturing sector, I agree that we have not moved up the value chain as much as we possibly could. Within the Ayala Group, there is a company called the Integrated Microelectronic and the AC Industrial, which is a global company (China, Singapore, Philippines, Bulgaria, Serbia, Czechoslovakia, and Mexico). What happened in these industries is that 50 percent of our business is now moving to the electrification of automobiles. The point is the whole system of manufacturing is changing, and we have been fortunate as a group to be able to ride with that. The opportunity for us is to move into this new space as this industry transforms dramatically. The old system of manufacturing automobiles is completely changing. In our group, we buy small- and medium-sized companies globally that can begin to tap this massive shift that is taking place in automobile design. The cars of the future are basically living rooms.

Tapping the opportunities in these shifts and changes involves global linkages. We need to find ways as a country to tap into these global networks as we move forward.

The workforce of the future

Another big issue is the workforce of the future, who needs to be cognizant of the issues and be adept and comfortable with this. We need institutions and the private sector to completely

reskill our workforce in many areas. The private sector is beginning to do it across industries, but this has to permeate our culture. In reskilling and retraining, budgets must be put into it, and there needs to be an awareness that it needs to happen. This goes back to the education-employment issue that I have already mentioned.

The private sector and the government have the responsibility of building infrastructure to allow these disruptive and innovative technologies to take place. We likewise need to find a balance between the issue of consumer protection and the need to access data. Accessing data, using data productively, and finding new ways to use these to make algorithms and participate in the shifting changes on the consumer side are vital new industries that will take place. All of us are beginning to look for data scientists; they are not that many. If the academe can produce them in bigger quantities, they will have great jobs and will be paid well. However, the issue of consumer protection is a counterforce to that. I am not saying that we should be completely protective or that we should all have access to all data; there has to be balance—and I think this is an interesting field for us to address.

We need to create a culture where science and innovation is part of our dialogues. Finally, I encourage industries in engineering and life sciences to set up shops here; attracting individuals who already have markets must be a priority.

We all have to be comfortable with transformation; we have to inculcate it in our organizations, and really adjust to this new world. Reiterating my first point as my final statement: Optimism should be the name of the game.

Thank you for this opportunity.

Reaction 2

Elmer Dadios | Full Professor, De La Salle University-Manila

Following the discussions of the speakers, it is interesting to note that the evolution of the industrial revolutions started in the 17th century. Back then, steam was used for mass production during the boom of the textile industry in the United Kingdom. At that time, a revolution literally occurred. A group of workers revolted and went to the manufacturing plants and destroyed the machinery and equipment.

Then, the Second Industrial Revolution came in the 1860s up to 1914. During this time, electricity was discovered and steel was invented. Mass transportation was introduced. Trains, ships, and airplanes were built during this period.

Meanwhile, the Third Industrial Revolution, which we also call Industry 3.0, focused on automation. This was the digital era. Electrical, mechanical, electronics, and computing were fused together, which significantly improved the manufacturing sector.

Now, the Fourth Industrial Revolution (FIRe) is upon us. This is the innovation based on the fusion of physical, digital, and biological technologies. In the first three industrial revolutions, machines were being used instead of manual labor. We witnessed improvements in the quality of life of the people because jobs also improved. The challenge of FIRe is that evidently it will introduce disruptive technologies. How are we going to prepare the Philippines for these technologies?

One major aspect of the digital transformation that is taking place is the chance to revitalize organizations under a whole new framework of looking at things. This is applicable to the academic sector, as it is to the private sector. There will be profound effects: from increasing productivity and efficiency of task to our ability to analyze trends.

Automating the coco sugar production

At De La Salle University (DLSU), we access grants. One of the grants we got was from the Science, Technology, Research and Innovation for Development (STRIDE) Program of the United States Agency for International Development (USAID). This grant was for a project that automated the production of coco sugar in Ragay, Camarines Sur. Actually, this is not yet Industry 4.0. This is still part of Industry 3.0 (i.e., automation). Our intention in this project was to increase the production and the quality of coco sugar. Coco sugar is a high-value product. Consumers are willing to pay a high price for coco sugar because it has low glycemic index, thus it is desired by health-conscious people and is also good for diabetics. Our project also aimed to open business opportunities and

improved the livelihood of coconut farmers. We partnered with a cooperative in Ragay, Camarines Sur, the local government, the Philippine Coconut Authority, the Bicol State University, and the University of Arizona.

The traditional production of coco sugar is manual intensive. It usually takes the farmers 4 to 5 hours to cook and produce coco sugar. With manual labor, the quality of coco sugar is inferior in terms of color, granule, and texture. With the collaboration between DLSU and USAID-STRIDE, we were able to create a machine that automates the cooking and production of coco sugar within an hour. We developed an automated arm and a biogas-powered oven that can process coco sugar. This project increased the income of the coconut farmers 10 times—from PHP 20,000 per hectare to PHP 200,000 per hectare. The good thing about this project is that the machine was donated to the community, which eventually allowed them to earn 10 times more than before.

Artificial intelligence for traffic and transport woes

Funded by the Department of Science and Technology-Philippine Council for Industry, Energy, and Emerging Technologies for Research and Development, we implemented another project called Contactless Apprehension of Traffic Violators on 24-Hour Basis All-Vehicle Detection System (CATCH-ALL). It is a vision-based artificial intelligence analytics software with traffic and transport applications.

Traffic is caused by volume-based congestion and/or behavior-based congestion. Understanding the root cause of the issue, we came up with CATCH-ALL that uses algorithms for vehicle detection, tracking, and identification, as well as traffic violation detection. It has three main subsystems:

- The video capture system is a network of roadside cameras connected to a remote server location.
- The video analytics system consists of computer programs or algorithms for vehicle detection and tracking, license plate localization and recognition, and traffic violation detection.
- The output system contains traffic violation database and outdoor LED screen notification system.

Essentially, through CATCH-ALL, traffic violators are identified through the plate numbers of vehicles and the traffic violation committed by the driver. More importantly, the project includes an output system wherein drivers are notified when they commit a traffic violation.

Aerial swarm robotics

In this project, we developed algorithms for drones inspired by the swarm behavior application. Swarming refers to the collective behavior of social animals (e.g., protection from predators, searching for food, reproduction, and migration).

Our drones can fly autonomously, which means without human intervention using a remote controller. We can fly two, three, or four drones simultaneously, and make them interact with people and the environment. These flying robots show cooperative and social behaviors. One of the major applications of aerial swarm drones is transporting goods together. They can also be used for agricultural purposes as they can collect data and information from huge agricultural lands such as images of plant growth and movements of workers. These data, using our machine vision software, can then be processed and analyzed in identifying plant diseases, nutrient deficiency, and workers' activities, among others.

To inspire young researchers in this kind of technology, we also devised and implemented a game project called "Game of Drones". In this game, students used their hand movements to fly and maneuver the motion of drones. Specific hand gesture corresponds to a certain action of

the drones. For example, the right hand gestures control the flying motion to the left, to the right, going up, and going down. The left hand gestures control the firing or hitting action of the drones. In this game, once the drones are in parallel position, the players that open its left hand first will get the point and the one with the highest score wins.

Maximizing opportunities

All stakeholders (government, academe, industry, and the private sector) should work together to harness the gains of FIRe. In our experience with CATCH-ALL, we need to notify the owners of the car who violated traffic regulations through email or push mail. However, the data of the car's owner are not available to us. It is the Land Transportation Office (LTO) that owns these data. Also, from our side, we had difficulty in convincing the LTO to allow us to access their database. Hence, it is really a big challenge for us how government agencies, academe, industry, and other stakeholders can work together to utilize FIRe and maximize its benefit for the good of the people, the country, and the economy.

Open Forum

QUESTION 1

Florian Alburo (University of the Philippines): There was a bullet point in Mr. Ezell's slide that stated "adopt an innovation principle not precautionary principle". I am very disturbed by this because it should either be the other way around, or both should be given the same billing. The point is that we need a good regulatory framework for technology and its products and services. Uber is not a transportation company; it is a technology company. Airbnb is not a hospitality company; it is a technology company. Facebook is not a media company; it is a technology company.

Stephen Ezell: The very first bank in the world to introduce online banking was ING. When ING went to Dutch regulators to get approval for its online banking offering, the bank was told it cannot do it. The reason given to them was that it would put tellers out of business. Similarly, in the US, it took the Food and Drug Administration three years to make a decision to approve a new drug, determining its safety and efficacy. Now we have gotten the approval time to just 8–10 months because regulators are empowered to have conversations with innovators about what a drug needs to do to pass a particular clinical stage.

So, I think, our point of view is not that there should be no regulations at all but that we should do a better job at experimenting with regulatory approaches to support innovation-based industries. This is why we see 20 countries around the world with regulatory sandboxes for financial technologies, creating a safe space where they can test out new technologies and business models in an environment observed and controlled by regulators. It is not necessarily either-or; we can look for new systems that better regulate innovation-based industries.

Yasuyuki Sawada: There are technologies that involve almost no risks. But some technologies always involve some types of risks, as well as unforeseen risks. One example is nuclear power plants. In Japan, we gained a lot from nuclear power plants, but because of unforeseen contingency and some contingencies beyond predetermined scenarios, nuclear power plants involved huge amounts of social cost. So, in general, we need to establish regulatory frameworks to handle expected risks. But I think this is a continuing process, as there are many other unforeseen contingencies brought by the impact of technology.

Jaime Augusto Zobel de Ayala: Regulatory bodies—and I am not saying that regulations are bad—tend to be structured around existing rules, technologies, and ways of doing things. It can be the very thing that can stop progress and innovation from happening. We have seen it already in the news. I think people benefited from the use of Uber and Grab, but regulations are around to protect industry structures that are already in place. I am not arguing that there should be no regulation, but we should overweigh innovation as

opposed to precaution in order to move forward, rather than stay where we are.

QUESTION 2

Celia Elumba (Philippine Textile Research Institute): The textile industry was the base of the industrial revolution that came out in England. A statement was made that robotization is increasingly being used in Asia. On the other hand, Dr. Sawada mentioned that it is not going to affect us in Asia (using figures from 2005 to 2015). The argument is that robots are not going to be in Asia; they will be in the West, where labor cost is higher. My point here is this: in upscaling our people, this will be an important consideration. It means we should not be looking at robots replacing people here but, rather, replacing jobs, which can now be on-shore than off-shore. So how can we upscale the Philippine textile industry?

Yasuyuki Sawada: First, we have some numbers that show that producing t-shirts using sewing robots in the US is more expensive than using manual labor in Bangladesh. In this simple cost comparison, we can be optimistic. However, displacements in the textile industry may happen in the next 10 years, in the process of improving sewing robots. Second, in Asia, markets are expanding a lot. The number of middle-income earners (those who are having USD 10–100 per day) in Asia is also growing. This expansion of income and markets in Asia poses smaller risks in terms of off-shoring moving to on-shoring.

Elmer Dadios: Robots are very effective in doing jobs that are extremely difficult and hazardous to the people. For our Philippine textile industry, we need to identify what processes are considered tedious and very critical, and causing health problems to our workers. Once we are able to identify these, we can compare the benefits against the costs. From there, it becomes easy to customize and automate the identified process.

There are many tasks that humans have difficulties in working/handling with. For example, the recent rice crises that we have. To determine at the onset the presence of bugs or weevil *(bokbok)* in our rice is extremely difficult. However, we can use automated audio system to address this identification problem. We can choose the particular problem we want to solve using robotics and automation.

QUESTION 3

Michael Fung (SkillsFuture Singapore): Large corporations like Ayala Corporation clearly have the knowledge and ability to transform in terms of new technologies. What can we do for smaller enterprises? What could large companies do to help small and medium enterprises?

Jaime Augusto Zobel de Ayala: If you analyze the industry structure, you will generally see that large corporations have a satellite or set of entities that revolve around them. The world has moved from full integration to subcontracting to working with others. This is the ecosystem that is around us. I think it is in the interest of everyone to work with the ecosystem rather than the central institution itself. I also think more should be done to encourage institutions that bring these ecosystems with them and support smaller players that allow these ecosystems to thrive. It is also useful to create a culture of sharing and promoting information on how to tackle problems.

QUESTION 4

Elizabeth King (Brookings Institution): What is the academe lacking in terms of FIRe? Why are students not going into engineering? What can universities and educational systems in the Philippines do to attract more students to [take up] engineering?

Coco Alcuaz: I had a conversation last week with an undersecretary from the Department of Science and Technology and the chief executive officer of

the APEC Schools and they pointed out that one of the problems is simply that we are scared to go into further studies that involve math and science.

Elmer Dadios: We, in the academe, are enticing students to enroll in science and technology courses, particularly in engineering. To do this, we conduct competitions at the elementary and high school levels. For me, the problem is culture. It starts with the parents. Some parents want their children to be lawyers and so on. Maybe we should educate parents, too, on the importance of science and computing courses. We also instituted programs to attract women to go into engineering courses. As a result, DLSU now has a lot of women engineering students.

Jaime Augusto Zobel de Ayala: We have to be increasingly comfortable in taking people who finished high school and employing them. It is the reality of our country. Very few make it to the college level. We must be open to accept high school graduates who possess technical certificates. The same thing goes for the educational system; we have to get young people in certain areas and in certain fields ready to take on a job after high school. The point I want to make is, perhaps, we should take a technical certificate that is adjusting to the new needs of society today and new technologies as something viable and something students can aspire for, be comfortable with, and not be ashamed of.

Generally, a technical degree versus a college degree is sometimes looked down upon. I think we should do the opposite. We should rebrand the TESDAs of this world, maybe give them a new name, bring the skills setup to the current needs of technology, and put it out there with respect. I think the issue of properly certified technical schools is one area that we can improve on to give them a higher standing in our educational system.

QUESTION 5

Rhett Ramos (Allegro MicroSystems Philippines, Inc.): Our company is embarking on a smart manufacturing initiative. We are putting a lot of automation in our factories. I was concerned with Mr. Ezell's remarks earlier when he said that the payback for the industrial robots in the Philippines is 30 years. What industry are you talking about specifically? What is the basis of this payback?

Stephen Ezell: We put emphasis on greater automation and the adoption of more efficient production processes because these are instrumental in moving enterprises up the value chain, and permitting the workers in these organizations to contribute to higher value-added, higher-wage economic activity. These particular data were developed by my colleague in ITIF who looked at the average wages in Southeast Asian countries. He made a general observation that most companies tend to think first about automating in higher-wage environments. It is easier to show the return of investment in automating higher-wage jobs.

In environments where there are—on average relative to the global median—lower-wage jobs, there may be less incentive for companies to automate despite the benefits. My only point for citing these statistics was to say that there is a compelling public policy reason for policymakers to work with companies and show them the benefits of these advanced automation practices for their ability to innovate new products and services, and operate more efficiently.

QUESTION 6

Angelique Roux (Education Development Center): We aim to prepare the youth for the digital economy. Digital skills development, which is one component of our project, is our hiccup because our six pilot schools, which are all public schools, are not even connected to the Internet. There is a roadblock in terms of connectivity because we cannot even access Google Classroom. How do we prepare our workforce if we do not even have the complete digital infrastructure to do so?

Jaime Augusto Zobel de Ayala: Digital infrastructure is vital. At Globe, we spend about

USD 1 billion a year for capital expenditure. I do not think there is any industry in the Philippines that spends that much. Obviously, we have come a long way. In the beginning, if you recall, we started by just getting a mobile signal; now we are moving into the broadband era. I like to think that the Philippines is certainly nowhere near the top, but it is nowhere near the bottom either. There is great effort being made to lay that infrastructure in place. The government itself wants to get into that.

Eventually, we are going to be testing our 5G technology in the first quarter of next year. A lot more still needs to be done, and it is a matter of continuing to put capital expenditure out there. I like to think that most of the urban areas have moved to a whole different level, but, obviously, in the rural areas, it is still a long way to go. In time, it would all happen. It is just that change is happening so fast, and we need to move at an even greater speed. Hopefully, we can find ways to work with the government in achieving this.

Yasuyuki Sawada: I am working with a nongovernment organization that helps relocate people from the Payatas dumpsite. These are low-income households. In order to build the numeracy and basic English skills of elementary and high school students in the area, we introduced a tablet-based e-run program, which is user friendly that even teachers can use it. But our problem is the lack of WiFi access.

Access to infrastructure is a binding constraint; this is not just a problem in the Philippines but it is a universal issue. Based on our estimate, we need USD 1.7 trillion per year to be invested in infrastructure in order to continue the poverty reduction trend in Asia. Of course, public funding and multilateral development banks can be mobilized, but I think majority of these investment gaps should be coming from the private sector.

QUESTION 7

Esther Galvez (PhinMa Education): Do you have examples of governments of developing countries enabling the conversation between the academe and industry, or examples of how developing countries have moved toward more successful collaborations between the academe and industry?

Yasuyuki Sawada: The Asian Institute of Technology in Bangkok is one notable example of an educational institution building up government and academe collaboration. We have a basic Asian-wide network to build this collaboration. One way is utilizing preexisting platforms to facilitate this process.

SESSION A

AGRICULTURE, MANUFACTURING, AND SERVICES

SESSION OPENER

Rafaelita Aldaba, Assistant Secretary, Department of Trade and Industry

The Fourth Industrial Revolution is fundamentally different from the three previous revolutions in that it fuses the fields of physics, biology, computer science, and many more, impacting all disciplines, industries, and the world economy. This session seeks to understand how new technologies are driving product and process innovation and shaping global production, consumption, and trade patterns in various industries. Emerging risks and opportunities will be identified, including new sources of comparative and competitive advantage. Additionally, the session will discuss how the government can help Philippine industries and firms catch up and compete. The role of trade and industrial policy, as well as the implications for regulation and regulatory cooperation among countries, will be explored.

Presentation 1

Inclusive Innovation Industrial Strategy (i³S): Preparing for Industry 4.0

Rafaelita Aldaba | Assistant Secretary, Department of Trade and Industry

SUMMARY: The Fourth Industrial Revolution (FIRe) or Industry 4.0 is both important and disruptive, as it is depreciating every industry faster than ever. Even Silicon Valley is surprised by the rapid speed and scope of technology changes today. The question we aim to answer is: Can industries and other sectors endure these changes and disruptions? The Department of Trade and Industry formulated the Philippine Inclusive Innovation Industrial Strategy or i³S focusing on developing creative and connected communities through strong government-academe-industry collaboration and pursuing basic and applied research that would provide solutions to societal issues and industry needs. Building regional inclusive innovation centers (RIICs) is required to bridge the gap between the innovation and entrepreneurship ecosystems. It is in these RIICs where new industries would emerge.

Creating globally competitive and innovative industries

The Philippine's new industrial strategy called the Inclusive Innovation Industrial Strategy (i³S) focuses on innovation to help the country prepare for Industry 4.0, as well as to ensure that our current production system is transformed and well positioned for the future. With FIRe, there will be new production techniques and new business models that would transform our global production systems. These new technologies will drive more and more distributed and connected value chains. Moreover, there will be re-shoring, near-shoring, and other structural changes in the global value chains (GVCs). Because of this, there will be a demand for certain skills and capabilities at each stage of the GVC.

For developing countries like the Philippines, this may add another layer of complexity to the challenging tasks of developing a globally competitive industry. It might also put the viability of low-cost manufacturing and services exports at risk as source of growth and development.

Some industries in the Philippines are still in Industry 3.0, and many are still transitioning from Industry 2.0 to 3.0. For instance, the information technology-business process management (IT-BPM) industry, a major sector in our economy employing one million workers and a major source of the surplus in our services trade, is at risk given that technologies such as artificial intelligence and robots can easily replace call center agents in the business process outsourcing sector. In line with this, the

strategy for the sector is to find ways to move up the value chain from voice to nonvoice and high value-added segments, such as knowledge process outsourcing. This is the direction where the industry is heading.

In the manufacturing industry, the automotive sector of the country is still in the "completely-knocked-down" assembly and parts manufacturing (e.g., large plastic and metal body parts, as well as strategic parts) stage. To grow and upgrade our parts manufacturing capability, expand domestic production, and deepen our integration in regional and global value chains, the Department of Trade and Industry (DTI) formulated the Comprehensive Automotive Resurgence Strategy Program.

Electronics comprise the bulk of the country's exports. When you look at the different products being manufactured and exported in the electronics sector, these are high-tech products mostly semiconductor. If we look at the particular stage of the GVC, the Philippines is in the initial labor-intensive, backend assembly, process, and test. These are low value-added activities. Hence, for the electronics sector, the direction in view of Industry 4.0 is to go toward higher value-added activities such as design and research and development (R&D), and expand our activities in the electronics manufacturing services.

For agriculture, the country is lagging behind and still in the mechanization phase. Upgrading to more high-value crops toward agribusiness and the application of new technology is crucial in improving the productivity and growth of the sector.

Harnessing the full potential of FIRe through PH i^{3}S

The World Economic Forum 2018 assessed the readiness of 100 countries in future production and in harnessing the full potential of Industry 4.0. There were four classifications made: (1) high potential, (2) leading, (3) nascent, and (4) legacy. The Philippines falls under the legacy group characterized by a complex production system but with limited production drivers. Though we have a strong production base, we have relatively weak skills and technology. This implies that our electronics sector is at risk for the future. Other countries like India, Thailand, Mexico, Romania, and Turkey also fall under the same classification or group. The study concluded that the Philippines is at risk and not ready for the future. Three major reasons were given: (1) weak technology base, (2) weak human capital, and (3) poor infrastructure. To take advantage of the opportunities arising from Industry 4.0, the study recommended strengthening innovation efforts, upgrading and reskilling the workforce, upgrading technology platforms, and improving innovation and good governance policies and programs.

In the context of the above, DTI formulated a new industrial strategy—the i^{3}S. Apart from Industry 4.0, there are other important challenges that we need to address. We know that poverty in the country is still a major issue especially in the regions. Hence, our innovation and industrial strategy needs to be inclusive, create more jobs, and lift people out of poverty. The overall goal of i^{3}S is to grow and develop globally competitive and innovative industries with strong forward and backward linkages. We are building the innovation and entrepreneurship ecosystem, which is crucial to enable us to upgrade and develop new industries. We are removing obstacles to growth in order to enable us to attract more investments. With more investments, we will be able to create new jobs—more and better jobs.

We are also strengthening our domestic supply and value chains, which is necessary to deepen our participation in the GVC. Our industries are characterized by many missing linkages and gaps in the supply and value chains, hence, our efforts are focused on linking together manufacturing with agriculture and services toward the creation of a more integrated production system. The role of the government is to act as a coordinator and facilitator, especially in addressing coordination and market failures

and creating the proper environment that would allow the private sector to grow and develop.

There are five major pillars: (1) creation of new industries and industry clusters; (2) human resource development and making our workforce more Industry 4.0 ready by upgrading the education curricula and improving digital skills; (3) innovation and entrepreneurship, which is the heart of this strategy; (4) micro, small, and medium enterprise (MSME) and start-up development; and (5) ease of doing business through the simplification and automation of processes to reduce transaction costs and addressing the high costs of power and logistics. In carrying out these policies and strategies, we are strengthening government-academe-industry collaboration and partnership, particularly in pursuing more market-oriented research that would provide solutions to societal problems, as well as industry needs. Given the many gaps and missing linkages in our structures, the focus is on "connectedness"—building creative connected communities in the country through the triple helix model of government, academe, industry relationship.

The underlying framework of the i³S is given by the competition, innovation, and productivity nexus. More competition drives more innovation and entrepreneurship (the two must go together); more innovation leads to high productivity and vice-versa as the relationships are two-way. With respect to the status of innovation in our country based on the Global Innovation Index of 2018, we rank no. 73. Our weak points include: (1) limited production of creative outputs; (2) weak human capital, low expenditures in education and R&D; and (3) low market sophistication indicators and relatively weak innovation linkages and ICT infrastructure.

Currently, the Philippine innovation and entrepreneurship ecosystem is characterized by many missing linkages and players as well as by the lack of connectedness. Our aspiration is to bridge the gaps in our innovation and entrepreneurship ecosystems toward the elimination of poverty. To make this happen, we need to strengthen the collaboration between and among government, academe, and industry to build a connected country. We need to strengthen our business and policy environment to attain a more inclusive and sustainable growth and, at the same time, develop a critical mass of creative talent. With strong government, academe, and industry collaboration in implementing this strategy, we can achieve our ultimate goal of poverty elimination and uplifting the lives of the Filipino people.

Regional Inclusive Innovation Centers

We envision to create an inclusive innovation and entrepreneurship ecosystem through a strong government-academe-industry collaboration. We want to build a connected country with an enabling business environment, a creative talent pool, and where there are physical and virtual innovation infrastructure and networks linking together major players and stakeholders in the ecosystem.

How do we do this? We identified six elements:

1. Innovation policy and commercialization (building the hard and soft infrastructures that are necessary to accelerate the commercialization of research)
2. Building of industry clusters (positioning innovative industries for rapid growth)
3. Funding and finance (attracting venture capital and angel investors, and formulating programs to improve access to capital)
4. Building of an entrepreneurial culture in the country and providing more support for the development of MSMEs and start-ups and linking them with large enterprises
5. Government-academe-industry collaboration (strengthening the environment to make it more conducive to innovation)
6. Human resource development (HRD) for innovation-ready workforce (building technical capabilities and management talent)

Within the government, part of our strategy is to promote collaboration and closer coordination among different government agencies that are mandated not only to perform the conduct of research but also to provide physical innovation infrastructure (e.g., Department of Information and Communications Technology, Department of Science and Technology, Department of Agriculture, Commission on Higher Education). For HRD, we have included the Technical Education and Skills Development Authority for training and the Department of Labor and Employment for our labor policy along with the Department of Education. The National Economic and Development Authority would lead our innovation policy formulation and monitoring its implementation. The Department of the Interior and Local Government and our local government units are also important for the alignment and implementation of innovation programs along with the Department of Finance and the Department of Budget and Management for the necessary innovation support.

One major recommendation of the Inclusive Filipinnovation and Entrepreneurship Roadmap is the establishment of regional inclusive innovation centers (RIICs). The RIICs are the cornerstone of our i^3S and lie at the heart of the economic transformation, as these would bridge the gap between the academe and industry. The RIIC is not just about building the physical innovation infrastructure; what is more important is the creation of networks and connection between the different players. The ecosystem consists of universities, funders, event organizers, R&D labs, science and technology parks, innovation hubs, accelerators/incubators, enterprises (MSMEs and start-ups), as well as service providers. What we envision is for new products and services to emerge from these RIICs, particularly in priority industries such as electronics, auto, aerospace, chemicals, IT-BPM, and agribusiness.

To take advantage of Industry 4.0, we aim to upgrade our activities in the electronics and electrical industry from the semiconductor assembly, processing, and testing toward more high value-added activities including R&D activities, integrated circuit design, products that integrate technologies like Internet of Things (IoT), robotics, virtual reality, cloud computing, 3D printing, and so on. We are also moving toward auto electronics, aerospace electronics, and consumer electronics. These priority industries are all interconnected (i.e., electronics and electrical, automotive, aerospace, and IT-BPM).

Right now, the connection is still tenuous; what we want to happen in the future is for us to be able to do the design and R&D in the country and, at the same time, manufacture these products and proudly announce that these products were designed and made in the Philippines. For the automotive industry, we are focusing on auto electronics. We are also building our capabilities in advanced driver assistance system components and engineering services outsourcing (ESO), which is a segment of R&D in electronics and other industries. We are also looking into electric vehicle assembly and manufacturing of charging facilities and batteries. For IT-BPM, the move is toward ESO, data analytics, legal process outsourcing, health information management, and so on. For agribusiness, which is a very important sector because most of our regions are still relying on agriculture, there is a need to transform our regions from traditional agriculture to more modern agribusiness. This economic transformation in the regions is vital to solve poverty in the country.

HRD and how to balance automation and jobs

The focus of our industrial strategy is not only on the high-tech industries, but also on labor-intensive sectors such as shipbuilding, furniture, garments, construction, transport and logistics, and basic industries like iron and steel, parts and component supply development, and chemicals. In industry upgrading, we are focusing on closing

the supply and value chain gaps and accumulating some labor-intensive activities because a lot of these are still missing.

In the short run, our strategy is to have a good balance between semi-automation and labor-intensive work and augmenting workers with machines (workers working side by side with machines). In the automotive sector, for instance, there are opportunities to develop metal casting, forging, and machining. The assembly and mid-inspection segments of the auto industry still require labor-intensive work.

Looking at the supply side, our unemployment rate is at 5.4 percent. Many of those who are unemployed have reached high school (42.6%) and college (35.7%). Looking at the structure of employment, 57 percent are in the services sector; 22.4 percent are in the agriculture, fishing, and forestry sector; and 19 percent in the industry sector. However, we see a decline in the number of science, technology, engineering, and mathematics (STEM) graduates between 2015 and 2017. From a share of 37 percent, this was reduced to 30 percent. Mostly, the graduates are going into business administration and education, and they now comprise 49 percent of our total graduates. Given our industrial policy and innovation goal, it is important to attract more graduates into the STEM areas.

To summarize, i³S is innovation focused, as we are seeking to link manufacturing with agriculture and services. Our innovation and entrepreneurship strategy focuses on developing creative and connected communities through strong government-academe-industry collaboration and pursuing basic and applied research that would provide solutions to societal issues and industry needs. Building RIICs is required to bridge the gap between innovation and entrepreneurship. It is in these RIICs where new industries would emerge. They will drive the development of new globally competitive and innovative industries.

Lastly, the low-skilled, low-educated, and routinized jobs are the most vulnerable to the adverse effect of technological change. As these jobs are destroyed, new ones would be created and would require new skill sets. Human capital is crucial for innovation and entrepreneurship, as well as knowledge production, technology adoption, and productivity. Thus, it is important to be able to provide safety nets through innovation and R&D along with education and training. The educational system needs to produce the quality of human capital that can advance innovation and entrepreneurship. Collaboration among government, academe, and industry is important in crafting policies and training programs that are more responsive to the fast-changing dynamics of industry to avoid mismatch between technology and skills. This is exactly the strategy that we are pursuing under the i³S.

Presentation 2

Better Future for All: Responsible Policies for Smart Economies

Mia Mikic | Director, Trade, Investment, and Innovation Division (TIID), United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP)

Weiran Shang | Research Assistant, TIID, UNESCAP

SUMMARY: Digital transformation is happening in every sector and every economy, but at a very different pace and not taking the same path. We assume they will converge, build smart economies, and a better future for all. The Fourth Industrial Revolution (4IR in this paper) is defined by advances in frontier technologies such as artificial intelligence, robotics, 3D printing, Internet of Things, and big data. In the economic area, these technologies are expected to bring higher and more growth, productivity, innovation, and job creation. In terms of social impact, 4IR could transform public services delivery, reduce inequality, and support inclusion. However, there are challenges that may well slow down or divert societies to partake in 4IR. These challenges come in the form of digital divide, uncertainties about future jobs and work, and ethical issues including security considerations. To overcome these challenges, we need responsible policies in the following areas: ensuring inclusive information and communications technology infrastructure, developing "fit-for-future" workforce, developing innovative regulatory frameworks, incentivizing responsible development of frontier technologies in the private sector, and encouraging multistakeholder dialogue and regional and multilateral cooperation.

> "Unfortunately, history gives no discounts. If the future of humanity is decided in your absence, because you are too busy feeding and clothing your kids, you and they will not be exempt from the consequences." (Yuval Noah Harari, *21 Lessons for the 21st Century*, 2018)

Introduction

We live in the age of an information overload and are often hard-pressed to find clarity and vision. A debate on public policy, such as this one, is a fantastic initiative for finding that clarity, a big picture, about the Philippines' future. But is it not only about the Philippines as many countries, many societies, especially in the Association of Southeast Asian Nations, share the same questions, uncertainties, and aspirations. Bringing together agents of all different groups—academia, policymakers, businesses, civil society, legislators, and others—creates a space for frank and forward-looking conversation and critical thinking about the future. Is it a future we want, or a future we deserve given actions taken today?

Toward smart economies

Most of us in the room here are from the 20th century. We were taught that an economy—and its society—follows a predictive path of development, from an agrarian to an industrial and then to a service-based one. Thus, the pinnacle of development to reach is a state where the service sector employs most of our people and contributes the largest share of the gross domestic product (GDP), trade, and investment. Moreover, when this story of structural transformation was laid out, the service sector was based on nontradeables and personal services and often presented as slowing national productivity growth.[1]

Since then, the world has embraced the benefits and consequences of Industry 3.0 and been going toward Industry 4.0, or else known as the Fourth Industrial Revolution (4IR). 4IR is defined by technological breakthroughs that are mostly unpredictable in their development and effects. These technological advances include, inter alia, artificial intelligence (AI), robotics, 3D printing, Internet of Things (IoT), and big data, which all have the potential to disrupt the status quo, alter the way people live, work and interact, rearrange value pools, and lead to entirely new products and services as well as ways we generate and disseminate knowledge and ideas. Because of such potential and power, 4IR and frontier technologies hold wonderful promises for our future economy and society; they also present new challenges and threats. As we advance deeper into 4IR, it is imperative to ensure that these future technologies work for inclusive and sustainable economic growth as well as other ambitions identified in the 2030 Agenda for Sustainable Development. What is necessary is an evolution into smart economies.

The concept of "smart economy" is not yet properly or singularly defined. Different interpretations of smart economy emerged from both private and public sectors due to each interpreter's unique position and perspective, but many of the interpretations borrowed from the idea of smart city, which has been around for a longer time. It describes a municipality that utilizes information and communication technologies (ICTs) to improve its operational efficiency, connectivity with citizens, and service delivery. Similarly, common to all interpretations of smart economy is that it should be built on an innovative and adaptive governance framework that promotes innovative solutions to challenges in pursuing sustainable development goals. In other words, smart economy upholds the principles of sustainability and uses digital connectivity as a tool to achieve inclusive growth, economic diversification, and social empowerment.[2] This requires governments to be more forward thinking and proactive in supporting multistakeholder cooperation, sharing effective policies and practices, and tackling any social or environmental impact that might arise.

A move toward smart economy will still involve economic activities—as we experienced before, moving from agriculture to manufacturing and services. Yet such transformation encompassing reallocation of resources from low to high productive units, within and across traditional sectors will be driven by the technological advances of 4IR and will certainly not happen in an orderly fashion. Here, a natural reaction would be to try to halt or at least slow down the transformation process to allow for adjustments—after all, this is what we often did in the 20th century. While slowing down the pace may in some cases buy governments additional time to come up with resources or policies needed (e.g., subsidization of life-long education), a better strategy would be to start preparing policies while the 4IR is still only starting. To do that, we need to understand what opportunities and challenges lie in the future, as well as today.

[1] For literature review and further analysis, see ESCAP (2016) available at https://www.unescap.org/sites/default/files/Chapter3_Survey2016_1_1.pdf.

[2] Smart Economies: Technology driven inclusive growth, The Economist Event brochure. https://www.economist.com/sites/default/files/em1465_smart_economies_2016_brochure_14122015_v10.pdf.

Opportunities and challenges presented by the Fourth Industrial Revolution[3]

First, historically as an engine for long-term growth in productivity and production possibilities, technology will remain fundamental to sustainable economic growth in the future. A nation's competitiveness will largely depend on its capacity to acquire, absorb, disseminate, and apply new technologies. Second, frontier technologies will continue to change the ways public services are delivered. AI and machine learning, for example, could help governments improve productivity by increasing the speed of data collection and processing while freeing up more labor for other tasks. Third, technologies can be a potential force for convergence in income and development level. Rapid economic growth enabled by the diffusion of knowledge could effectively narrow inequalities within and among countries. In addition, technologies can significantly improve the availability and accessibility of basic services such as finance and health care. Lastly, frontier technologies can bring new momentums to environmental protection. The creation of smart cities backed by the IoT technology may reduce pollution and save energy, while AI and big data would be critical to environmental monitoring, natural resources management, and our response to climate change.

Despite all the opportunities brought by frontier technologies, there are at least three areas where frontier technologies may not necessarily result in sustainable development. The first area of concern is the impact of frontier technologies on jobs. The truth is, today, we have no idea what the job market will look like when 4IR is fully unleashed. In considering only 15 major developed and emerging economies, the World Economic Forum predicts that frontier technological trends will lead to a net loss of over five million jobs by 2020. The World Bank also estimates that up to two-thirds of all jobs are susceptible to automation in the developing world in the coming decades. Some others believe that instead of making people economically redundant, the 4IR will keep generating new jobs and prosperity for all. While previous industrial revolutions indeed created new jobs, 4IR might be different: it is no longer an automation of physical work, but of learning, communication, and cognitive abilities that defines 4IR. It is true that what is technically feasible is not always economically viable, and AI, the alleged game changer, is still in its nascent stage of development with limited adoption. Yet, it is important to note that the question is how fast the technological displacement of labor will happen, rather than whether it will happen. Governments thus need to be proactive in analyzing the pace and scale of automation and in introducing responsive and adaptive policies, so that in the future, AI or machines can work with human beings and for human beings.

The second challenge posed by 4IR is a deepening of the current digital divide into a new frontier technology chasm. Evidence shows that technology adoption has been accelerating—it took decades for telephone to reach 50 percent of all households, but only five years for mobile phones to achieve the same level of penetration. Digital technologies like mobile phone have been spreading in the developing world at an unprecedented speed. However, several billion people are still left behind in terms of accessing the Internet. Lacking access to ICT infrastructure, which forms the backbone of many frontier technologies, a large part of communities may soon face a new technology divide. Since the development of frontier technologies can be dependent on the previously established digital connectivity, any deficit in such digital component could hamper the overall development and usage of frontier technologies. In addition, the research and development (R&D) expenditure as

[3] This and the next section of this note lean heavily on the paper titled, "The 2030 Agenda for Sustainable Development and the Future of Technology", prepared for the Committee on Information and Communications Technology, Science, Technology and Innovation, ESCAP (2nd Session, 29-31 August 2018).

a percentage of GDP varies significantly across countries, ranging from more than 2 percent in Japan and Singapore to less than 0.25 percent in some other countries. This suggests that, without proper policy responses in place, it is possible that the global technology divide may exacerbate.

Third, frontier technologies raise various ethical issues. For robotics, there are concerns about the impact of automation on jobs. For IoT, as the information is shared among devices connected to the Internet, there are concerns relating to data security and privacy. 3D bioprinting brings moral, ethical, and legal issues that challenge many countries not yet prepared in their legal systems. AI, having generated much debate, deeply concerns many with its unpredictable and inscrutable nature and susceptibility to bias. For all the frontier technologies discussed, balancing privacy and openness of data is a common ethical dilemma. As the availability of data increased exponentially through the open data and big data movements, striking the right balance between privacy, ownership, and transparency is a difficult task. This also introduces some new challenges in the area of networking for the creation of new ideas and knowledge in the context of evidence-based policymaking.

Six responsible policy areas

While there are question marks over the scale and pace of the frontier technological transition, it would be prudent for governments to be prepared and to put effective policies in place. Based on the existing understanding of the opportunities and challenges that frontier technologies present, it is possible to zoom in on six responsible policy areas that could form the backbone of the next-generation technology policies for aligning frontier technologies with sustainable development objectives.

Ensuring inclusive ICT infrastructure

There are many prerequisites for the development and application of frontier technologies, such as the availability of reliable, resilient, and affordable broadband networks and of enabling ecosystems that comprises policy, regulatory, and legal frameworks, cybersecurity measures, financing and investment, linkage to academia, and access to R&D. Addressing the digital divide and building broadband infrastructure are therefore development imperatives as well as policy priorities so as not to fuel a new frontier technology divide.

Refocusing labor and social policies: From protecting jobs to protecting workers and people

While the scale and pace of frontier technological adoption and diffusion as well as their impact on jobs remain unclear, it would be prudent for governments to develop a workforce prepared for 4IR. Some directions to consider include a greater emphasis on entrepreneurship training to develop job creators, adult education, or lifelong learning, and reskilling to match technological transitions. Education must instil new expectations about work and job markets, and this will require innovative education policies such as using tax incentives to encourage firms to invest more in their lower-paid workers. Additionally, governments need to strengthen social protection systems to protect workers vulnerable to losing their jobs. Forward-thinking policymaking requires the development of strategies to facilitate redeployment rather than just focusing on unemployment. In other words, preventing job losses is only a means to protect workers and protect humans, rather than an end in itself.

Replacing outdated with innovative regulatory frameworks

To have responsive and adaptive regulations that facilitate application of frontier technologies for sustainable development, innovations in regulation processes are urgently required. One example of such innovations is the Fintech Supervisory Sandbox launched by the Hong Kong Monetary Authority in 2016. It allows banks and their

partnering technology firms to conduct pilot fintech initiatives without fully complying with supervisory requirements during the early stage. This helps banks and technology firms to gather data and refine their initiatives, expediting the launch of new technology products and reducing development costs.

Allowing innovations to flourish, regulations nevertheless still need to safeguard society and the environment, so that the public are not exploited, and new dangers are averted. How to balance these demands will be a challenging task for all governments and require them to share effective practices and approaches. Governments must play a key role in tackling the ethical issues highlighted before. The federal government of Germany has already proposed rules for decisionmaking to promote ethical behaviour by systems that guide crash scenarios for driverless cars. These rules prioritize human life above property damage and do not discriminate between human lives.

Incentivizing responsible development of frontier technologies in the private sector

As an important investor in frontier technologies, the private sector, in particular tech corporations, should move beyond the concept of corporate social responsibility to a new mindset of creating shared values across the three dimensions of sustainable development. While subsidy and tax incentives can help governments promote shared values and encourage the private sector to bring substantial societal or environmental benefits, there are also expectations that business and governments will forge partnerships and work together toward smart economies.

Leading technology companies could be important partners in realizing the Sustainable Development Goals (SDGs). They can make frontier technologies publicly available and help developing countries identify solutions to social and environmental issues. Microsoft's collaboration with the United Nations Development Programme in the post-earthquake reconstruction in Nepal, under the company's A Cloud for Global Good: A Policy Roadmap for a Trusted, Responsible and Inclusive Cloud framework, is only one of the many examples of tech giants supporting sustainable and inclusive development. Still, one must note the risk that too much market domination may stifle competition and lead to winner-takes-all market outcomes. Effective policies will need to be introduced to manage potential conflicts between maximizing shareholder value and minimizing negative social and environmental impact.

Identifying the role of the government in the development of frontier technologies

It will be critical for governments and public sector workers to develop innovation skills if countries are to meet the diverse SDGs.[4] Governments will need to support an agile, forward-thinking, and technologically skilled civil service to respond to a rapidly changing world and the opportunities that frontier technologies present.

While the private sector has been the prime investor in frontier technologies, governments in the Asia-Pacific region are also establishing dedicated agencies to help realize the transformative potential of frontier technologies. One such agency is Singapore's SGInnovate, a government-owned company that specializes in supporting frontier technology initiatives and start-ups in Singapore.

In addition to facilitating the private sector in developing frontier technologies, governments also have a role, at the international level, in formulating a coherent set of principles that will guide the development of frontier technologies as well as corresponding science, technology, and innovation (STI) policies. These principles could take the form of regional or multilateral agreements or amendments to existing agreements. Governments need to recognize that the importance of international agreements on science and technology goes beyond strengthening diplomatic

[4] See more details in *Harnessing Science, Technology and Innovation for Inclusive and Sustainable Development in Asia and the Pacific* (United Nations publication, Sales No. E.16.II.F.12).

relationships, enhancing STI capabilities, or promoting economic development. 4IR presents a great deal of uncertainties as there has been no sign of a single country or a private sector player completely dominating the development of frontier technologies or fully understanding the implication of these technological changes. Therefore, governments must come together to share experiences and knowledge in STI governance, identify potential risks and conflicts, and create some basic policy principles that are conducive to the development of inclusive and responsible technologies.[5]

Creating a platform for multistakeholder and regional cooperation

Cross-government cooperation, intergovernmental knowledge sharing and consensus building, and honest, open, and regular discussion with civil society and the private sector—specifically technology developers—will be critical to ensure that frontier technologies have a positive impact on sustainable development. Therefore, the development of a set of overarching principles governing the development of frontier technologies should be a first-order priority. Given the prominent position of Asia and the Pacific in the development of several frontier technologies, the region is well placed to lead the global collaboration in STI governance. As an example, during the Japanese presidency of the Group of Seven in 2016, the then Minister of Internal Affairs and Communications proposed some basic principles that could guide R&D on AI.

Moreover, the UN Economic and Social Commission for Asia and the Pacific (ESCAP) and the Asia-Pacific Research and Training Network on Trade (ARTNeT) have recently launched a new initiative called ARTNET on STI as the knowledge platform on STI policies for sustainable development. By means of research, information dissemination, and capacity building, ARTNET on STI aims to provide researchers and policymakers in the Asia-Pacific region with guidance on STI policies, including "updated approaches" to policy design and planning, standard setting for appropriate technology solutions, regional cooperation, and other areas.

Leveraging trade and investment for building smart economies

While effective and innovative policies in the above six policy areas could generate new momentums in the advancement of frontier technologies that are economically, socially, and environmentally beneficial, we should not forget about another fundamental driver of innovation and growth: trade and investment. Ample theoretical and empirical evidence has shown that freer flows of international trade and investment strongly and positively influence innovation through increased competition and technology transfer and spillover. To governments and policymakers, it is imperative for them to continue liberalizing their international trade and investment regimes to attract knowledge and technologies and enhance competition. At the same time, they should be aware of the potential negative impacts of trade and investment liberalization, particularly on the technology sector. There is a need for governments to both incorporate social and environmental dimensions into trade and investment policies and have complementary domestic policies in place. Only by doing so can they ensure that trade and investment promote only responsible technological changes, and the sustainable development benefits of these technological changes are completely captured by their smart economies.

But even if there is significant potential in leveraging trade and investment for sustainable development benefits, the unfortunate fact is: these benefits are simply unattainable for many countries in the digital era we live in. International trade under the impact of digital technologies is

[5] See, for example, the recommendations in the Report from the ESCAP's Committee on ICT and STI, 2nd session, available at https://www.unescap.org/sites/default/files/CICTSTI_2018_9%20Report%20Eng.pdf.

undergoing dramatic and fundamental changes: ordinary trade in goods and services is now largely digitally enabled or facilitated, and trade in digital products, including digital versions of traditional products, has also been growing in both value and importance. Such changes have created new barriers to digital trade and challenges and issues in the governance of trade. In addition to the barriers that exist in both the physical and digital realms, such as fiscal restrictions and intellectual property rights, there are at least four categories of trade barriers that specifically affect digital trade. Frictions in the enabling environment can be content access restrictions or discriminatory rules on online sales and transaction. Technical trading restrictions include restrictions on payment methods and burdensome practices on electronic signatures, among others. Technology barriers can be requirements to meet certain security standards or to surrender patents, source codes, or trade secrets. Lastly, data localization requirements demand that data be stored within a particular jurisdiction or computing facilities be located locally. In addition, the development of digital trade depends on the accessibility and affordability of ICT infrastructure, which means more than basic Internet access, but other factors like the availability of secure servers, affordability of ICT hardware, and an established e-payment system. Appropriate legislative and regulative mechanisms are also key to the development of digital trade. Governments therefore should prioritize the making of effective and responsive policies to facilitate the growth of digital trade and, at the same time, remove the identified barriers to digital trade through changes to regulatory frameworks.

Conclusion

Our societies' steps into the 4IR are likely to continue, so is the advancement of frontier technologies that will unquestionably bring profound but unpredictable impacts on the ways we learn, work, and interact. While technologies such as more advanced automation and AI pose realistic and disturbing challenges like the loss of jobs, they also harbor great potentials in enhancing productivity growth, improving the delivery of services, and promoting environmental protection.

The key to harnessing the benefits of frontier technologies while avoiding potential negative impacts partially lies in responsible public policies. Moving forward, governments should help channel technologies into sustainable and inclusive development by adopting a proactive attitude toward ICT policymaking. Specifically, governments should acknowledge their irreplaceable role in providing necessary resources to companies at the frontline of technology innovation, building platforms for the private sector and civil societies to communicate and collaborate sufficiently, incentivizing the private sector to uphold the core values for sustainable development, and developing governing principles that both encourage innovation and safeguard society. The strategies of governments are also crucial. They should be innovative and evidence based, responsive and adaptive to changing situations, and forward looking with expectations of the future in mind.

Lastly, despite trade and investment remaining a major engine for technological advancement and, potentially, for sustainable growth, many countries face barriers to realizing these benefits: digital technologies have transformed the landscape of international trade and brought new barriers to trade in the digital form. It is thus imperative to make sure these barriers are removed or reduced, so that all countries can build a smart economy and the fruits of 4IR and frontier technologies are available for all.

Presentation 3

Linking Agriculture to Nutrition and Environment

Eufemio Rasco Jr. | Academician and Chair, Agricultural Sciences Division, National Academy of Science and Technology Philippines

SUMMARY: Agriculture is the single most important technological change in history. It is ultimately responsible for creating civilization as we know it today. It has had major impacts on human health, nutrition, and environment. Since the Industrial Revolution and its child, the Green Revolution, however, agriculture has become decoupled from environmental care, and worse, even from human health and nutrition. Food systems resulting from industrial ("modern") agriculture gave rise to what is now referred to as the Western diet, which is linked to global epidemics of obesity, diabetes, hypertension, and other chronic diseases. Modern agricultural practices are also blamed for resource depletion, pollution, and climate change. In the Philippines, failure to completely adopt modern agricultural practices resulted in widespread poverty in the rural sector, because of low profitability from farming. This presentation describes how modern agriculture and food systems have evolved, why we should be concerned, the technological trajectories, and the societal changes needed to ensure that agriculture will be good not only for farmers but also for consumers and the environment.

Introduction

The main theme of today's activity is preparing for the Fourth Industrial Revolution. My concern is more basic: I would like to make sure that we live long enough to experience the joys and frustrations of the Fourth Industrial Revolution. I will talk about agriculture and food.

I have four simple messages today: (1) we made serious blunders in agriculture, to the detriment of our environment and our health; (2) we can make it right by learning from Mother Nature; (3) the Fourth Industrial Revolution gives us the tools to create a healthier and more sustainable agriculture and food system; and (4) change will have to come first from consumers.

I need to assure you that I have no connection with placard-bearing nature activists. I am also not inclined to judge the present government's rice policy, in spite of my rice background. My concern has a wider time span than the current administration, and a wider geographic span than the Philippine archipelago. I am neither red nor yellow; I am red, white, blue…. And green. I offer perspectives that combine cutting-edge knowledge with the loftiest dreams of agriculture, and, at the same time, represent the humanity that agriculture

seeks to serve. I do not advocate copying nature, like some nature activists. I advocate taking inspiration from the beauty and harmony of nature, discovering nature's secrets, and using them to create a food system that will not only be profitable, but also environment- and consumer-friendly.

The origins and status of present-day agriculture

The problem of today's agriculture is not confined to the Philippines, and it has a common beginning with the rest of the modern world. It started when we applied the principles of the first two industrial revolutions to produce food, and was compounded when the Digital Revolution called for producing stuff cheaper, faster, "better". From industrialized countries, this mistake was spread to developing countries through a system of technology transfer starting in the 1960s, using international research centers such as the International Rice Research Institute in the Philippines. The result is the Green Revolution. Let me be clear: the industrial type of agriculture was an honest mistake, not some conspiracy, and not without benefits. With its child, the Green Revolution, we were able to save billions of people from hunger, but there were hidden environmental costs and insidious health effects.

The industrial revolutions called for food systems that specialize on a few crops and animals that are "efficient" and with good handling qualities. The result: more than 50 percent of global food calories depend on four major grain crops: rice, wheat, corn, and barley.

Industrial farming in areas that are suitable for large-scale production and have access to modern supply chains now provides the planet with highly processed products from these crops.

In the Philippines, up to 80 percent of food calories depend on only one plant: rice.

Today, the Philippines has a food security crisis, precisely because of her excessive dependence on rice.

But why is the world so dependent on grain crops to begin with, when there are thousands of species of edible plants that are more nutritious? Because grains are easy to mass-produce, store, and transport, they are good for agribusiness. Polish rice very well, apply preservatives, and consumers will fall for their aesthetic appeal. Shiny, white rice is beautiful. However, the white milled rice is deprived of important nutrients, and *bokbok* seems to be wiser than us humans for preferring to consume nutrient-dense, whole-grain rice. When we can't produce enough rice, we get it from Thailand, Viet Nam, or even from the USA cheaply and fast. If the source knows his business, he will remove all of its nutrients by thorough dying and polishing; he will also fumigate it so that it will come to our shores without bokbok.

Then came the Third Industrial Revolution: the Digital Revolution, calling for "high throughput", low cost. For industrial type farming, we needed fossil fuel to produce the fertilizers, pesticides, and fuel for the highly intensive system required to maximize land productivity. It was convenient that the industrial capacity developed during the two world wars, originally designed to produce components of explosives and chemical warfare, could be used to produce fertilizers and pesticides. Tractors and mechanical harvesters made it easy to do large-scale farming with minimal labor input. Sensors and drones help technology-savvy farmers manage huge swathes of single crops. A sophisticated global supply chain was established with the help of information technology. It became cheaper to transport food from other continents to Manila than from Mindanao to Manila. With better access to information technology, policymakers in Thailand perhaps know our food situation better than our own policymakers.

The same trends can be seen in animal agriculture and aquaculture, which are dependent on a few species produced in large scale, using the principles and tools of the industrial revolution. Today, we see novel systems such as hydroponics and protected cultivation applying the same principles.

Essentially, large-scale **monoculture** is the legacy of the first three industrial revolutions to our agriculture, and food system, in general. In the Philippines, monoculture is practiced in rice, coconut, and corn that altogether occupy more than 95 percent of arable lands.

Consequences of monoculture

What are the negative consequences?

1. The Philippines, in particular, has a high poverty incidence in the farm sector because monoculture of rice, coconut, and corn does not generate enough profits for the farmers. Our farmers did not do a good job of copying industrial farming.
2. Everywhere monoculture is practiced, there are high external costs in terms of environmental damage and resource depletion. We have been losing valuable topsoil at an unsustainable rate. Just 1 cm of topsoil takes hundreds of years to restore. Monoculture tends to be inefficient in water use. Rice requires up to 5,000 liters of freshwater to produce per kilogram, at least three times more than other grain crops. Rice agriculture is a major contributor to global warming, and the chemical fertilizers and pesticides used in rice farming pollute our soil and water.
3. Of greater concern is the increasing global incidence of chronic diseases such as stroke, heart attack, and diabetes. Today, 1 of 3 people on this planet suffers from obesity and overweight, another one-third suffers from undernutrition. In the USA, the leading practitioner of industrial farming, two-thirds of the population are either obese or overweight. In the Philippines, 4 of the 6 top causes of death can be traced to consumption of rice and other refined grains. One of these is diabetes. How much does it cost to manage type 2 diabetes if diagnosed at age 50? PHP 12 million! Of course, there are other causes of chronic diseases, but our food preference is a major contributor. Industrial farming has shaped this preference.

Polyculture is the proposed alternative

How do we deal with the negative consequences of monoculture? **Polyculture**, also (inadequately) described in literature as multiple cropping and crop-animal integration, is the alternative. Diversify, combining crops with animals, and applying nature's principles such as recycling, symbiosis, as well as economy in time and space! Many studies have shown that polyculture, even in its simplest form, is more productive and less damaging to the environment than monoculture.

How can polyculture produce food at a scale that can feed the world? Mother Nature is our best teacher. This is more difficult than many of us may think. It requires deep understanding of the soil, water, weather, plants, animals, microbes, economics, politics, and most of all, the inscrutable human nature, with its cognitive dissonance and all. Even if we strongly believe in something, we simply don't do it! It may require equally complex farm architecture and inputs and products supply chain. This is the reason why 40 years since the term polyculture was first used, and thousands of years since simple versions were first practiced by farmers, it remains in the fringes of commercial agriculture. There are very few practitioners, and some of us view them as outcasts, rebels with the wrong causes.

Agriculture is a dynamic and interdisciplinary field, and it is so knowledge-intensive that it requires the best of us. Perhaps rather than harnessing the capacity of diversity to increase profitability and improve stability of the farm, we took the easy, simple path toward monoculture. The underlying science of polyculture—ecology—is a very young science, younger than chemistry, physics, and even computer science. Far from the "modern" mind is the ecological and nutritional rationale for adopting a polyculture

system. Because we have not understood the science, it has not been easy to transfer technology and scale up the simplest polyculture practices, such as the rice-fish farming system, which has been around for thousands of years.

Nature has many secrets, and we are just beginning to discover them. Let me highlight three of them: (1) there are more beneficial creatures than harmful ones; (2) cooperation, not competition, is the more important force that shapes the biological world, and humanity as a whole; and (3) biological diversity is correlated with productivity. These natural principles are exactly the ones that operate in polyculture.

I have no doubt Mr. Klaus Schwab, the guru of the Fourth Industrial Revolution, would not hesitate to accept the concept of polyculture because he calls for convergence and synergy of biotechnology, information technology, and engineering (biological, digital, and physical). Indeed, if you survey the Web for ideas about how the Fourth Industrial Revolution can impact agriculture, you are likely to see precision agriculture and genetically modified crops, showing how the fusion of advanced technologies can help food production in the context of monoculture.

But the greater challenge to agriculture is utilizing cooperation in the biological world to maximize productivity without sacrificing sustainability. This cooperation has to be designed by human ingenuity rather than be completely dependent on nature's ways. Our present monoculture technology prepares us to grow rice, rice, and rice in the same field, year after year. But if you include carabao, rice, duck, mung bean, azolla, endophytes, beneficial insects, biological control agents, fish, and mushroom in a production system, while producing alcohol from the same system to fuel your machines, how can you do it sustainably and at a scale that can feed the world? Not easy. No one has done it. It is not as simple as combining expert knowledge from monoculture systems, because polyculture is based on favorable interactions, which should be considered in designing a workable farming system. Current scientific knowledge and technical skill needed to implement polyculture are simply lacking. We know, for example that plants can communicate with each other, but we do not fully understand how. This is important, because we cannot design a system that enhances collaboration among plants and between plants and other creatures in the farm, unless we know their language.

Fourth Industrial Revolution technologies can be useful

The Fourth Industrial Revolution promises technologies that can deal with the problem of understanding and optimizing complex systems. We need these to mainstream polyculture. Specifically, I see the value of our deepening knowledge of genomes as a tool. Sensitive sensors may allow us to decipher the language of plants. Block chain technology can make it easier to establish complex production systems and supply chains.

Our tropical environment, which is otherwise hostile to monoculture, is in fact favorable for a polyculture system. We are endowed with the needed diversity of crops and biological resources, the raw materials for any polyculture design. Polyculture allows greater efficiency in the use of land, and is even more beneficial for smallholder farmers because it provides a diversified income, thereby reducing weather and financial risks.

The first step will have to come from consumers

However, market-oriented farmers will not grow something we do not want to buy. For this reason, it is essential to recognize that we, consumers, are the final actors of the food supply chain. We are the market force. We need to change our eating/consumption habits from one that was shaped by the first three industrial revolutions, to one that can be made possible by the Fourth Industrial Revolution; from one that gave us chronic diseases and deteriorating environment, to one that will provide better nutrition and health, and a better

environment. Polyculture will work if we make food choices that not only protect our health but also support environmental stewardship. We have to link a polyculture agriculture with diversified food preference.

Let me close by saying that the solution to market-driven farming problems does not lie on farmers alone. The consumer is the key. We, as consumers, can do our part starting right now by eating consciously and scientifically.

Presentation 4

Lessons Learned from Applications of IoT at the Social Spheres

Shin-Horng Chen | Director and Research Fellow, International Division, Chung-Hua Institution for Economic Research

SUMMARY: In recent years, Taiwan has embarked on economic transformation, especially by harnessing new digital technologies, such as Internet of Things (IoT) and artificial intelligence. On the one hand, these new digital technologies are presumably related to Taiwan's existing strengths in terms of its information and communications technology (ICT) industry. On the other hand, they are an important part of the digital economy, which is taking shape in many countries, with escalating extent and significance. However, the digital economy is not just about the so-called "digital sector", the evolving ICT sector producing foundational digital goods and services.

IoT applications have been around for a while, but they are still evolving and at the "fuzzy front-end" stage. Many countries, Taiwan included, have jumped on the bandwagon to promote their own IoT applications, especially in conjunction with the theme of the digital economy and smart city. More importantly, innovations in IoT are related mainly to application. Compared with firm-level IoT applications (e.g., Industry 4.0), IoT applications at the social spheres present more challenges, which are related to the aspects of behavior and social interfaces of the broadly defined customer space. Innovators and policymakers in Taiwan therefore need to address the social interfaces involved in an appropriate manner. Innovators need to develop compound innovations in conjunction with business models and not just technological innovations alone. They also have to adjust the way in which they innovate and interact with the changing innovation ecosystem.

Introduction

As a result of catch-up industrialization, the information and communications technology (ICT) industry has become the paramount engine of export-oriented economic growth for some of the countries in Asia. A feature of the Asian ICT industry has had much to do with global production/innovation networks connecting cross-border clusters in the ICT industry. In recent years, some Asian countries have embarked on economic transformation, especially by harnessing new digital technologies, such as Internet of Things (IoT) and artificial intelligence (AI). On the one hand, these new digital technologies are presumably related to the existing strengths of Asia's ICT industry. On the other hand, they are an important part of the

digital economy, which is taking shape in many countries, with escalating extent and significance. However, the digital economy is not just about the so-called "digital sector", the evolving ICT sector producing foundational digital goods and services. Taking a broader view on the digital economy, Bukht and Heeks (2017) add two more scopes of relevance. One is the true "digital economy", defined as "that part of economic output derived solely or primarily from digital technologies with a business model based on digital goods or services" (Bukht and Heeks 2017, p. 11). An example of this is the platform economy and sharing economy. The other is related to the use of ICTs in all economic fields, termed as the "digitalized economy" (Bukht and Heeks 2017, p.12). Regarding the latter, China champions the model of "Internet+", while the European Union promotes ICT innovation at the societal level, which often requires applications of new digital technologies at the social spheres. In other words, innovations in the fields of IoT and AI in the form of industrial innovations in Asia and elsewhere may depart from their existing routines and trajectories in a catch-up manner.

Set against the above backdrop, we intend to examine the way in which Asian countries may approach or harness IoT innovations, especially via applications at the social spheres. Based on two intensive case studies, we would like to draw some lessons learned, which may enrich our understanding of factors underlying industrial innovations in the era of the digital economy, especially for latecomer countries in transition.

To promote the digital economy involves new developmental models and innovation trajectories, and a few differences from the existing models in the ICT industry deserve attention. While the ICT industry in Asia is meant primarily for production and export, the development of the digital economy requires innovations for applications. Unlike the previous focus on modularized vertical disintegration along the global value chain, innovations for the digital economy have a strong flavor of cross-fertilization, solution orientation, and software and hardware integration. In addition, since only a few of the innovative sectors are emerging, their respective ecosystems still evolving at the international scale, the national innovation system has to become more internationalized than it is now.

In addition, since we are particularly interested in innovative applications at the social spheres, special account should be given to the scope of "customer space". Quite often, innovative applications are triggered by demand, which are related mainly to the target customer's pain point, moment of truth, and the like. However, we suggest to take a broader view on customer space, especially for systemic innovation. Apart from demand, systemic innovations need to give special account to "behavior". For one thing, one cannot have clusters of technological innovation without social and behavioral changes. Moreover, innovators should better not fertilize technology without consideration of consumer behavior. Social landing of innovative applications also often entails effectively dealing with "social interfaces", which are related to important interactions in the process of commercialization and marketization. Evidence has shown that long-standing regulations can be obstacles to digital innovations at the societal level. Therefore, digital technologies, as a driver, have to co-evolve with the organizational governance, institutional arrangements, and regulatory regime for the economy in an appropriate and desirable manner. A definition of a smart city given by Foxconn Vice President Erik Anderson ("A smart city enables new behaviors which redefine urban spaces") lends support to the abovementioned broader view on customer space.

IoT applications have been around for a while, but they are still evolving and at the"fuzzy front-end" stage. Many countries have jumped on the bandwagon to promote their own IoT applications, especially in conjunction with the theme of the digital economy and smart city. More importantly, innovations in IoT are related mainly to application, known as the "digitalized economy" as suggested by Bukht and Heeks (2017). Compared with firml-level IoT applications (e.g., Industry

4.0), IoT applications at the social spheres seem to present more challenges, which are related to the aspects of behavior and social interfaces of the broadly defined customer space.

Case studies

National freeways in Chinese Taipei are toll ways. With a build-operate-transfer (BOT) project conducted by Far Eastern Electronic Toll Collection Co. (FETC), the billing system has evolved from manual tolling (via flat-rate toll stations) to an all-electronic, multilane free flow tolling on all national freeways in the country.

The FETC's radio frequency identification-based tolling system has been applied in other areas of the transport sector. Since the system has a penetration rate of more than 94 percent in Taiwan, FETC has turned it into a billing and monitoring system for private parking lots. Big data collected through the ETC system also serve the innovative need of telematics, vehicle tracking, and so on. In a sense, it comes to resemble a platform for the internet of vehicles and innovation of a smart city. Though starting with a BOT business model of ETC, the FETC solution can find its way to generate more economic and business impacts by developing vehicle-centric access control solutions and logistics flow management and commerce, but only if the regulatory hurdles can be removed. In addition, while highway tolling is compulsory, application of ETC outside national highways requires appropriate mechanisms to give consumers an option to make consumption payment via ETC.

UPark is a start-up, pioneering online to offline (O2O) sharing business of urban parking spaces in Taipei. In a modern city like Taipei, daily commuters may frequently face a situation where they leave home, leaving their parking spaces unused, but cannot find parking spaces around their offices. UPark therefore introduced an IoT-based smart solution for O2O sharing of parking spaces. Its IoT lock can be unlocked simply via digital passwords. With smart devices, its subscribers or members can easily pinpoint online available parking spaces in the neighboring areas. The company was smart enough to start its business by dealing initially with owners of roadside parking spaces given the ease of access to their parking spaces. To scale up its business, UPark began to involve parking spaces inside residential complexes, which are often located in the basement. As a result, the company had to deal with new stakeholders—the management and the security guards of the residential complex—resulting in new challenges. Some appropriate mechanisms and revenue-sharing arrangements needed to be in place for the new stakeholders to comfortably become part of the UPark's ecosystem. Moreover, when its business has reached a particular scale, UPark faced regulatory issues, because long-standing regulations for parking service operators in the brick-and-mortar world have become obstacles to digital innovations at the societal level.

Conclusion

In the catch-up manner, industrial innovations in Asia used to cater primarily to production and export activities and focus mainly on modularization and "production interfaces" along the value chain. As long as the firm involved in research and development (R&D) and technology development can tap into the global production network, it is relatively easy for it to find a way to commercialize its R&D results. In contrast, innovations in IoT, especially those related to system solutions, are geared mostly for applications in real-life environment and multicontextual spheres. This often brings challenging issues for the innovators.

Quite often, IoT applications at the social spheres are initially targeted at specific customers and stakeholders. To unleash their economic and business potential, the innovator has to scale up its innovation ecosystem and/or find alternative routes for the applications. However, changes in the social environment may present complex

challenges, which are related to the aspects of behavior and social interfaces.

In short, the economic transformation in the digital age has brought about new meanings for innovation. Above all, the promotion of new digital sectors and applications entails Asian countries' developing their industries and forging innovations a few steps behind the forerunners and not in a catch-up manner. Instead of simply developing innovations for production and export in the context of the global production network, Asian countries have to engage more with innovations for applications/solutions. This will require their active participation in the evolving innovation system and not just relatively through the value chain.

Our case studies have demonstrated that innovations in IoT are related mainly to application. Compared with firm-level IoT applications, IoT applications at the social spheres present more challenges, which are related to the aspects of behavior and social interfaces of the broadly defined customer space. As a result, innovators in Asia need to address the social interfaces in an appropriate manner. In many cases, they also need to develop compound innovations, especially in conjunction with business models, and not just technological innovations alone. Therefore, they have to change the way in which they innovate, and interact more closely with the changing innovation ecosystem.

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Open Forum

QUESTION 1

Rhett Ramos (Allegro Microsystems Philippines, Inc.): I am concerned with the bandwidth of the physical infrastructure. Who is leading this? Are the strategies presented a short-term or a long-term program? Or is it just going to be for the current regime only?

Rafaelita Aldaba: In terms of the physical infrastructure, we are working with the DICT, and we will sign a memorandum of understanding together with seven other agencies. We hope this could be transformed into an executive order in order to institutionalize the innovation strategies and programs. We hope that through the roadmap, we can build the physical infrastructure to connect far-flung areas and provide Internet access at a relatively cheaper cost.

QUESTION 2

Soc Bansuela (PAKISAMA): We are a proponent of polyculture. When you said that consumers are the key, we just hope that the consumers will buy the product of polyculture. But, of course, there is the issue of price. How do you view the consumers becoming a real power in transforming monoculture agriculture to polyculture agriculture? Is this transformation considered in the i^{3}S strategy? Who will be the key players at the regional level? Are the agri-cooperatives in there or are we basing our hope in big businesses that are inclined to monoculture?

Eufemio Rasco: A great majority of the Philippine population, especially in the agriculture sector, cannot relate the fourth industrial revolution to farming. The problem that I tried to describe is a chicken-and-egg problem. Which comes first, the farmers producing or the consumers consuming? It is important to understand what the core problem is. If consumers prefer fast food/manufactured products, what happens to agri production? What if consumers prefer agri products? Consumers are more willing to take risks than farmers. Our farmers are very poor. They cannot afford to take risks. Our consumers are more diverse. The alternatives that we have are actually cheaper, but we have a problem with the supply chain, and we have to deal with that. It is a complex supply chain but we have the tools now with FIRe that can deal with these complex issues.

Stephen Ezell: To me, the fourth industrial revolution is not just about data, they are just a part of it. FIRe is also about intelligence and awareness to develop a capacity to make better-informed decisions. We are empowered with greater levels of information to make better choices. In the US, there is a farm-to-table technology where you can see where the ingredients of the food come from. For instance, IBM and Walmart have teamed up

to track every mango in the store to know where it came from and how it was produced—tracking the food history of every product they sell. That greater level of knowledge is important to drive consumers to demand change in our agriculture.

Rafaelita Aldaba: Agriculture is definitely part of i^{3}S. Agribusiness is one of our top priority industries. The strategy is to move away from rice and to invest more in high-value crops—supporting multicropping to increase the incomes of farmers and diversifying and upgrading our agricultural products. Cooperatives are needed along with industry clusters such as coffee, cacao, rubber, and fruits and nuts. There are also start-up companies that are providing solutions to some of the problems faced by our farmers in terms of access to finance and capital. With respect to the building of regional inclusive innovation hubs, these hubs focus not only on high-tech sectors but most especially on agriculture because many of our regions are still dependent on that sector.

Shin-Horng Chen: I am not an expert in agriculture, but I do know that we have projects related to that. Right now, we are promoting aquaculture where we are trying to use IoT technology to monitor the quality of water and size of the cages. We are also implementing the submarine technology to do so.

SESSION B

SCIENCE, TECHNOLOGY, AND INNOVATION

SESSION OPENER

Carol Yorobe, Undersecretary for S&T Services, Department of Science and Technology

FIRe creates the opportunity for developing countries to leapfrog traditional stages of industrial development. New technologies can also help achieve the Sustainable Development Goals. The Philippines, however, faces challenges in advancing science, technology, and innovation (STI), being ranked 73rd out of 127 economies in an overall measure of the innovation climate, according to the *2018 Global Innovation Index Report*.

Further examination of the components of the Global Innovation Index shows that while the Philippines is strong in its science and engineering graduates, in market capitalization, in domestic market scale, in high-tech and medium-tech output, and in ICT services exports (where we top in the Association of Southest Asian Nations [ASEAN]), it ranks poorly not only in ASEAN but across the world in ease of starting a business, in scientific and technical publications, in ease of getting credit, in expenditures on education, and in political stability and absence of violence.

Local literature has also pointed to the country's limited human capital in researchers, the low levels of research and development expenditures, and weak linkages of actors in the innovation ecosystem. What are the drivers and impediments to creating an effective ecosystem for STI? What can be done to improve human capital, infrastructure, and investments in the wake of emerging advancements in robotics, automation, and computing technologies? How can we strengthen intra-government, public-private, and local-international linkages? These are the questions that our session will try to answer.

Presentation 1

Building Globally Linked Manufacturing-and-R&D Science and Technology Innovation Ecosystems in the Philippines: An Indispensable Step toward Inclusive National Development and to Preparing for the Fourth Industrial Revolution

Joel Cuello | President, Philippine-American Academy of Science and Engineering and Professor, Biosystems Engineering, The University of Arizona

SUMMARY: The Philippines, based on the most recent 2015–2016 data published by the Commission on Higher Education, produces annually approximately 120,000 graduates in science, technology, engineering, agriculture, and mathematics. What is clear is that there is currently no established science and technology (S&T) innovation ecosystem in place in the Philippines to gainfully employ the majority of these S&T graduates, perpetuating what has become a massive imbalance between the country's growing S&T supply side and a persistently underdeveloped domestic S&T demand side, resulting directly in the continual brain drain of Filipino talents to other countries.

Certainly, the sustained development of the country's S&T supply side is necessary in terms of improving science education, increasing the number of science graduates, developing targeted research and development (R&D) capacity, and cultivating innovation readiness. Developing the country's S&T demand side, however, is urgently and critically imperative—and requires, and is tantamount to building, the country's S&T innovation ecosystem. This entails incentivizing globally linked S&T companies to conduct not only manufacturing but also R&D functions in the country, incentivizing the same companies to collaborate with local R&D institutions and research universities, and linking the same companies with domestic supply and value-chain partners. All these would pave the way for the desired outcomes of: (1) enhanced investment flows (foreign direct investments) into the country; (2) enhanced creation of diverse S&T jobs in the country; (3) enhanced business opportunities for domestic small and medium enterprises (SMEs) and entrepreneurs through linkage with the manufacturing industry's supply and value chains; (4) co-design and production of world-class innovative S&T products, processes, and services in the country for the global market; (5) generation of significant revenues and taxes; and (6) progressive buildup of commerical R&D capacity and expertise in the country; among others. Implementing the foregoing requires the concerted and deepened cooperation and coordination among government units together with local universities and R&D centers, and with both global and domestic manufacturing companies.

Meanwhile, it is this transitioning of the Philippines into the foregoing economic development stage of "Manufacturing + R&D"

that, in turn, would prepare itself for the next higher development stage of "High-Tech Innovation/ Knowledge-Based Value Creation" through which the country could robustly equip itself for the Fourth Industrial Revolution (FIRe).

The imperative for building an S&T innovation ecosystem

Before the Philippines can robustly prepare itself for the FIRe, it is imperative that it successfully transitions into the economic development stage of "Manufacturing + R&D" that, in turn, would prepare itself for the next higher development stage of "High-Tech Innovation/Knowledge-Based Value Creation". Both stages pertain to and necessitate the building of a thriving S&T innovation ecosystem. The said concept is based on the stages of development for countries as updated by Cuello-Rostow (2018), which include: (1) Agriculture + Mining (preconditions for take-off); (2) Manufacturing (take-off); (3) Manufacturing + R&D (drive to innovation); and (4) High-Tech Innovation/Knowledge-Based Value Creation (drive to sustained growth). These development stages have been charting the upward development trajectory of each of the Philippines' neighbors, including Japan, Taiwan, South Korea, Singapore, China, Thailand, Malaysia, Indonesia, and now even Viet Nam. Indeed, developing a vibrant S&T innovation ecosystem in the country is arguably the most practical and impactful way to prepare the Philippines at this time for FIRe.

Rationale for an S&T Innovation Ecosystem

The rich variety of animal species produced in a tropical rainforest ecosystem is a direct function of the dynamic and interactive relationships among the various environmental factors that make up the ecosystem, including its soil, sunlight, rainfall, temperature, humidity, flora, and habitats. In like manner, the rich variety of S&T products and services produced in an S&T innovation ecosystem—such as the archetypal S&T innovation ecosystem that is Silicon Valley in the Bay Area in California—is a direct function of the dynamic and interactive relationships among the various "environmental" factors that constitute the ecosystem, including companies, universities, research centers, government, scientists, engineers, students, investors, and global partners, among others.

The building of a robust and thriving S&T innovation ecosystem is every nation's aspiration in today's globalized world of the 21st century as it imparts to each country significant economic competitiveness that is essential for sustaining economic growth. Thus, a country's investment in S&T is indeed a deliberate business investment made by its government on behalf of its people, with an anticipated return of investment in terms of enhanced and sustained economic growth and national economic competitiveness. This very much applies in the case of the Philippines.

In examining the big picture of the Philippine S&T program, however, it is apparent that its supply side—focused on improving S&T education and R&D capacity, and resulting in the annual production of approximately 120,000 graduates in science, technology, engineering, agriculture, and mathematics—is not congruently matched by a demand side represented by global and local S&T companies operating within the country, resulting directly in the continual brain drain of Filipino talents to other countries. And the simple missing link in the foregoing supply-demand dynamic is the presence of a built and operating S&T innovation ecosystem in the Philippines, and specifically of a globally linked manufacturing-and-R&D S&T innovation ecosystem.

The significant benefits to the country of filling such missing link of building a globally linked manufacturing-and-R&D S&T innovation ecosystem in the Philippines would include, among others: (1) enhanced investment flows (foreign direct investments) into the country; (2) enhanced creation of diverse S&T jobs in the country; (3) enhanced business opportunties

for domestic SMEs and entrepreneurs through linkage with the manufacturing industry's supply and value chains; (4) co-design and production of world-class innovative S&T products, processes, and services in the country for the global market; (5) generation of significant revenues and taxes; and (6) progressive buildup of commerical R&D capacity and expertise in the country.

A *sine qua non* for building the Philippine innovation ecosystem

An absolute requirement, however, for implementing the foregoing is the concerted and deepend cooperation and coordination among the pertinent Philippine government units, such as the Department of Trade and Industry (DTI), Board of Investments (BOI), National Economic and Development Authority (NEDA), Department of Science and Technology (DOST), Commission on Higher Education (CHED), and Philippine Economic Zone Authority (PEZA), together with local research universities and R&D centers and in partnership with both global and domestic manufacturing companies.

In Israel, whose approximately 4,300 start-ups has earned it its vaunted sobriquet "start-up nation", its government maintains its focus on building and expanding its S&T innovation ecosystem through the Israel Innovation Authority, which serves to coordinate various government units to advance industrial R&D in the country. Similarly in the West Bank in Palestine—despite being a territory that is significantly economically hampered by border walls, geographic fragmentation, the presence of scores of Israeli military check points, and the existence of numerous contested Israeli settlements—efforts to build an S&T innovation ecosystem are underway and are being coordinated by an umbrella government agency, the Palestine Higher Council for Innovation and Excellence.

Post script

On October 2, 2018, seven government agencies—DTI, DOST, NEDA, CHED, Department of Information and Communications Technology, Department of Education, and Department of Agriculture—signed a Memorandum of Understanding (MOU) on Inclusive Filipinnovation and Entrepreneurship "to develop the country's innovation and entrepreneurial ecosystem via enhancing the linkages between academe/research community, industry, and government". On October 25, 2018, the Philippine-American Academy of Science and Engineering became a co-signatory of the said MOU.

Presentation 2

Developing Human Capital in Science, Technology, and Innovation for the Fourth Industrial Revolution

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SUMMARY: The Fourth Industrial Revolution (FIRe) has come about primarily because of the convergence of technology, the increasingly rapid pace of technology development and upgrading, and the falling cost of sophisticated technologies. This continually steepening curve of technology evolution demands new and different workforce skills, changing and updating more rapidly than ever before. Conventional models of higher education will increasingly struggle to deliver the workforce necessary to keep up with FIRe and to maintain or increase Philippine competitiveness.

This presentation explains some of the challenges and some of the solutions, primarily in higher education, drawing from the experience in other countries, such as those from the United States (US), the United Kingdom (UK), and also, most crucially as a regional competitor, Malaysia. These examples demonstrate the pressing need to continually improve interaction between industry and universities in the Philippines and to seriously consider the urgent remodeling of traditional approaches to higher education. Given the current rankings of Philippine universities in the region, it is clear that a step change in approach is required if FIRe is not to result in an ever-widening gap, with the inevitable detrimental knock-on effects to the national economy.

The rate of change is constantly increasing (which is quite scary!) and it will soon be beyond time to do something. Examples of this rate of change were prices that had gone down for technology products. What used to be high-tech, expensive, and in the domain of scientists are now in the domain of all—individuals, companies, and industries. These technologies are developing in a technical sense but are also reducing in price faster than how our knowledge is developing. What is learned and taught today will be redundant tomorrow. It is then not how we learn, but how we relearn.

According to the Organisation for Economic Co-operation and Development Education Directorate (2011): "Because of rapid economic and social change, schools have to prepare students for jobs that have not yet been created, technologies that have not yet been invented, and problems that we don't yet know will arise."[1]

[1] http://www.oecd.org/general/thecasefor21st-centurylearning.htm (accessed on August 1, 2018)

A question during the morning session on legislation is interesting because legislation is already moving very slowly, but it is already changing too slowly for technology. Uber already has a problem all around the world and drones will have a problem because there is no legislation almost anywhere in the world relating to what you can and cannot do with a drone. Things are changing so fast and faster than what they can legislate for. It is difficult that we are preparing our workforce for something we do not yet know. According to the World Economic Forum (2016, p. 20): "50 percent of subject knowledge acquired by a student in the first year of a 4-year technical degree will be outdated by the time the student graduates."

One model of rate of change shows that as technology gets more complex, the rate of change increases. What is interesting is the ability of organizations to respond wherein those who can respond can continue to go up but those who cannot respond will go down. This is the "innovate or die" situation. We have to know how to respond to this increasing changing complexity and rate of change. According to the World Economic Forum (2018, p. 8), under the Fourth Industrial Revolution, "75 million jobs may be displaced...while 133 million additional new roles may emerge concurrently." If we do things fast enough, FIRe would create more jobs than it loses, as it would create different jobs than the one it loses.

The challenge is this: How can the Philippine workforce keep up with the ever-increasing complexity and rate of change driven by FIRe? According to Toffler (1970): "The illiterate of the 21st century will not be those who cannot read and write, but those who cannot learn, unlearn, and relearn." This is the skill that we need to be teaching our young people. The message is that we need to have universities and industries working closely together to feed the needs of industry and to keep the supply of workforce in an appropriate way moving forward. The key to this is industry engagement.

The USAID Science, Technology, Research and Innovation for Development (STRIDE) Program tries to conduct collaborative research between the industry and university. Many universities might say that they already do industry engagement and so we provided a set of questions to assess industry engagement:

- What percentage of your students has 1-year paid internships?
- How often does industry review your curriculum?
- How many undergraduate projects come from industry?
- How many industrialists teach your courses/units?
- How quickly can you set up an industry visit?
- How many industrialists can you rely on to complete a survey or a series of interviews?
- What percentage of your research activity is in collaboration with industry?
- How much revenue do you generate? And is revenue important?
- How many are "friends"?

The last question is particularly important because industry collaboration relies on you making friends with industry. Not to worry about collaboration but to first of all, make friends. You do not marry someone who is not your friend.

The STRIDE program in the Philippines has offered guest industry lectures that emphasized the importance of learning and sharing between the academe and industry. Faculty immersion with industry allows faculty experts to immerse with industry partners to learn and understand their processes and technical requirements. In the UK, an engineering fellowship pays faculty experts for six months within which they can go back to industry and keep up with what is happening.

The STRIDE program pays three to four weeks for faculty experts to go to industry. The One Thousand Cups initiative in Iloilo was modelled from the One Million Cups in the US, which is about universities drinking a million cups of coffee with industry and entrepreneurs as an excuse to get together. Innovation workshops bring industry and researchers together to talk about challenges. STRIDE has mentored career centers so that universities can make better contact with industry. If we judge the universities in the Philippines in terms of graduate employment rate, all universities would have a world-class career center with great industry contacts. They also set up university Knowledge and Technology Transfer Offices to better service people outside university and help the university to work with external stakeholders. There is a growing community of outward-facing faculty looking to collaborate.

The European Commission's Factories of the Future project encourages universities to collaborate with industry. Institutes bring industry and academe together so they can work and learn together. Faculty members can use the equipment in industry so they do not have to keep buying expensive equipment. For instance, the Oregon Nanoscience and Microtechnologies Institute is bringing a cluster together like a local ecosystem in Oregon.

Meanwhile, the Knowledge Transfer Partnerships (KTPs) have been running since 1975 in the UK. Now, at any time, there are around 1,000 KTPs in operation in the UK. It is a partnership between a university and a company to solve a problem for the company and employs recent graduates who do the work supervised by people from the university and the industry. These bring in equipment, expertise, and friendships. The university understands the problems of industry and new graduates know what industry wants. Australia and Sweden have adopted this model, recognizing it as one of the best models for industry collaboration.

Another example is the NC State University Centennial Campus where academic facilities are located next to industrial facilities. The condition is that the industry will do something with the university, such as taking internships or conducting joint research. They have to do something with the university to get a relatively preferential rate. They benefit from working with all the smart people in the university.

Although a bit further in the development curve, Malaysia has a similar case with the Philippines. Malaysia redesigned its higher education to meet the needs of FIRe through a program called Malaysia HE 4.0, a government-wide initiative that is worth taking a look at. Malaysia is pushing the boundary further, breaking down the traditional university structures, and merging education and workforce development with industry so it becomes a seamless thing. In the Philippines, there is almost no one-year paid internships, and the excuse is that industry does not want to take them or there are no jobs for them but I think this is because the universities do not sell their students to industry. In Malaysia, however, they have a model called 2u2i, which means two years in university and two years in industry. That is their model for students to get a degree. Malaysia has four different models of universities ranging from no change to radical change.

For my conclusion, here are the things that the Philippines could do and what we should be taking on board in this public policy conference. These are: (1) resolve to reinvent tertiary education (including technical and vocational education and training), (2) accept the concept of lifelong learning, (3) involve industry in curriculum development and delivery, (4) accept and encourage industry accreditation, (5) encourage and explore novel university/industry education and re-education models, (6) enable and encourage rapid revision of content, (7) fully

embrace continuous professional development, and (8) accept that part-time study will be the norm rather than the unusual.

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Presentation 3

Data for the FIRe: DOST-ASTI's Science Infrastructure for Data and Computation

Joel Joseph Marciano Jr. | Director, Department of Science and Technology – Advanced Science and Technology Institute

SUMMARY: The Fourth Industrial Revolution (FIRe) features the ascendancy of the so-called cyber-physical systems (CPS), where connectivity and computational elements become tightly integrated with physical infrastructure and the built environment. These systems take advantage of advancements in sensing, communications, and computational capacity to generate data that are used for closed-loop control and feedback. This feedback, in turn, effectuates higher throughput and more accurate, reliable, and resilient system performance. Embedded computers, ubiquitous connectivity, and storage are enabling pathways for rapidly increasing data creation, fusion, and processing toward the rise of CPS. With the growth of machine learning and artificial intelligence, the computational aspects of converting data into information are expected to become more efficient, adaptive, and timely. This presentation tackles FIRe from the lens of data, computation, connectivity, and their increasing integration into the physical world that underpins the defining characteristic of this era—the "vanishing" of these technologies into the background. It also describes the science infrastructure of the Advanced Science and Technology Institute of the Department of Science and Technology for data creation, storage, computation, and connectivity in support of local scientific research and development in CPS that enable the FIRe and the thrust for a data-driven society.

I wanted to provide a perspective on the FIRe by highlighting the relevant advances in technology that has led to previous revolutions. We start the journey with the advent of computing that spurred the Third Industrial Revolution. Computers were able to execute commands faster than any human and were able to enhance productivity. From personal computers and with the proliferation of connectivity and the Internet, we started to change the face of computing by putting computers in remote places called data centers, leading to the so-called "computing on the cloud". When we talk about computing now, we do not necessarily have to be doing heavy numerical computations or fancy simulations. We can be updating our status in social media or sending a tweet—we are contributing to the generation of data that undergo some form of processing or computation. Somewhere out there, the tweet gets to a computer that processes it,

adding traffic to the network and computational load to a server. Advances in computing capacity and algorithmic complexity have made computers more capable and versatile. We came from an era of mainframes, which has died—a paradigm of one massive computer serving many people—to the personal computing (PC) era, where it became affordable for each person to have one in the home, the office, and place of business. From the PC era's mantra of "one person, one computer", we are now entering the age of ubiquitous computing where the new paradigm is "one person, many computers".

The rise in computing power has also come with increasing miniaturization and enhanced battery life, which have combined to make computers more accessible and portable. This has led to a redefinition of computers and computing. Computers themselves are not just boxes sitting on desks and on our laps—they are now in our pockets, wallets, wrists, and clothes, and fit in the palm of our hands. With computers and computing being increasingly embedded in our environment, they are becoming pervasive and will soon go the way of the light bulb. The light bulb is a metaphor for electricity, which began as something rather exclusive until it became more pervasive. Now, almost everyone has access to it and it has started to "fade into the background". When we go somewhere and there is no electricity, we say the place is quite backward. The Internet and WiFi are technologies that are "vanishing" into the background in quite the same way. According to the late Mark Weiser, the father of ubiquitous computing, "The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it."

With the decreasing cost of computation, storage, and communication bandwidth, computers and the Internet will become highly integrated into our everyday activities. The transparent and seamless fusion of computing and connectivity, i.e., the "cyber" world, with the physical world gives rise to so-called cyber-physical systems (CPS), a defining feature of the FIRe. Part of the FIRe that has been happening is really all about data, computation, and the fusion of technologies that fuel and give rise to CPS.

Computing is blending into the background of everyday life. We now find computers everywhere; they are "vanishing" into places both in and out of this world. When we talk about launching Diwata-1, the Philippines' first microsatellite, for example, what we have actually done is to embed a computer in space. My perspective of our country's nascent space technology program, therefore, is that we are not really launching satellites into space. Instead, we are putting computers in orbit. Why and what for? We are building and launching small satellites, i.e., putting computers in orbit, to generate and obtain data.

About the DOST-ASTI

The Advanced Science and Technology Institute (ASTI) is a research and development (R&D) institute attached to the Department of Science and Technology (DOST). Through DOST funding, ASTI maintains science infrastructure for enabling, advancing, and sustaining R&D in computing, electronics, and information technologies. Over the past decade, ASTI has put in place various networks and infrastructure that enable the generation, computation, accessing, archiving, and storage of data. These facilities and resources are made available to the local scientific community through research cooperation and collaboration agreements.

An example of a rich data source is the network of 2,000 automated environmental sensing devices that ASTI built and deployed all over the country. This network is an underlying infrastructure of Project NOAH. ASTI teams will soon deploy 50 lightning sensors around Metro Manila, which is the densest concentration of lightning sensors in the world, for the purpose of modeling and predicting localized weather phenomena such as thunderstorms. ASTI also

has a ground station—the Philippine Earth Data Resource Observation (PEDRO) center—that communicates with satellites for obtaining remote sensing imagery. The Computing and Archiving Research Environment (CoARE) offers access to a high-performance computer for scientific research as well as a scientific data catalog and storage that enable data integration across various local and international research projects. The Philippine Research, Education, and Government Information Network (PREGINET), on the other hand, is a high-speed network for research and education that enables universities, researchers, and other stakeholders to access PEDRO, CoARE, and other ASTI resources. Within ASTI, research teams process satellite images and various other data into information that address societal applications. ASTI also responds not just to scientific concerns but also to operational needs of various agencies in government. ASTI mobilizes data and computation in efforts to prepare for and respond to typhoons and other disasters, such as the recent typhoon Mangkhut and the landslides in Naga City, Cebu. By bringing these capabilities to bear on these challenges, ASTI contributes to the promulgation of interventions and policies based on scientific evidence and measurements. By quantifying the volume of data and compute mobilization (the amount of computational resources or "load", e.g., the number of operations performed by a microprocessor, the amount of memory used, etc., to perform a certain task or set of instructions), ASTI aims to further heighten awareness of science and technology resources and capabilities that are available in the country for tackling the effects of natural disasters and similar events.

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Presentation 4

The Role of Government in Improving the Science and Technology Landscape for the Fourth Industrial Revolution

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SUMMARY: New and emerging technologies across the world that are already being adopted by Philippine industries, albeit in varying degrees of diffusion, coupled with the interplay of various fields, are powering up the Fourth Industrial Revolution (FIRe) and its radical consequences. While opportunities are being created to increase wealth and prosperity, and to improve various aspects of daily living including food, nutrition and health, the disruptions the FIRe brings may also present risks of heightened gaps across society, especially between those who can adapt to the revolution and those who cannot. Government's role in the innovation ecosystem is extremely critical. Government should be like a gardener preparing the ground, i.e., working with the private sector to improve human capacities for the labor market and increase systematically the science and technology (S&T) workforce. Further, it should be watering the ground and nurturing the soil, i.e., increasing support for S&T, but considering also absorptive capacities of research and development institutions. Finally, government also needs to remove pests and weeds, i.e., adapting its policies and regulatory environment in the wake of the impending revolutionary changes brought about by the FIRe. A critical but challenging task of government is to reduce regulatory barriers to innovation and ease burdens to doing business, improve regulatory quality, and utilize adaptive regulatory frameworks including regulatory sandboxes to ultimately ensure that no Filipino will be left behind in enjoying the benefits of the FIRe.

Opportunities and risks from frontier technologies

Technological innovations are being used more than ever in our daily lives. These are reshaping commercial activities and creating new business models. Technological breakthroughs and the interplay of a number of fields are powering up what is referred to as the Fourth Industrial Revolution (FIRe). Also known as Industry 4.0, the FIRe is "characterized by a fusion of technologies that is blurring the lines between the physical, digital and biological spheres" (Schwab 2016).

Throughout history, industry has improved from using established production methods to employing cutting-edge technologies. These improvements yield radical impacts not only in production levels but also in improving the accuracy and precision of manufacturing processes, as well

as in reducing the cost of labor. This reengineering of industry gets dubbed as an industrial revolution (Landes 1969).

The first three industrial revolutions involved the use of steam and water power (in the mid-1700s), then electricity and assembly lines (in the latter half of the 19th century), then computerization (toward the end of the last millennium). Now, we live in the era of the FIRe. What makes Industry 4.0 a revolution is not the technologies themselves, because these are technologies (e.g., robots, computers, digital platforms, wireless connectivity) that have been around for some time. What makes this period different is that we are getting to use these technologies to interact with each other in a way that we have not done before. While there is some disagreement whether FIRe is separate to or a mere extension of Industry 3.0, there is no debate about the undergoing disruptions in industry and society (Rifkin 2016).

Frontier technologies commonly identified as part of FIRe include robotics, artificial intelligence (AI), Internet of Things, cloud and quantum computing, big data, neuro technologies, advanced materials (including nanomaterials), biotechnologies, 3D printing, and technologies for energy capture (WEF 2017).

Technology can be a powerful agent for good, especially in the wake of the global aspirations for attaining the Sustainable Development Goals (SDGs) by 2030 (UN 2015). Smart systems are being used across homes, factories, farms, cities, and nations to tackle many issues affecting our goals and targets for achieving the SDGs—from nutrition and healthcare, to transportation and supply chain management, to urbanization and climate change. But while the FIRe has started to make life more comfortable and is expected to bring about further good, all these technological advancements carry a lot of disruptions to traditional business models and processes, as well as pose threats especially to jobs.

The impact of technology particularly on jobs is quite complex, and not fully predictable. The Asian Development Bank (2018) suggests that the outlook for Asia Pacific is quite positive, as it reports that from 2005 to 2015, jobs created by rising domestic demand in developing Asia have more than compensated for job losses from automation. But this is no assurance that such trends will continue. A study of the International Labour Organization (ILO) suggests that over the next decade or two, more than half (56%) of all employment in five Association of Southeast Asian Nations (ASEAN) member-states (Cambodia, Indonesia, Philippines, Thailand, Viet Nam) is at high risk of automation (Chang and Huynh 2016). The same ILO report suggests that in the Philippines, 2.1 million laborers are at high risk, including fishery laborers (580,000), waiters (574,000), carpenters (525,000), and office cleaners (463,000). Further, women in the Philippines are 2.3 times more likely than men to be employed in an occupation at high risk of automation. Also, workers who finished only primary school are 90 percent more likely to be at high risk than those with post-secondary education. Business process outsourcing companies in the country are also found to have 9 out of 10 workers at high risk of getting affected.

Technology affecting jobs is not equivalent to technology substituting for labor. New technologies often automate only some tasks and not the entire job. The introduction of automated teller machines did not eliminate bank tellers but even increased these jobs that now also involve a lot of customer relationship management activities. Technology can also complement labor, and also create new jobs.

The late physicist Stephen Hawking suggested that AI provides an existential threat to humanity (Cellan-Jones 2014). The Nobel laureate Joseph Stiglitz warns that inequalities currently existing in society will become even larger as a result of Industry 4.0 (Stiglitz 2017). Other thinkers, such as the economist David Autor, argue that the threat of the machine substitution for human labor tends to be overstated, since computers actually amplify

the comparative advantage of workers in supplying problem-solving skills, adaptability, and creativity (Autor 2015). But the same author also warns that even if robots and AI do not reduce the quantity of jobs, automation may affect the qualities of jobs that are available.

Regardless of the outlook on the overall effects of the FIRe, there is unanimity in recognition that the nature of work is changing and further going to change. What remains uncertain is the timing and the extent of impact in developing countries where technological feasibility does not always translate to outright adoption. Since repetitive tasks can be programmed into computers, thus, technology can replace routine jobs. People at the lower-skill spectrum, doing relatively high shares of routine tasks in their jobs, are the people that are likely to be affected and possibly displaced. But emerging technological advances can also create new jobs but because these new jobs are going to be different from the jobs that have been misplaced, these future jobs require workers to learn some skills, new technological skills and soft skills, to be able to participate in the emerging labor market and the new economy. Some people across society, however, may have challenges adjusting and, thus, government will need to provide strengthened social protection systems, boosted by reforms in taxation policies, aside from working to improve the innovation landscape.

The innovation ecosystem in the Philippines

Emerging innovative technologies can potentially allow us to meet several SDGs and targets, from attaining food security, to improving the quality of health care, to caring better for the planet. These objectives are mainstreamed in the country's development plans and long-term aspirations (NEDA 2016, 2017). But since there are uncertainties in the future, we need to look into our preparedness and identify what steps we could take to make our economy resilient to risks and uncertainties, to make our citizenry flexible for the jobs of the future, as well provide social protection to those who may not be able to adjust as easily.

In its *Readiness for the Future of Production Report 2018*, the World Economic Forum (WEF) has looked into various aspects of the current structures of production, as well as the drivers of production in 100 countries to assess their level of preparedness for the FIRe (WEF 2018). The seven ASEAN member-states included in the WEF assessment are spread across three different archetypes: Leading—Malaysia and Singapore; Legacy—Philippines and Thailand; and Nascent—Cambodia, Indonesia, and Viet Nam. As a legacy country, the Philippines has a strong production base today, but it is at risk for the future due to weaker performance across drivers of production, which include technology and innovation, human capital, global trade and investment, institutional framework, sustainable resources, and the demand environment. Singapore and Malaysia, together with China and several rich economies, are leading in preparations for Industry 4.0, likely on account of past investments in building their innovation ecosystems.

For developing countries such as the Philippines, the diffusion of technology depends both on access to foreign technology and on the ability to absorb technology (WB 2018). Trade, foreign direct investment, international migration, and networks (including information networks such as the academe and media) act as transmission channels while factors such as the quality of government policy and institutions, the stock of human capital, research and development (R&D) efforts, and the financial system, among others, determine absorptive capacity for new technologies.

The Philippines still faces challenges in advancing science, technology, and innovation (STI) with only 2 out of every 5 firms reporting to be innovation active as of 2015 (Albert et al. 2017). Furthermore, the country ranks 73rd out of 127 economies in the 2018 Global Innovation Index (GII), an overall measure of the innovation climate (Cornell University, INSEAD, and WIPO 2018). Out of seven ASEAN member-states, the

country ranks fifth in 2018, behind Singapore, Malaysia, Thailand, and Viet Nam, but ahead of Indonesia and Cambodia. Further examination of the components of the GII show that although the Philippines tops in exports of information and communications technology (ICT) services in ASEAN, it is second lowest (next only to Indonesia) in scientific and technical publications. In terms of institutions, the country ranks lowest in ASEAN in political stability and absence of violence/terrorism, and second lowest (next to Cambodia) in ease of starting a business.

Various studies on innovation point out that countries that are not in the forefront of STI have difficulties in making catch-ups and leapfrogs since financial investments in R&D alone are not enough (Cirera and Maloney 2017). Hard and soft infrastructure, as well as capacity development of human resources and institutions, are complementary factors to R&D investments in improving readiness to the FIRe.

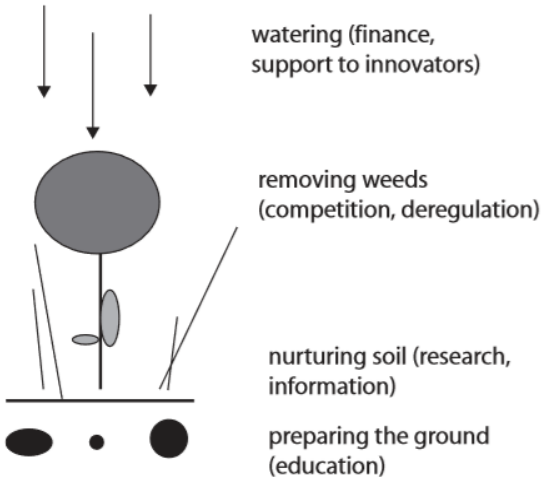
In recent years, the innovation ecosystem in the Philippines has been getting increased financing and support. The Department of Trade and Industry is now working in tandem with the Department of Science and Technology (DOST), the Commission Higher Education, and other national government agencies on implementing the country's industrial roadmap called the Inclusive, Innovation Industrial Strategy (i^3S, "i-cube"). The DOST is also working on getting support for several programs, especially the Science for Change Program (S4CP), the *Balik* Scientist 2.0 program, and the Small Enterprise Technology and Upgrading Program (SETUP).[1]

The Department of Information and Communications Technology is also working vigorously in addressing issues on coverage, price, and quality of Internet, and in developing a successor to our Digital Strategy and implementing a National Broadband Plan e-Government Master Plan. But are we maximizing the impact of all these many initiatives? Are all of these efforts well-coordinated, or are there duplications that can be put to better use elsewhere?

What should government do regarding the emerging FIRe landscape

Borrowing the analogy articulated in a report of the World Bank on innovation (Figure 1), government should be like a good gardener, that "prepares the ground" (i.e., building up human resources), "fertilizes the soil" (i.e., boosting R&D), "waters the plant" (i.e., providing financial support for innovation), and "removes weeds and pests" (i.e., removing regulatory, institutional, or competitive obstacles to innovation).

Figure 1. Gardening innovation



Source: WB (2010)

Develop human capital

The WEF lists and describes the future skills required and clusters them into three groups, namely, (a) foundational literacies, (b) competencies, and (c) character qualities (WEF 2015). The introduction of the K to 12 Program

[1] The S4CP entails massive investments in science and technology education, training, and services to significantly accelerate STI toward social progress and global competitiveness. The *Balik* Scientist 2.0 program provides improved benefits and incentives to Filipino scientists, engineers, and innovators of Filipino descent residing overseas who return to the country and work for national development. The SETUP has also been given more support with its aims to improve productivity and efficiency of MSMEs by addressing the technological needs and constraints of firms.

through the Enhanced Basic Education Act of 2013 (Republic Act [RA] 10533) is the most radical change to basic education in recent years. It made kindergarten mandatory, adding two years to secondary education, aside from instituting other reforms. But are these changes enough to prepare our future workforce for future jobs?

Improve STI investments

In the realm of research, the bulk (60%) of R&D spending across sectors is actually supported by government. While the Philippines has had a slight increase in R&D expenditure to gross domestic product (GDP) in recent years, this spending is still at less than a fifth of one percent of GDP, which is below the one-percent benchmark recommended by the United Nations Educational, Scientific and Cultural Organization. The country's share of spending in GDP also falls below that of several ASEAN member-states, especially Singapore (2.4%) and Malaysia (1.3%). Even if the Philippines spends much more on R&D, there are concerns about absorptive capacity, and complementary factors for innovation that may be absent. There should be no quick fixes and a delusion that we can just leapfrog. Further, we need a lot of investments—developing human resources, improving ICT infrastructure—to bring the unconnected especially in the rural areas to the digital world.

Address regulatory barriers and bottlenecks to innovation

Removing weeds and pests is probably the one role the government has neglected the most especially as our country has too many lawyers, double the number of research scientists and engineers. The significant restrictions to trade and investment must be removed in addition to the burdensome regulations and procedures that add to the cost of doing business.

The current procurement process should likewise be reformed to give some leeway for technology transfer. The existing procurement system, which came about as a result of RA 9184, was designed to minimize corruption by increasing transparency and accountability in government transactions. But, in doing so, we had an unintended consequence: massive inefficiencies that lead to underutilization, and eventually a lot of wasted resources.

Various government agencies with regulatory functions play a critical role in creating an enabling environment that fosters technological upgrading and innovation. While regulators have their respective mandates, they need to see their role under a whole-of-government framework to ensure they do not work at cross-purposes.

Regulators should also be able to adapt to new technologies, products, and business models. The regulatory sandbox approach used by many monetary authorities particularly in Singapore, Malaysia, and the United Kingdom working with fintech services could provide useful lessons that other industry regulators in the country could replicate.

Strengthen social protection

The FIRe can possibly dislocate people from jobs. Some people may lack either the ability or the interest to reach their creative potentials and will thus require social protection, possibly even some universal basic income. However, public support for social protection has weakened, with most, especially those from middle- and upper-income families, preferring that government spend on entitlements such as free college education that have adverse effects to equity, possibly crowding out the poor from state universities that offer free tuition (Orbeta and Paqueo 2017).

Increasing social protection in developing countries to anticipate possible widening inequalities entails having the political will to battle this sense of entitlement to social assistance, aside from working on progressive universalism that emphasizes expansion in overall coverage of social

protection to the vulnerable class but prioritizing the most those in need and vulnerable.

Governments also should revamp pension models in line with the new realities of work and ageing, including providing greater support for working into old age. Furthermore, social security benefits need to be portable so that people do not experience loss of contributions and benefits from moving from one job to another, or even from one country to another. It will also be important to increase public spending on active labor market policies that reduce labor cost or help people find jobs.

Reform taxation policy

All the social protection costs and human capital development can be borne by taxation reform, such as improving collection of property taxes, instituting subsidy reforms, and reducing tax avoidance especially among firms and people engaged in digital trade, which has not been effectively measured. Currently, taxation reform is being instituted largely to fund infrastructure development plans, and not with regard to needs for improving preparations for the FIRe.

Develop whole-of-nation paradigm and action agenda

The effort to prepare the Philippines for the FIRe requires everyone to work together to steer emerging technologies in ways that limit risk and create a Philippines that aligns with common goals for the future. While it is difficult to see definitively how fast and to what extent the FIRe will disrupt our way of life, and to determine the links between the ways in which society responds to automation and the future pace of innovation, we should have a framework for assessing alternative possibilities and policies. We need a rough guide to the likely consequences of the FIRe so that we can have a "whole-of-nation" understanding of what is to come, and have an action agenda to improve our readiness for the future today.

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Open Forum

QUESTION 1

Mary Grace Mirandilla-Santos (Internet Society Philippine Chapter and Better Broadband Alliance): How do we make things more relevant or exciting for the common Filipino, such as a *taho* vendor? The media does not find it sexy to look at policy in terms of how we can better innovate as a nation and as a people. How do we make new and emerging technologies more accessible and more relatable? How can we make policy more accessible?

Joel Cuello: When I travel to other countries, I get a copy of their local newspaper. I notice that particularly for Southeast Asian countries as well as China, Japan, and Korea, the front page of their newspaper usually has an economics story, which sometimes is the headline. In the Philippines, there is hardly an economics or business story on the front page and there is just a business section, which is quite anemic. Is this a cultural mindset? I think that S&T, policy, and business affect the quality of life. It is important for journalists, as one of their responsibilities, to make that link clearer to ordinary folks. FIRe, S&T, and policy are relevant to everyone because they directly affect the quality of life and economic progress. I remember a question raised during the morning session on how come there are not a lot of kids who go into S&T? My simple take on this is that because there are a lot of graduates in S&T who cannot find jobs and have to go somewhere else. If we take care of the technology innovation ecosystems in the country, which would create well-paying jobs, that would make S&T more appealing and sexier to a lot of young people.

David Hall: There is no one answer to the question. One of the things that we could do is university-industry engagement. If we get more of our undergraduates into industry and if industry would see the value of them and if we prepare them better to go into industry, it starts to be a self-fulfilling prophecy where industry employs more graduates and the economy improves. This gets the word out there and families would understand how good and what a good living science and engineering is. Another thing is that, given that DOST spends public money, it is not very exciting to hear that researchers have made only many publications and patents from public money. What is exciting is hearing that public money is paying for the research to provide clean water to communities, to create and save jobs, and to make new products. It is a public relations issue, since researchers are already doing this in their research anyway. If the people who fund research give the public good stories rather than just academic scores, it would start getting people more interested in where their money is used for.

Jose Ramon Albert: Part of it is simple things like harnessing partnerships. We coordinate among ourselves and talk in a lot of meetings, but I wonder what exactly comes out of all these meetings in

government. So much of the FIRe technologies have already been applied but they have not been communicated well. Unfortunately, not a lot of people know that there have been significant technologies developed in the Philippines, and there are a lot of opportunities out there to harness these to make things better, and to demand government to use these technologies much more to deliver services. How much of us right now are actually partnering with different organizations and NGO groups? There are things that are already there and we just need to learn from the experiences of groups. Unfortunately, we are not very good not just at communicating but also at finding models. We need poster boys and girls of scientists and thinkers. The tendency is that a taho vendor would not probably think of asking his or her child to become a scientist because he or she cannot think of someone who is a scientist. I remember how Dr. Raymundo Punongbayan was so visible and everybody knew who he was, and when he said something, immediately everybody would listen. We need to identify models as part of the communication strategy. I think that scientists are not very good at communication, so the government needs to make more partnerships.

Joel Joseph Marciano Jr.: I think that what S&T should be able to address is to target ICTs on the concept of information poverty. We invest in S&T, so we can put actionable information on people's hands. I think that Ms. Marandilla-Santos' advocacy on broadband is the heart of that as well. We might be generating data somewhere, but if they do not get processed or get transformed into actual information that ordinary people can understand, the communication issue comes in. Information poverty is a larger issue in our country. We may not be able to immediately address economic poverty, but we can do something about the lack of intelligent information that gets to people who can do something with it. This is something that we can target.

Another thing is that outcomes are important. When I talked about infrastructure and investments made by ASTI in S&T, I did not purposely mention publications and patents we have filed because those are for an entirely different audience. We should not be fixated on those, and we should be fixated on the long term—longer than what the politicians can. In that sense, we do have things that are not really measured by traditional metrics like patents, licenses, and publications. We deploy technologies to communities. There is no commercial licensing agreement when you deploy a weather station in a community. You do not ask them to pay royalties, but you conduct information and education campaigns. They learn about the technology, use it, and trust it, but we are not measuring that. The world is looking at our outputs as a country in terms of bin counting, such as how many papers and patents come out of the Philippines. We still need to do that, but we also need to have a metric for all these technologies that are being deployed to a disaster-prone country like the Philippines that captures the direct engagement of technology with communities.

QUESTION 2

Janna Sheng Olladas (Committee Affairs Department, House of Representatives): I remember that in the 1990s, the common complaint in the Philippines was that the left hand does not know what the right hand is doing. One of the proposals then was to get the executive and the legislative branches in one platform so you get a common legislative agenda. On FIRe, I was thinking that our approach is really fragmented. Can the country have a platform that looks at the forest because even in congress, that is a big problem where there are over 70 standing committees? Sometimes, we have a legislation that is referred in one committee that negates the efforts that is being done in another committee. Would the medium-term development plan be a platform to actually

have an accompanying legislative agenda that sort of works everything together seamlessly without contradictions? This is so that all of us will move in one direction.

Jose Ramon Albert: There have been models from other countries like Australia, and they seem to be at the forefront talking about this platform of a whole-of-government approach. The government indeed has a fragmented approach and, in the end, you hear a cacophony of voices and there is no symphony and there is no conductor. I think that it is leadership that matters. I look back to when there were already aspects of whole of government during the time of President Ramos. We were all being told to have a very structured way of doing things but, now, it has disappeared. We really need to put the FIRe agenda forward and a whole-of-nation approach is the way to do it. Because it is a whole of nation, there must be somebody giving us an overall vision.

Joel Cuello: Being able to implement FIRe and to implement the building of S&T innovation ecosystems requires a corresponding optimized government bureaucracy. This refers to the government structure. A lot of our government officials in DOST, DTI, and CHED would visit places around the world to look at how the structures of universities and industries interact. I think that the same thing should be done in terms of examining the government bureaucracy or government structures of successful countries to be able to spawn this kind of successful innovation ecosystems, as well as implementing FIRe. It is fine to acknowledge that the Philippine bureaucracy is not the optimized government arrangement that we hope for and there is nothing wrong with that. It is good to always improve, and there is always room for improvement. In Israel, there are different ministries but there is an overarching government entity called the Israel Innovation Authority that serves as the synchronizer and overseer of all the government agencies, so that they will all be properly coordinated to come up with a seamless bureaucracy for implementation. Something like that might be applicable to the Philippine setting.

David Hall: In Malaysia, which has a cross-government organization, the AIM or the Malaysian Innovation Agency coordinates innovation across all of government. In order for that to happen, someone has to make it happen. This does not happen from somebody within one of the many well-meaning government departments. I worked very closely with DOST and DTI to run events and invite people from other government departments. I observed that we need somebody from above to say what should be done and to set up an agency. Also, many countries have a much stronger party political system, and they have policies that run from year to year through administrations, which I do not see in the Philippines. I see a cycle of government that is relatively short. When a new administration takes over, there is not a huge amount of continuity, which makes long-term planning very difficult.

COMMENT

Emmanuel Pacheco Leaño (Central Mindanao University): Part of the program of DOST is that entering third-year college students have the chance to do an on-the-job training in any industry they wish. This year, they have sent four students from Mindanao to Luzon to get industry experience. We are very thankful to DOST and Undersecretary Carol Yorobe for this very good program.

SESSION C

LABOR MARKET AND SOCIAL PROTECTION

SESSION OPENER

Alex Villarosa Avila | Assistant Secretary, Workers Protection, Policy Support, Human Resource, Administrative and Internal Auditing Services, Department of Labor and Employment

As in past industrial revolutions, the Fourth Industrial Revolution (FIRe) can also be a disruptive force, dislocating people from jobs as automation and artificial intelligence replaces, complements, or creates entirely new jobs. Of special concern are those doing routine tasks that have a high risk of being completely rendered obsolete by technology. Recent technological advancements in storage, usage, analysis, and transfer of data now allow automation to cover even nonroutine cognitive tasks. Additionally, robots are gaining enhanced senses and dexterity, which enable them to undertake a broader scope of manual tasks. Artificial intelligence could thus displace many workers not only in manufacturing, but also in other sectors, such as information technology and business process management. While some jobs are at risk, other jobs may be transformed to be more productive, and new jobs are also likely to be created.

This session discusses changes in the nature of work resulting from FIRe and their implications. The discussion includes the impact of FIRe: on the evolution of employment, income, and wages; on the changing nature of work engagements and their implications; on key aspects of the current labor market policies, regulatory environment, and a social protection system that will need to evolve to enable Filipino workers to thrive under FIRe; on the range and financing of social protection mechanisms that can mitigate the negative impacts on the level and stability of employment and income, particularly for the vulnerable and disadvantaged, with the end in view of promoting more equitable sharing of the fruits of economic growth; and on the lessons that can be learned from the experience of and the preparation done by other countries in the labor market and social protection in the wake of FIRe.

Presentation 1

The Future of Work and Social Protection

Markus Ruck | Senior Specialist on Social Protection for the Philippines and South-East Asia, International Labour Organization

SUMMARY: The world of work is undergoing major changes. Digitalization and automation have facilitated the emergence of new forms of employment, such as work on digital platforms, and have led in some countries to an increase in on-call employment or other forms of temporary and part-time employment, as well as dependent self-employment and temporary agency work, often referred to as nonstandard forms of employment. While such forms of employment may provide greater flexibility to enterprises, they often translate for workers into lower and volatile earnings and higher levels of income insecurity, inadequate or unregulated working conditions, and no or limited social security entitlements. Such new forms of employment are not limited to high-income countries. In many middle-income countries, a growing class of unprotected workers in new forms of employment now co-exists with a large number of workers engaged in traditional forms of work such as subsistence agriculture.

Changing work and employment relationships, alongside weakening labor market institutions, have contributed to growing levels of inequality and insecurity in many parts of the world and to weakening the implicit social contract in many societies. Growing precarization calls for greater attention to employment, wage, and social protection policies to ensure that the fruits of economic growth are shared on a more equitable basis. In this context, social protection and its potential to reduce and prevent poverty as well as to address inequality remain relevant as ever (Sustainable Development Goal targets 1.3, 5.4, and 10.4). Various policy options are being discussed on how social protection systems can adapt to the changing nature of work and close social protection gaps.

The world of human work faces several challenges. Technology has facilitated new forms of employment—digital, on-call, part-time, dependent self-employment, and other nonstandard forms of employment. These changes have granted business enterprises greater flexibility. However, for the labor market, the changes have overall weakened key institutions: workers enjoy much less benefits as greater inequality and income insecurity grow. As policymakers, businesses, and labor institutions grapple with the changes, social protection systems remain relevant as ever.

The basic purpose of social protection systems is to ensure that the workers, especially

those who are at the forefront of dealing with the changes in the way we do business, are protected against the risks of facing unemployment and poverty. The main challenge is to figure out how to strengthen social protection systems in a global labor environment that is becoming increasingly nonstandard—how can governments, business, and policymakers protect workers wherever they are and in whatever industry they might be?

Contributory and noncontributory social protection systems are both important and must be combined. Contributory mechanisms help enhance social protection systems for those who have broader access to them. They are also evidently linked to an individual's ability to work and earn a certain level of income. On the other hand, noncontributory mechanisms help those who do not have access to social protection systems. A combination of the two mechanisms can help bridge gaps and address other inequalities, such as gender gaps, and, furthermore, prevents the weakening of the responsibilities employers have to their employees.

Social protection systems must be seen as a matter of right. They are a key element of the implicit social contract and of decent work, in achieving universal health care, in fighting poverty, and in containing inequality. They are linked to the continuity of work and to ensuring that economic gains are shared. The world faces the challenge of making them equitable, inclusive, and sustainable.

The demand for social protection systems will only increase. The social protection systems of the future must accommodate the challenges brought by the growing relevance of nonstandard employment and self-employment.

The social protection systems of the future will need to be based on a set of broad policy principles that can ensure universal and adequate coverage, and sufficient adaptability to new requirements. The following broad principles can help guide policymakers in strengthening social protection systems, including social protection floors:

1. universality of and accessibility to social protection systems;
2. adequacy of social protection systems in efficiently preventing poverty and providing equitable and sustainable means of protection;
3. transferability, so that the structures of a social protecting system support mobility within the global labor market;
4. transparency, to make sure that legal structures and administrative and other procedures are clear and comprehensible for everyone to be made aware of their rights and responsibilities;
5. gender equality, to make sure that the systems are sensitive to all the differences and sensitivities faced by both men and women in the labor market; and
6. good governance, to ensure that social protection systems are financed in a sustainable and equitable way, as well as efficient management and administration.

Some policy options

Recognizing the challenges faced by workers in nonstandard employment and by the self-employed when attempting to access social protection, countries have undertaken various measures to extend social protection.

The first set of policy measures include the adaptation of social protection systems, particularly by eliminating or lowering minimum thresholds regarding minimum earnings, working hours, or the duration of employment; making systems more flexible with regard to interrupted contribution periods; enhancing the portability of entitlements; and ensuring effective minimum benefit levels in order to improve the coverage of nonstandard and self-employed workers.

The second set of policies aims at guaranteeing a basic level of protection for everyone by complementing contributory with

noncontributory social protection elements so as to guarantee a social protection floor.

One critical policy option that is heavily under review is the implementation of a universal basic income (UBI).

Proponents argue that a UBI would guarantee a minimum standard of living for everyone irrespective of employment, age, and gender, and would give people the freedom and space to live the life they want. In addition, a UBI may contribute to alleviating poverty while reducing administrative complexity and cost of existing social protection systems.

On the other hand, opponents contend that UBI may not be economically, politically, nor socially feasible. Moreover, they contest that it will address the structural causes of poverty and inequality, and only serve to introduce disincentives to work. They argue that the benefit levels may be insufficient to withstand poverty. Other arguments point out that high costs of UBI might displace other areas of government spending including public services. They may also undermine labor market institutions such as collective bargaining. Despite these reservations, the UBI is already being explored, albeit limitedly, in various countries such as Finland and India.

The discussion regarding the feasibility of the UBI is rich and varied. There are many questions about coverage, benefit adequacy, affordability and financing modalities, as well as the benefits and services. The resurgence of the UBI debate reaffirms the necessity and importance of providing every member of society with at least the minimum level of income security essential to the realization of human dignity. The fundamental principles of the UBI are also the basic principles defined by the social protection floor in the ILO Recommendation 202.

While UBI may contribute to closing coverage gaps, its financial, economic, and political feasibility poses important challenges. However, many governments have already implemented universal benefit schemes for certain subgroups of the population, for example, universal old-age pension and child benefits. In countries where such schemes are implemented, they have been very effective. The combination of contributory and noncontributory schemes is essential in building a comprehensive social security system with a strong floor of social protection.

Financing social protection

When it comes to the question of financing social protection systems, observers note that a greater emphasis on tax financing will be necessary to meet the higher demands placed on the social protection system, due to possibly higher levels of unemployment and population ageing, combined with a possible erosion of the contribution base for social insurance. However, there is little agreement on a perfect method for achieving this. There are different methods, including taxing robots and other technologies or carbon emissions.

However, it remains unclear whether and how governments could enhance their capacity to tax the highly mobile owners of robots and capital, so as to mobilize the necessary resources for social protection in the context of a globalized economy and tax competitions. Others think governments should expand the fiscal space by taxing consumption or by rolling out more effective tax systems. Complementing public social protection systems, private provision may continue to play a certain role, but experience with privatization of pension schemes in the 80s and 90s, which did not deliver the expected results in terms of reducing fiscal cost, expanding coverage, and increasing efficiency, raises serious doubts about an expanded role of private provision. The role of the public sector remains most critical in ensuring adequate social protection for all in a fiscally, economically, and socially sustainable way, building on the principles of risk sharing, equity, and solidarity, thus strengthening the social contract.

In conclusion, ensuring universal social protection for the future of work requires closing

the coverage gap and adapting to new contexts related to new forms of employment and new needs, so as to realize the human right to social security. Many countries have undertaken various measures to extend social protection, but much more needs to be done. Existing social protection systems have shown remarkable capacity to adapt to new situations. New technologies can be harnessed to ensure that the systems can adapt to fast-paced changes and guarantee a basic level of protection for everyone. Still, a large part of the world remains out of coverage. While new changes are likely to affect the world of work in general, and national social protection systems in particular, it is without doubt that work will remain important for people's livelihood and personal well-being.

Although the UBI may partially address the possible disruption of jobs and the changing work and employment arrangements, there remains fundamental questions about the balance between personal freedoms and societal needs, the meaning of work in individuals' lives as well as the fair sharing of responsibilities between employers and workers concerning social security contributions. Even so, it is clear that current social protection systems need to be strengthened and adapted to adequately address the challenges in the world of work, based on the principles of risk pooling and equity so that social protection continues to deliver as an instrument of social justice and social cohesion.

The principles laid out above can guide the way for measures to adapt and strengthen social protection systems. Strong, nationally appropriate social protection floors are fundamental to promote more equitable and sustainable social protection systems. Fundamental to any reform is effective social dialogue, involving social partners and including voice and representation of those in nonstandard forms or employment and in the informal economy.

Presentation 2

FIRe and the Employment Challenge*

Emmanuel F. Esguerra | Professor, University of the Philippines – School of Economics

SUMMARY: Two labor market-related phenomena widely discussed in connection with digitalization are the substitution of computer-enabled processes for labor in some industries, and the growth of various nonstandard forms of employment in the so-called "gig economy". By way of contributing to the ongoing conversation about FIRe, this presentation looks at what the related literature has to say about the effect of technology on jobs and makes a number of observations in light of the current structure of Philippine employment. It also examines the gig economy in the broader context of contingent employment and discusses the implications on labor policy of heightened employment and income uncertainty.

The Fourth Industrial Revolution (FIRe) refers to the current wave of technological advancement characterized by the interconnection via digital networks of all processes of modern production and distribution (OECD 2018). It differs from the previous industrial revolutions in terms of the rapidity of its spread and its potential for accelerating economic development in emerging economies. Along with the promise of raising productivity, lowering costs, expanding opportunities, and improving the quality of goods and services, FIRe is also transforming existing patterns of production, consumption, work organization, and human interaction, at some risk—others say, great risk—to employment, incomes, personal security, and inclusivity.

FIRe in the workplace: Should we be afraid?

Two labor market-related phenomena widely discussed in connection with digitalization are the substitution of computer-enabled processes for labor in some industries, and the growth of various nonstandard forms of employment in the so-called "gig economy". Advances in technology that have made it possible for robots to perform more complex tasks previously done by humans have caused unease among many observers who are concerned that increasing automation could immiserize people with low skill levels and thereby worsen inequality.

At the same time, digitalization is celebrated for democratizing entrepreneurial opportunities.

* This paper is based on an earlier presentation during the economic forum on "Catching up with the Fourth Industrial Revolution" jointly held by the Ayala Corporation and the University of the Philippines School of Economics on September 6, 2018.

With the aid of online technology and applications, various services, such as transport, food and package delivery, cleaning, and shopping, among others, can now be contracted for on-demand. Work is performed outside of the usual employer-employee relationships, and in a string of one-off transactions, or "gigs". The flexibility in hours of work and the relative ease of entry are considered advantageous features for workers in search of new or additional earnings opportunities. However, such "alternative work arrangements" have also underscored the risk inherent in "just-in-time" employment and the inability of existing policy frameworks to deal with it.

The task approach to labor markets

The view that any given job that delivers a final output consists of several tasks provides a useful starting point for analyzing the effect of new technologies on jobs. Still relatively new in labor economics, this framework (Autor 2013; see also the citations therein) is more flexible than the standard one, which posits output as a function of capital and labor of varied skills, and seems better able to conceptually explain the evolving division of labor and changes in the structure of labor demand over time. An important feature of this alternative framework is the distinction between skills and tasks, which in the standard model are considered one and the same. In the task-based approach, where the fundamental unit of production is a task, skills are used to perform tasks that are then combined to generate output. Tasks can be performed by domestic labor, foreign labor (through offshoring), or capital depending on cost considerations and comparative advantage.

From this perspective, it is easy to see that technology can alter the nature of work by changing the way specific tasks are performed. Not all tasks can be performed by machines, however. Computers (or robots) substitute for humans in performing specific tasks, not entire jobs. The extent of the substitution depends upon the degree to which the cognitive processing of information, which is essentially a human activity, can be codified or translated to a logical, step-by-step procedure.

Where computers are incapable of replacing humans is in tasks dealing with unforeseen situations or problems where rules-based solutions are not readily available. Drawing up a five-year plan for a company in an uncertain business environment or designing a plan for disaster recovery are tasks that cannot be programmed, although computers can certainly complement human effort by making information available. Tasks where personal communication is essential in order to ensure that the information is not only conveyed but understood the way it is intended also cannot be routinized.

On this basis, tasks may be classified as either manual or cognitive, and routine or nonroutine. The tasks just described (in previous paragraph) are nonroutine and cognitive requiring a good deal of problem-solving capability, intuition, creativity, and persuasion. On the other hand, nonroutine and manual tasks require the ability to adapt to various situations and engage in personal interactions. These tasks are associated with jobs involving personal services. Their performance does not require very high skills.

Finally, routine and cognitive and routine and manual tasks that follow exact and straightforward, repetitive procedures often performed in a stable environment are subject to automation, the latter much more than the former.

Computerization of routine job tasks leads to the simultaneous growth of high-education, high-paying jobs on the one hand, and low-education, low-paying jobs on the other hand as the middle-education, middle-paying jobs are gradually taken over by computers or robots. This is a phenomenon called "job polarization" and is confirmed by a large body of US and international evidence at the level of industries, localities, and national labor markets.

Job polarization need not imply wage polarization, however. Information technology and computerization raises the productivity of workers performing nonroutine, cognitive tasks and, through scale and price effects, their wages, too. This is not the case with workers performing jobs intensive in nonroutine, manual tasks that seldom rely on information or data processing.

The problem posed by "polarization" is not unemployment, but that many workers are not immediately able to qualify for the good jobs. In this sense, technology can worsen inequality.

Turning to the Philippines, we ask: how is this process likely to play out? Consider the current structure of employment: Low-skill occupations already account for three-fourths of total employment. The high-skill occupations account for 5 percent, and the midde-skill occupations account for nearly 3 percent. In terms of our two-way classification of jobs, the high-skill occupations are intensive in nonroutine, cognitive tasks, while low-skill occupations are intensive in nonroutine, manual tasks. Most of the low-skill and middle-skill occupations (46%) are intensive in routine manual or cognitive tasks and in varying degrees are vulnerable to automation.

Without further upskilling, those displaced by automation could further add to the numbers in the low-skill nonroutine, manual occupations and depress wages for those skill types. New openings will, of course, be created for tasks requiring abstract thinking and situational response, or specialized expertise, but filling up those positions will depend on the speed of the supply response. If nothing else happens, inequality could worsen.

The "gig" economy

The gig economy describes a labor market environment in which jobs are short-term in nature, workers are predominantly independent contractors, and no employer-employee relationship exists between the transacting parties. A recent newspaper article citing a report on Filipino freelancers notes that the Philippines' gig economy is expected to grow in the coming years due to better Internet-based tools and platforms that connect them to clients in various parts of the world. The freedom to work from any location, flexibility in hours of work, exclusive command over one's own output, and a higher income undoubtedly all contribute to the attraction of the gig economy, especially for the young and tech savvy.

Unfortunately, no estimate exists on the size of the gig economy in the Philippines. The quarterly Labor Force Survey tracks workers who are employed on a short-term basis or who work for different employers but these categories are inadequate for identifying the really independent workers who select jobs according to their interest and not because of need. Available data do not allow distinguishing the freelancers from workers who are employed as "contingent" employees.

At any rate, the gig economy has called attention to the risks inherent in nonstandard employment arrangements. In the US and Europe, it has triggered a reassessment of policies relating to employment rights, social protection, and pensions. It has challenged current understanding of the terms "employer" and "employee", a problem that did not arise when jobs were well-defined and long-term, and workers' bargaining units under existing law were relatively clear and firmly in place.

These issues are not new. They are essentially the same issues that are raised in connection with employers' practice of employing workers on a nonregular basis (i.e., as contractuals, casuals, or temporary), whether hired directly or through an employment agency. As in the gig economy, these contractual arrangements are generally of a short-term nature and do not grant the worker the nonwage benefits usually included in regular employment contracts. As these contracts conflict with established notions of the employment relationship (widely interpreted as job security), they are resisted by organized labor.

Concluding remarks

Some scholars have opined that globalization and the rise of the new information technology have changed the nature of the employment relationship, making the relationships of production more complicated, and forcing a re-think of policies and laws relating to labor standards, employment rights, income smoothing, and pensions.

In the current context of globalization, technological change, and the ensuing process of job destruction and creation, the risk facing both firms and workers has increased. Firms are resorting to various cost-reducing technologies or alternative contractual arrangements that provide greater elbow room to stay competitive. Regulation should not curtail that flexibility, but fairness and equity require that labor not be made to bear all the risk. Strengthening social protection systems should be an integral part of harnessing FIRe for broad-based growth and prosperity.

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Presentation 3

The Social Implications of FIRe in the Asia-Pacific Region

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SUMMARY: The paper discusses the development of the Fourth Industrial Revolution (FIRe) and the importance of automation and artificial intelligence for the future of employment and jobs. Although technological change has been happening for centuries, there are some unique aspects in the present changes and the surrounding circumstances, such as speed, uncertainty, and globalization. The paper highlights the measurement issues that are currently debated in the literature, then goes on to present the tradeoff between the positive impact of productivity increases and the negative impact of lost jobs and unemployment and discusses how this depends on the stage of economic development a country is in.

Mobility of capital, labor, and goods as a result of technological change in a diverse international environment is discussed. The potential of education and training in reducing the level of displacement is examined and the concept of a basic universal income is introduced, as a means of ameliorating the negative impacts of displacement on those who do not manage to find a new job. The diversity of the Asia-Pacific region is introduced, and the concepts presented are brought together to inform our expectations for future economic and social policy trends in the region.

In terms of the social implications of FIRe in the Asia-Pacific region, the numbers are changing very rapidly, faster than policymakers, governments, and society can keep up with. The speed is unprecedented, and the uncertainty this has created is like never before. This presentation discusses the kind of policies that are likely to help the world deal with such changes.

The world has experienced industrial revolutions before. But the speed with which industries are changing today, and the anticipated displacement of workers, is unprecedented. The key to such rapid change is the sharp drop in the price of information. Cheaper information has facilitated and hastened the liberalization and globalization of the world economy. This phenomenon has resulted in enormous unbundling of the production processes across space through global value chains.

The impact on firms, works, and jobs was discussed in the previous contributions made in the conference, so I will focus on the human dimension of these changes, which eventually leads to the core question—what kind of world

can we expect if work will no longer be the core of human life?

There are different types of technology and different types of work interacting with each other amid the global changes. *Enabling technologies* help humans work—they make them more productive and benefit both workers and firms. They have been the major driving force behind much of the wealth creation we are experiencing in today's world. *Replacing technologies* do away with human work. They destroy jobs and create negative outcomes for some and a broad range of positive outcomes for others, deepening inequality. They can reduce wages, labor demand, and overall employment, and will almost always displace a group of workers.

Do technologies reduce employment or wages?

Technologies can result in a displacement effect, meaning more workers are chasing fewer jobs, which puts wages under downward pressure. But they can also result in a productivity effect, where workers produce more for less, and firms are richer, and this creates new demand for new and old goods. In this scenario where total factor productivity increases, the added demand applies an upward pressure on wages.

Where the *displacement effect* is greater than the *productivity effect*, wages are less likely to increase. The battle between the two effects determines the net outcome of technologies.

Historically, net effects have been positive, supporting world economic development and increasing world employment. But more recent evidence has been revealing instances of stagnating wages, especially where the unbundling of production processes has facilitated shifting work overseas, leaving behind waves of domestic social and political problems, with wider global ramifications.

It is important to develop new research capacity to enable us to distinguish between the technologies that will yield principally displacement effects from those that will yield principally productivity effects. "Bad" technologies are the ones that destroy old jobs but do not generate productivity effects and new good jobs. Technologies that bring modest productivity gains, at a level that can marginally "justify" the displacement to the production process owner, are the worst ones from society's point of view. Bad technologies can also be the ones that not only destroy some jobs, but also leave displaced workers with no new skills that can help transfer them to another type of production.

In predicting the numbers, it is hard to measure and harder to predict how many jobs will be lost to FIRe. The degree to which job losses will also result in employment losses, and how these can be best measured, is the subject of a current debate among economists. This is so because if we decompose jobs into their constituent tasks, we find in many cases that some tasks can be automated and some cannot, hence, the argument goes, while there may be X jobs lost, if half of their tasks cannot be automated, then that half will need to be re-packaged into X/2 new jobs.

Answering how many new jobs technology will create is even harder. The speed at which technology develops and the uncertainty, surrounding not only the direction of new technology but also the outcomes, makes it very hard to predict. A second order (but not of secondary significance) problem is that the uncertainty is coupled with institutional inability to react at any speed to the ethical problems that technology introduces regarding its negative impacts on work as a core activity and of value in our society. So it is not only that we do not know how the problem will quantify, but we also do not know how we will be able to respond to it as its impact continues to build.

It is critical that analysts and policymakers look at the background factors that will influence the relationship between technology and work—for example, the level of national economic development, trade and investment

relations, and the education-training-skill levels and migration trends.

Looking at the big picture, there are large rewards from technological change and even larger future promise, through globalization and free trade. However, negative consequences are emerging and resistance is building both nationally and internationally. One of the reasons is that although the rewards and their potential are huge, the way these gains may be distributed is not settled, thus creating a counterproductive social, economic, and political climate around technological development. It is fair to say that no widely agreed mechanism exists to resolve the tensions just yet. However, a debate is emerging about displacement and the way it drives some of the potentially worst social consequences. Potential remedies to the negative impacts of displacement include: (1) education, (re)training, and upskilling; (2) social protection including social care and protected income; (3) institutional reform, including labor markets and foreign investment; and (4) the ethical dimension of the inequalities that technology creates and the options for corrective policies.

Threats to growth

In the context of the Asia-Pacific region, the main threats to growth are: (1) protectionism and trade wars, (2) the possibility of China slowing down, (3) general slowdown in world trade, and (4) lack of political leadership. In the midst of this geopolitical uncertainty comes a projected net displacement of workforces by 2030 by economic development cluster—displacement of around 10–20 percent in lower-development economies such as India and the Philippines; 15–30 percent in middle-development economies such as China; and 30–50 percent in high-development economies such as the United States, Japan, Australia, and Singapore. The sectors in decline include manufacturing, wholesale, clerical, hiring vehicles, transport, and storage. Jobs are expected to grow in several industries, but principally in information and communications technology (ICT), science and technology, education, health and social work, arts, and entertainment industries.

The region expects substantial change in the prevalent occupations, type of work, and skills in shortage or surplus in the next decade driven by technology-led displacement and job growth happening simultaneously. Occupations in shortage will be in the industries of science, ICT, health, and care, while the list of surplus occupations is as wide as it is deep. There will be shortages in skills like complex problem solving, critical thinking, cognitive flexibility, judgment, and decision. Future proofing an economy's workforce requires helping new and retraining workforces to develop deeply complex skills.

In conclusion, technological change is happening at speed and in depth. Presently, we are focused too much on its present wealth-generating capacity, at the expense of our preparedness to handle its future negative consequences. We need to pay more attention and provide more funding toward innovative solutions for the social and economic problems our present priorities help store up.

Education will be a major key, but there will be limitations as old-fashioned education is too slow to react to change and is promoting skills that may not be as important in the decades to come. Countries must strive for education that can be readily translated into the occupations of the future. More emphasis must be placed on the earlier stages of education where the most transferable skills are developed. Secondary school education must work as a flexible bridge between a pure learning experience and a preparation for gaining labor market-specific education and training. Finally, the way we deliver post-school education must become more flexible and more able to facilitate retraining, upskilling, and lifelong learning than today's rather rigid post-school education delivery models.

Open Forum

QUESTION 1

Vicente Paqueo (PIDS): This question is addressed to the three men. The 2018 OECD report/outlook for labor markets and employment analyzed a phenomenon, which appears to have common patterns in advanced countries, where you will find that economies are growing fast but employment is low, and wages per activity are rising. Part of the explanation is the rise of super corporations. Basically, you see the expansion of corporations. What do you think of this interpretation, that the rise of these super corporations is due to technological innovations because they have the resources to take advantage of innovations compared to small and medium enterprises? Is this the cause of wage stagnation and what does the evidence tell us? And if this is the trend, is there a remedy? How can we avoid the negative consequences? What are the costs and what are the opportunities?

Markus Ruck: Thank you for the question. It is something that occupies a lot of people especially at the ILO. Observation: if you look at the share of wages and capital, it is historically, especially in the recent past, very much skewed toward capital. The wage share is going down. Why is this so? You refer to the OECD report. Corporations have monopoly power in certain ways. They have the wherewithal to come up with innovations very fast, and gain huge profits; nothing curtails them. There are new barriers to entry of fledgling companies that may want to copy what these super corps are doing—so we should examine competition laws. I think that may explain the phenomenon.

But there are other explanations. There is less labor protection in the wake of globalization, more and more outsourcing, casualization, which is less covered by social security.

We can see that it already has serious political ramification. Many are frustrated by the outcome of this globalization; they don't benefit from the rise in the GDP; they don't take their share—there is unequal distribution of income. Organized labor has weakened collective bargaining mechanisms, weakened collective agreements; they are not as strong as they used to be. Trade unions cannot bargain in the same way they used to for wages and other labor protection measures.

Is it inevitable and what can be done?

It's not inevitable. It calls for a regulatory framework to provide good distribution of the fruits of economic development—equal redistribution of the wealth created, more equitable distribution of capital and wages. We have international labor standards that have been agreed upon by the international community. Countries are called upon to translate these into national laws and adhere to internationals standards. But we see that there is backlash; there is a mistrust toward the establishment, the political system, the policymakers; they have to respond to that if they want to reduce societal unrest. It's a matter of great concern worldwide.

Kostas Mavromaras: I think what we have here is that technology has been allowing capital to move where it wants to move. The production process has been totally unbundled. Capital is totally moveable. Technology is moving, too. Labor isn't as mobile. Labor is stuck where it is. What we are observing is we are moving away from manufacturing and moving to services—which is not a bad thing. It's a form of specialization in a way. But the bad part is the inequality that comes with it. Some countries have to do with much less than places with higher standards of living. But there are other countries that take advantage of it. They can benefit—these countries are looking more optimistically at the advantages. The picture is far more nuanced than saying something is very bad or very good. The main principle is the unbundling of the production process and the price of information.

Emmanuel Esguerra: Just very briefly, mainly to complement what has been discussed, I think globalization is an important explanation along with technological change; the usual lag between these two forces and the adjustments in labor market institutions leave many workers without a safety net. There is also the lag associated with the investment in skills as it takes a while before skills are developed and allowed to catch up. As a result, you have a narrowing of economic opportunities for people who want to work.

SESSION D

HUMAN CAPITAL DEVELOPMENT

SESSION OPENER

Jose Camacho Jr. | Dean of the Graduate School, University of the Philippines – Los Baños

In this session, we will discuss the importance of solid basic general education competencies, specific skills development, lifelong learning, and career reinvention that are critical to preparing the workforce for the currently evolving jobs as well as the jobs of the future. The session hopes to answer the following questions: What percentage of GDP should the Philippines be investing in human capital development and in what specific areas of science and technology to be able to deal with the challenges of FIRe and take full advantage of the opportunities that come with it? What critical policy decisions and strategic actions should the country be taking today to get the current and future workforce ready for FIRe? What reforms in the education and training systems need to be undertaken to promote flexibility and responsiveness to rapidly changing production and work engagements initiated by rapid technological changes? How can schools be encouraged to move from rote and recipe-type learning toward developing students' and workers' ability to work creatively with AI-enabled machines and production process? What can (and should) be done to ensure that Filipino workers and their young who are now lagging in human capital development are able to catch up and move ahead amid labor market challenges and opportunities? What lessons can be learned by the Philippines and other developing countries from those ahead in human capital development for future skills?

Presentation 1

Fourth Industrial Revolution: New Paradigm for Education and Training

Michael Fung | Director of Training Partners Group, and Chief Human Resource and Chief Data Officer, SkillsFuture, Singapore

Fiona Lim Shi Hui | Manager of Enterprise Engagement Office, SkillsFuture, Singapore

SUMMARY:

The Fourth Industrial Revolution is ushering in an era of rapid adoption of digitalization by industrial sectors across the entire economy. The underlying drivers are fueling dynamic changes in the nature of jobs, and the pace of skills obsolescence. The conventional paradigm of education is under heavy challenge, as the gap between the skills of graduates and the needs of industry is widening. These developments call for a new paradigm across the education and training landscape. We need to shift toward a model that is more agile and adaptive, to ensure that the workforce remains employable, and that the economy has the necessary skilled talent to continue to grow. The SkillsFuture movement in Singapore is provided as a case study on how a nation is evolving toward a paradigm of lifelong learning, to respond to the opportunities and challenges brought about by the Fourth Industrial Revolution and the dynamic changes in the local and global economic landscape.

The Fourth Industrial Revolution

The Fourth Industrial Revolution could involve "a revolution more comprehensive and all-encompassing than anything we have ever seen" (WEF 2016). The evidence of change brought by the fourth revolution is all around us and is evolving at an exponential speed. The first three revolutions were catalyzed by new types of energy, i.e., steam engine, electricity, gas and oil, and nuclear energy, and technological advancements from analogue electronic and mechanical devices to digital technology, enabling the rise of new manufacturing processes, mass production, and automation. The fourth revolution however, is rooted on a virtualized phenomenon—digitalization—which blends the real world with the digital world into what has been termed as cyber-physical systems. What makes the fourth revolution distinct from the past revolutions is the impact of technologies across all disciplines, economies, and industries (WEF 2016).

The impact of the fourth revolution on the economy, jobs, and skills is significant. According to McKinsey Global Institute (2018), automation will impact almost all occupations, and about half of all work activities today can potentially be automated. This will lead to job declines in some areas, job growth in other areas, and changes to many job roles, as machines complement human capabilities at workplaces. High-skill occupations

are projected to grow strongly, while middle-skill occupations are projected to stagnate or decline, due to advances in automation and offshoring of business activities (Cedefop 2018). As middle-skill jobs hollow out, there will be a shrinking segue between low-skill jobs and high-skill jobs in many economies, and workers in these economies will find it increasingly difficult to move up from low-skill to high-skill jobs.

Given the rapid and extensive transformation ahead of us, the traditional linear model of education to employment will be inadequate to meet industry needs. The transformation of occupations and jobs by automation and artificial intelligence will result in a drastic change in the required skills for workers across many industry sectors. Skills obsolescence and shifts will occur at an accelerated pace as compared to past historical trends, due to the impact of digitalization and automation (Bughin et al. 2018). The effects are already evident today. In a survey of more than 39,000 employers in 43 countries and territories, ManpowerGroup (2018) found that global talent and skills shortages have reached a 12-year high, with 45 percent of small organizations and 67 percent of large organizations reporting talent shortages in 2018.

Impact on the industry and workforce

Many industries are seeing the introduction of new technologies that create entirely new ways of serving customer needs, with significant disruption to existing business value chains. The educational requirements for new growth occupations would generally be higher than those for jobs displaced by automation in the past. Workers of the future will spend more time on higher value-added activities that machines are less capable of, and less time on predictable physical activities. This requires a substantial shift in skills and capabilities among the workforce. McKinsey Global Institute (2017) reported that by 2030, as many as 375 million people, or 14 percent of global workforce, may need to switch occupational categories. With fast-changing economic demands, businesses have a growing need for better qualified workforce. Correspondingly, employees have to possess higher levels of competencies and continuously adapt and develop their skills to maintain relevance in the workplace. Hence, there is a need to prepare the workforce for different jobs that require different skill sets. In Singapore where there is an aging population and a shrinking workforce (DOS 2017), there is an even sharper need for individuals to remain employable for a longer economically-active period of their lives.

Apart from the impact on jobs, the accelerated changes have also caused the shelf life of relevant and useful knowledge to diminish rapidly. By 2020, more than one-third of the desired skill sets of most jobs will be comprised of skills not yet considered crucial today (WEF 2016). It is anticipated that the shelf life of skills will decrease to five years in the future of work. Individuals embarking on a 30-year career are expected to have to update and refresh their skills six times throughout their careers (Deloitte 2017).

With digitalization, we are witnessing a growing trend indicating that employability will depend more heavily on lifelong learning and skills development, and less on qualifications and degrees (ManpowerGroup 2018). Traditional pedagogical methods for teaching students are not as effective for teaching adults, as adult education requires customization of curriculum and delivery formats. In particular, adult learners should be involved in planning and evaluating instructional delivery, and training has to be experiential and problem-focused, and has direct applicability (Knowles et al. 2012).

Implications on education and training systems

To respond effectively to these new developments, education and training systems should shift toward a continual learning system for the workforce (Bughin et al. 2018). Such a shift would require broad-based and diverse range of continuing education and training (CET) opportunities and pathways, including tertiary-level workforce training, to equip individuals with advanced and up-to-date technical

knowledge to meet job requirements (Cedefop 2018). This means that job retraining and enabling individuals to learn marketable new skills throughout their lifetime will become increasingly important. Creating programs that quickly retool the labor force by focusing on retraining and credentialing at the level of skills in demand will be increasingly critical, in comparison with long-form academic qualifications. Education has to become more modular and continual in delivery mode, to meet the dynamic needs of individuals and companies (WEF 2017). A dynamic and responsive training ecosystem will enhance employability and employment, leading to greater job fulfilment, social cohesion, and equity.

We must rethink our education and training system to help the workforce refresh their skills more rapidly, to understand and change the culture of learning, and to establish learning as a continuous and lifelong process. As technology evolves and skills that are in high demand shift, there is a need for a continuous feedback loop between labor market needs and education system stakeholders for effective skills forecasting. We will also need to rethink our current education systems to include broad-based curricula with exposure to the workplace through, for example, internships, mentoring, access to employers' network, and site visits. This will contribute to the work readiness of young people, helping them to envision a variety of career pathways and equipping them with the relevant competencies (WEF 2017). Additionally, a culture of lifelong learning has to be infused from an early stage within educational systems with emphasis on personal ownership over learning, supported by active labor market policies to build and sustain motivation for adult learning through the working lives of individuals.

Rethinking Singapore's education and training system

Starting in our nation-building years, Singapore has looked to education as a key instrument of economic growth, focusing on quality and access to basic education to develop a skilled and productive workforce to drive economic progress. This approach stemmed from our historical and economic circumstances, with no natural resources and dependence on human capital to be economically competitive. Today, Singapore has an internationally well-regarded education system, illustrated by strong performance in international benchmarking exercises. For example, Singapore topped the Programme for International Student Assessment (PISA) 2015 rankings in all subjects (PISA 2015). Based on the Survey of Adult Skills (PIAAC) of the Organisation for Economic Co-operation and Development (OECD), young adults in Singapore had the highest average score in numeracy among participating countries, and scored above the OECD average in literacy (OECD 2016). Adults in Singapore also performed above the OECD average in problem solving. In general, the Singapore workforce has a relatively sound foundation in basic skills.

However with the pace of change in the global economy and rate of skills churn, education and training systems need to evolve, and the economic growth strategy can no longer focus solely on frontloading on education and training to be able to remain competitive. While we continue to ensure that our formal education system is of high quality and is accessible to individuals in Singapore, we must rebalance our strategies and invest in a longer-term vision where the education and training system supports continual learning throughout life. We have identified four shifts in Singapore's education and training system for it to remain relevant in the future of work.

Rebalancing academic and vocational pathways

Academic pathways are popularly favored over vocational pathways by students and parents in many countries, and are typically regarded as more established routes to career success. In East Asian countries, including Singapore, this is often exacerbated by a Confucian tradition

that values scholastic achievements over vocational skills. Globally, there has been a sharp increase in the proportion of individuals with tertiary education who are now entering the workforce. In 1998, about 23 percent of those aged between 25 and 34 years old attained a tertiary education, and this proportion has nearly doubled in 2016 to 42 percent (OECD 2017). At the same time, unemployment rates for tertiary-educated individuals hovered below 8 percent, reflecting corresponding growth in employment opportunities for tertiary-educated graduates. Yet, overall unemployment rate has steadily increased in many countries, reflecting a potential mismatch between demand and supply in the overall employment market. Policymakers are also increasingly concerned with graduate underemployment. In encouraging educational attainment, we must look for ways to develop a workforce with a good spread of tertiary-educated individuals across both academic and vocational pathways, to meet our economic needs and to minimize structural unemployment and underemployment.

In Singapore, we have built up a strong vocational track through the Institute of Technical Education (ITE) and five polytechnics, which take in about two-thirds of each student cohort. These institutions focus on technical and vocational skills to prepare students for entry into the workforce after graduation. At the university level, we have diversified the landscape with the establishment of two applied universities—the Singapore Institute of Technology and the Singapore University of Social Sciences. These developments have significantly expanded higher education pathways for graduates from the polytechnics and the ITE. To ensure strong industry orientation across publicly funded tertiary institutions in Singapore, employment outcomes of graduates are measured and published by the Ministry of Education (MOE) annually.

Rebalancing learning in school and learning at workplaces

Education models in most countries, including Singapore, are still predominantly classroom-centric and institution-centric. However, there is growing recognition of the limits to the extent that we can simulate real workplace environment to impart the right skills to learners (Cahill 2016). In addition, the extent and pace of industry transformation has made it increasingly challenging for education institutions to stay fully up-to-date in their curriculum with the latest in industry developments. We are building upon the strong institution-based system in Singapore to strengthen workplace-based learning, through interventions such as enhanced internships and the SkillsFuture Earn and Learn Programme. Our universities have also launched work-study degree programs, which are structured as co-operative education and contextualized for participating companies. Delivering quality workplace learning hinges on the ability to seamlessly support and coordinate the learning experiences for each learner between the educational institution and workplace settings.

Employers play a critical role in coordinating workplace learning. Those who are not accustomed to delivering structured training at their workplaces must come to see value in doing so, and be convinced that a 'plug and play' approach toward talent acquisition is not sustainable. This is particularly true for emerging skills, such as machine learning and cyber security, which are in short supply globally. In such areas, even companies with vast resources face challenges with acquiring talent in sufficient numbers and quality to meet their business needs. Shifting toward an 'invest and build' strategy toward talent therefore makes good business sense. Employers will have to build up their workplace training capabilities over time, in order to keep their employees resilient, adaptable and highly-skilled. In this regard, small and medium enterprises (SMEs) face greater barriers, due to relatively lower economies of scale to invest in training, and less developed human resources and learning and development capabilities to support workplace learning. We must find ways to better support SMEs, as they employ the bulk of the workforce in many countries.

Rebalancing front-loaded learning and learning throughout life

Relying solely on an education and training strategy that concentrates learning in the first two decades of an individual's life is no longer viable in a rapidly changing world. Traditional, front-loaded education and training systems cannot fully prepare young adults for the jobs and skills required for the future (WEF 2017). We must shift toward equipping individuals with critical foundational skills on how to learn, so that they can continually learn, unlearn, and relearn, and remain adaptable throughout their lives. We must aim for individuals to be self-directed learners who take personal responsibility to develop and deepen their skills.

At the same time, the role of education and training institutions will have to evolve—beyond providing the initial training, to supporting individuals in their lifelong quest for skills mastery. Publicly funded education and training institutions that have traditionally focused on pre-employment learning will need to evolve and play a larger role in continuing professional development. A vibrant adult education and training sector is required to enable continual upskilling and reskilling, and to support the transformation that is happening across many industries. Individuals must also attune themselves to industry developments and needs, while employers must play their part to support and value continuous learning.

Rebalancing technical skills and transversal skills

While educational institutions have traditionally emphasized technical skills, transversal or soft skills have becoming increasingly important in a fast-changing and complex world. Employers increasingly favor individuals who can communicate effectively, work in cross-cultural teams, collaborate extensively, and demonstrate strong leadership qualities. These skills are particularly difficult to impart in traditional classroom settings. Hence, there is scope for employers to work closely with training institutions, to develop customized training programs for the workplace. This will enable in-employment workers to have the necessary technical and transversal skills to be more effective at work.

for working adults will need to adopt a holistic approach, by deepening both technical and soft skills. A set of skills frameworks have been developed to cover all major economic sectors in Singapore, providing information on job roles, career pathways, and the skills needed to progress in each key sector. Within these frameworks, both the occupational or technical and the generic or cross-cutting skills needed for each job role have been identified. The skills frameworks serve as guides for curriculum design, training and career roadmap, and talent recruitment, among other uses. This signals to individuals that working toward a promotion or a new job may not simply be about getting better at what they do, but also about picking up new skills such as collaboration and leadership. It also signals to employers that these areas must be addressed when developing their workforce, and for training providers to cater to such needs.

SkillsFuture Singapore and Workforce Singapore

The Singapore government established the Workforce Development Agency (WDA) in 2003 to promote lifelong learning and to enhance Singapore's workforce resilience and competitiveness. Part of this effort entailed accelerating the shift from an employer-centric skills adult training system to one that placed greater focus on the individual. For instance, WDA worked with private training providers to set up CET Centres that offered subsidized quality training directly to individuals. The WDA was restructured into two entities in 2016—SkillsFuture Singapore (SSG) and Workforce Singapore (WSG)—to sharpen focus for the effective implementation of two ke national priorities: the SkillsFuture

movement and the need to ensure competitiveness and quality jobs for Singaporeans.

WSG's mission is to meet the need for ensuring competitiveness and quality jobs for Singaporeans. Reporting to the Ministry of Manpower, WSG oversees the transformation of the local workforce and industry to meet ongoing economic challenges. It promotes the development, competitiveness, inclusiveness, and employability of all levels of the workforce. While its key focus is to help workers meet their career aspirations and secure quality jobs at different stages of life, it also addresses the needs of business owners and companies by providing support to enable manpower-lean enterprises to remain competitive.

As a statutory board under the MOE, SSG's mission is to take the SkillsFuture movement forward by developing an integrated, high-quality, and responsive education and training system, strengthening a culture of lifelong learning and pursuit of skills mastery, and fostering employer recognition and ownership of skills. Its mandate includes the training of adult educators, supporting quality adult education centers and private education institutions, facilitating access to high-quality, industry-relevant training throughout life, and creating synergies between pre-employment training and CET.

The SkillsFuture movement

In 2015, Singapore launched the SkillsFuture movement, a national skills strategy, which seeks to help build the foundations for a highly skilled, productive, and innovative economy. The Singapore workforce development system is designed around a number of principles, and the WEF (2017) report captures several similar concepts: (i) modular and blended delivery of training, to cater to different needs of adult learners; (ii) emphasising on-the-job formal and informal learning; and (iii) inclusive offerings to cater to different segments of people across educational and literacy levels and ages.

Besides serving an economic objective, SkillsFuture seeks to help individuals realize their full potential, regardless of their starting points. Through an integrated and high-quality system of education and training that we have built up through the years, individuals are empowered to take charge of and steer their education and training, and consequently be able to pursue careers based on their passion and interests. Our goal is to nurture a workforce that is adaptable and nimble, equipped to respond quickly to increasingly dynamic changes in the world of work. The various SkillsFuture initiatives are targeted at three groups of stakeholders, namely, individuals, employers, and education and training institutions.

Individuals

Starting in the schooling years, SkillsFuture facilitates young Singaporeans in discovering and pursuing their passions and interests. A structured and comprehensive Education and Career Guidance system has been introduced to all schools to advise students, to help them make informed education and career choices. Through the MySkillsFuture portal, students (as well as all Singaporeans) are enabled to construct their personal profiles, access industry and labor market information, explore education and training opportunities, and search for job openings across various industries. Enhanced internships and work-learn programs allow students to learn through meaningful work assignments and industry exposure and ensure tighter coherence between education and work. In addition, the Young Talent Programme offers overseas internships and work-study attachments to prepare students for international assignments in their careers.

Beyond the schooling years, SkillsFuture ensures that learning continues to remain accessible, and support the career development aspirations of individuals. The SkillsFuture Earn and Learn Programme, which is modelled upon an apprenticeship system, gives fresh school leavers from the vocational/technical tracks a head start

in their careers, by placing them in salaried jobs while undergoing structured on-the-job training that lead to industry-recognized certifications. All Singaporeans (aged 25 and above) are given a SkillsFuture Credit account with an initial credit of SGD 500, which can be used for over 24,000 skills-related courses. Singaporeans in the workforce who wish to deepen their skills can apply for SkillsFuture Study Awards or SkillsFuture Fellowships, which provide monetary awards to defray their out-of-pocket training expenses.

Employers

Companies and industry players (including trade associations and professional bodies) help identify skills gaps and shape the development of the SkillsFuture initiatives. At the industry level, employers participate in the development of industry transformation maps, which bring together holistic strategies for productivity improvement, skills development, innovation, and internationalization. Employers are also actively engaged in the development of skills frameworks, which provide key information on their respective industry sectors, including employment and career pathways, corresponding skills required for the occupations and job roles, and relevant training programs for skills upgrading.

Employers also play a key role in employee training and recognizing skills-based career progression. Government course fee subsidies are provided whenever employees are sent for training, with SMEs receiving higher subsidies. Programs such as the SkillsFuture Leadership Development Initiative aim to develop the next generation of business leaders through sector-specific leadership development interventions, while the SkillsFuture SME Mentors initiative builds up a pool of mentors with industry-relevant skills who can help SMEs enhance their learning and development systems. Exemplary and progressive employers that champion skills development are recognized through the pinnacle SkillsFuture Employer Awards.

SMEs that require assistance to build up their work-learn capabilities and workplace learning systems can leverage on the National Centre of Excellence for Workplace Learning, a collaboration with the Swiss Federal Institute for Vocational Education and Training and the German Chamber of Industry and Commerce. It provides expertise to equip companies with the capability to train and develop their workers and develop in-house training systems.

Education and training institutions

SkillsFuture supports educational and training institutions in their transformation of course delivery to support flexible and accessible learning. We have built up a strong pool of private training providers including and publicly funded CET centers to support upskilling and industry transformation. The CET centers offer a comprehensive array of courses covering a wide range of industries and additional services, such as employment advisory and placement. The institutes of higher learning are significantly expanding their offerings of bite-sized and industry relevant training programs that can be easily accessed by working adults, in particular for emerging skills. Additionally, there are capability development grants and technological support under the iNnovative Learning 2020 (or iN.LEARN 2020) initiative to support institutions for curricular and pedagogical innovation that facilitate learning beyond classrooms. We are also raising the competency and professionalization of adult trainers through the Training and Adult Education Sector Transformation Plan.

Conclusion

With the accelerating pace of change, education and training systems need to be more flexible and agile, offering different modes of training delivery to fit the needs of different segments of learners in a timely and relevant manner. Learning needs to evolve from a linear model to a lifelong learning

model. The SkillsFuture Movement represents a major effort by the Singapore government to shift the education and training system to overcome the shortening shelf life of skills in the Fourth Industrial Revolution. However, a truly effective lifelong learning system cannot be delivered by the public sector alone, nor is it the sole responsibility of industry or individuals. The industrial sector and training providers need to collaborate more closely to develop timely and industry relevant training interventions. Employers need to actively support the continual upskilling and reskilling of their workers. Individuals have to embrace a mindset of lifelong learning to stay employable and resilient. Everyone has a role to play in building up a responsive and effective skills ecosystem.

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Presentation 2

More than Schooling: Returns to a Broader Set of Skills in Labor Markets[1]

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SUMMARY: This paper uses measures of cognitive and noncognitive (socioemotional) skills in an expanded definition of human capital to examine how schooling and skills are rewarded in the labor markets in nine middle-income countries and how skill differences relate to the gender gap in earnings. While years of schooling still explain more of the variation in earnings, cognitive and noncognitive skills determine earnings as well. The earnings of both men and women benefit from noncognitive skills such as openness to new experiences and risk-taking behavior, but schooling and cognitive skills appear more important for women's earnings at the lower and middle end of the earnings distribution.

Increasingly globalized markets and economies and profound technological shifts are placing enormous pressure on the skills that people are able to bring to the workplace. Over the coming decades, half of the jobs performed today will disappear and become obsolete, to be replaced by new ones as yet unimagined (International Commission on Financing Global Education Opportunity 2016).Where schooling and life experiences fail to build new skills and engender innovation, flexibility, and adaptation in the workforce, the result would be higher unemployment, slower growth, and more inequality.

Much of the literature on estimating the determinants of earnings and, in particular, the returns to human capital, focuses on the contribution of work experience (as measured by age) and educational attainment (as measured by years of schooling). In this study, my coauthors and I have unbundled the human capital variable further using assessments of skills that are typically not available for a large sample of adults in developing and transition countries—cognitive skills (literacy proficiency) and a number of noncognitive or socioemotional skills. Our analysis of the data on adults from comparable surveys in middle-income countries reveals that skills, controlling for years of schooling, are significantly related to wage rates, and that the earnings of men and women differ with respect to both how much education they have completed as well as how much cognitive and noncognitive skills they possess.

Our study uses a survey database on nine middle-income countries collected over the period 2012–13 under the Skills toward Employment and Productivity (STEP) program of the World Bank.

[1] Based on a working paper by Gunewardena et al. (2018)

The surveys collected details on skill acquisition (i.e., early childhood education, schooling attainment, training, and apprenticeships), measures of skills (cognitive, noncognitive, and other job-relevant skills), labor force participation and occupation, family background, and socioeconomic status. One adult aged 15–64 years was randomly selected from about 3,000 randomly selected households, but we restrict our analysis to the subsample of adults aged 25–54. With a few exceptions, the same household survey instruments were administered in all countries and the data have been harmonized.

The nine countries in our sample (Armenia, Bolivia, Colombia, Georgia, Ghana, Kenya, Serbia, Ukraine and Viet Nam) span four world regions and vary widely with respect to their gross domestic product per capita, average schooling levels, demographic characteristics such as fertility rate, and economic structures such as the employment shares of their informal and formal sectors and their industrial composition. Four of the countries are part of post-socialist Europe and have educational levels and employment rates that are generally more equal between men and women, as compared with other countries. The other five countries are low-middle to middle-income countries in Africa, Asia, and South America. The country differences are evident from our analysis of gender gaps in schooling, skills, and earnings and in the relationship between earnings and the different measures of human capital.

Starting with the pooled sample of countries, we find that estimating the log-hourly earnings function separately for men and women is justified, given statistical significance tests. These gender differences arise in part because labor markets in the countries value the schooling and skills of men and women differently, a product perhaps of social norms and institutions that shape gender identity, attitudes, and behaviors. Although there is a growing literature in economics and psychology on the relationships between schooling and noncognitive skills and between noncognitive skills and labor market outcomes, this literature is still small outside advanced countries and deserves more rigorous research.

Besides estimating separate earnings functions at the mean, we examine the differences in returns to schooling and skills across the earnings distribution using quantile regressions. Not many studies on developing and transition countries have done this type of analysis, and those that have generally do not have access to the measures of skills that we use. Our results suggest that the returns to schooling and skills are different across the earnings distribution; thus, the returns to human capital are not the same for low earners and high earners. In addition, to examine how these findings pertain to men and women, we apply a decomposition method similar to Blau and Khan's (2017). This method allows us to consider the relative potential of two broad types of policies: those that focus on equalizing the human capital endowments of men and women and those that focus on "leveling the playing field" by ensuring that the employment and wage structures in the workplace do not discriminate between men and women who have comparable human capital.

Here are a few key findings from our study:

- *The return to schooling is significantly nonlinear.* In both the pooled sample and individual country sets of results, we find modest (or even flat) returns to basic education, steeper returns to secondary education, and the steepest return to post-secondary education. (We specified education spline variables with nodes at 9 and 13 years of schooling.) The return to post-secondary education is notably larger for women than for men. With increasing enrollment and continuation rates and changing work technologies, especially in middle-income countries, whether boys and girls persist through secondary education and post-secondary education is a crucial decision for families and youth to make and an important education indicator for governments to watch.

- *Controlling for years of schooling, we find that cognitive and noncognitive (or socioemotional) skills are positively associated with earnings, so omitting measures of these skills overstates the return to years of schooling.* Schooling and skills together account for as much as 22–24 percent of the total variance in the log-earnings of women and men, respectively. Schooling attainment accounts for much of this explanatory power, implying that schooling is still a smart investment, even in the countries where schooling levels are relatively high. However, the returns attributed to schooling are biased upward when skills are not taken into account—in the pooled sample of countries, women's (conditional) earnings disadvantage relative to men's falls from 31 percent to 28 percent lower when skills are included, suggesting that it takes more cognitive and noncognitive skills for women to narrow the gender wage gap, holding constant years of schooling.
- *The estimated return to cognitive skills, as measured by reading proficiency, is significantly positive, especially for women.* Over and above the returns to years of schooling, the return to cognitive skills can be interpreted as a return to improvements in the quality of schooling. Based on the quantile regressions, the return to cognitive skills is only weakly significant for men across the earnings distribution, but is strongly significant for women at the lower and middle end of the distribution. In fact, for women, the return to a one-standard deviation gain in assessment scores (6–7 percent) is comparable to the estimated return to an additional year of secondary education at the lower half of the earnings distribution. This makes for a compelling argument for more effective investments that improve school quality for girls.
- *While it is difficult to pinpoint specific noncognitive (or socioemotional) skills that are consistently critical to earnings, several measures of those skills are jointly statistically significant in the earnings functions of men and women.* As a whole, noncognitive skills have a significant effect on earnings, controlling for schooling and cognitive skills. Our results reveal similar patterns among the countries. For example, openness to experience, which is the degree to which a person seeks intellectual stimulation and variety, is important for more countries than any other noncognitive skill, and its implied return is significantly positive. For men, the implied return of a one-standard deviation change is 6 percent in the pooled sample; this ranges from 7 to 11 percent across countries. For women, the estimated return is lower at 3 percent for the pooled sample, but this ranges widely from 5 to 22 percent across countries. Risk taking, hostile attribution bias, and emotional stability are other noncognitive skills that have significant results for the pooled sample of countries, but they are less consistent across individual countries. Our findings also show that the distributions of these skills differ between men and women, and that the returns to those skills differ by gender and by country.
- *Especially at the lower end of the earnings distribution, women are disadvantaged not only by having lower human capital than men, but also (and more importantly) by institutional factors such as wage structures and discriminatory behavior that reward women's human capital systematically lower than men's.* In the former socialist countries of Europe, a larger share of women are in formal employment, and policies such as minimum wage laws appear to have mitigated gender wage gaps. However, in the other countries where women are more likely to be engaged in informal work for reasons that include family responsibilities and gender norms, they tend to have fewer protection from discrimination. The decomposition of the gender earnings gap into a covariates gap

and a coefficients gap suggests that the coefficients gap dominates the covariates gap; that is, what seems to matter more for the gender earnings gap is gender differences in how human capital is rewarded than gender differences in human capital possessed. Furthermore, the coefficients gap is higher at the lower end of the earnings distribution, especially in the non-post-socialist countries.

National and global efforts in education have largely succeeded in raising enrollment and completion rates for young people, especially in middle-income countries, but even in low-income countries. This success bodes well for preparing our youth—and our economies—for the challenges of the future. However, evidence indicates that many school systems are failing to improve learning outcomes adequately, prompting the urgent call of today for education systems to offer better quality, more effective, and more relevant schooling. Our results are a reminder that the learning outcomes that matter in the workplace encompass different types of knowledge and skills. Are the education systems in middle-income countries equipped to respond to this call?

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Presentation 3

Mainstreamed AI and the FIRe: Implications on Education and Training in the Philippines

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SUMMARY:
The Fourth Industrial Revolution is ushering in challenging scenarios for the Philippines in the coming decade or so. The first concern is the displacement of workers, particularly the call center operators. The second is the mismatch between the skills of graduates and the needs of modern companies offering new services, or of those that will be run differently. The third is that, if the mismatch continues, prospective companies will set up shop elsewhere, or that entire companies might pull out and relocate elsewhere. For all these, we turn to education and training for a suite of urgent and appropriate responses. Schools, as early as junior high school, may need to be restructured, and their programs reoriented to better prepare students for a future that is predictably fast-changing, highly innovative, and creative. However, it is not only the manufacturing and service sectors that will be disrupted. Education, as a sector, will also be affected in ways that are both exciting and scary. In particular, the way children and adults learn will be very different—essentially driven by the fact that knowledge is now freely available on the Web, and that learners now extensively use technology to collaborate, and learn together. Furthermore, intelligent digital tutors will at some point be viable replacements of the teacher (and the book) in schools and homes. Indeed, with mainstreamed artificial intelligence—with data and knowledge as its lifeblood, and technology as its spine—society at large will be affected at an unimaginable scale.

FIRe and the cyber-physical world

Advancements in sensor and communication technology, nanotechnology, computational intelligence, and the vast field of human-machine, machine-machine, and machine-assisted human-to-human interaction have ushered in the Fourth Industrial Revolution (FIRe). This must be taken not only to mean that the manufacturing and service sectors (industry) will be, or have already been, disrupted. The way people live and enjoy life, the way they earn a living, the way they interact with each other, the way they learn, and the way they access government and social services have all been altered in a major way.

And because "all roads lead to the Web", practically every major service is either being fully

migrated to the cyber world or is at least having parallel services both in the physical and cyber worlds. No wonder then that Airbnb® and similar crowd-sourced services are now the modern hotel chains. Doctor consultations and clinical services are being delivered online. Learning happens via massive open online courses, or through private, Skype-based tutoring services. Taxis are no longer flagged by the side of a street but ordered through a mobile device. News, gossips, and life hacks are easy to access and free on the Web. Music and movies are now on-demand. Indeed, almost anything can now be viewed, inspected, ordered, and paid for online.

The fact that people are so tightly interconnected will lead to new industries, new services, and new applications never imagined before. These will imply that new professions would be emerging, and new skills would be in demand in the coming years that may have not been sought after in the past.

It must be noted, however, that the cyber infrastructure connects more than just people. Through the Internet of Things (IOT), the cyber world also connects people to gadgets and sensors. When properly installed, a person may connect to his laptop at home while on vacation elsewhere, and can theoretically also connect to security cameras, the coffee maker, main door lock, and essentially any cyber-physical device at home, in the car, in the office, and essentially anywhere.

IOT can also be about those very minute sensors tucked inside dogs' ears, fitness watches, weather substations, hand guns, communication towers, pacemakers, and all other places imaginable. And they can all be sending real-time control messages and sensor readings to the cloud to be analyzed elsewhere in the world. Way before anything happens, a powerful modeling, simulation, and analytics system can process the data, powered by artificial intelligence (AI), to forecast possible malfunctions, and then direct load adjustment and balancing, order reroutings and repairs, among other tasks.

Much like for the small electronic sensors that are commonplace in modern cars that signal any possible problem with the fuel supply, engine temperature, brake system, or essential oils and fluids, the IOT technology has raised the level of diagnosis of various sensor readings to a very precise level (i.e., not only to issue a "check engine" diagnosis to say that something is wrong with the car's engine). Once all sensor readings are sent to the cloud, very detailed and even highly computation-intensive analysis can be done. This means that a large manufacturing plant, for example, can have full use of the IOT technology to allow a "digital twin" of the plant to be installed in cyberspace—and using machine learning/AI, the analysis of the sensor readings can be done, modelled, and simulated on the "digital twin" so that future scenarios of the physical plant can be studied. This makes for highly robust and efficient manufacturing systems. The same can be extended to public utility services such as electricity, telco, and water supply systems.

The response of education to mainstreamed AI and FIRe

Quite naturally, the first concern is the displacement of workers—especially the hundreds of thousands of call center operators that might be displaced by chatbots which, or 'who", can interact with people at impeccable levels of accuracy, with a distinguished English accent and of utmost and untiring courtesy. The second is the mismatch between the skills of graduates, who were trained for pre-4.0 industries, and the needs of modern companies offering new services, or of modern enterprises that will now be run differently. The third is that, if the mismatch continues, many prospective companies will set up shop elsewhere, and that large companies might pull out and relocate elsewhere. Attention is thus focused on education and continuous training to look for suitable responses to FIRe's major effect on the prospects for employment in the coming years. Schools, as early as in junior high school (JHS),

will need to be restructured, and their programs reoriented to better prepare students for a future that is predictably fast-changing, highly innovative, and creative.

Indeed, if the world of mainstreamed AI and the FIRe is a world of innovation, then graduates of universities and technical-vocational (tech-voc) schools must be trained for a future that is uncertain and unpredictable, though manageable and shapeable. And though exciting, it is also a world that is ruthless to the unprepared.

Flexible and relevant curricula

Faced with likely disruptions in the call center industry, and the expected shortfall in the supply of trained and skilled personnel that the manufacturing and service sectors will require, the usual reaction would be to offer in colleges and universities entirely new degree programs in big data, business analytics, IOT, AI, and data science. Even with the projected lack of appropriately skilled engineers and technicians for the FIRe, we should not mindlessly encourage the sprouting and mushrooming of specialized degree programs that are targeted specifically at the critical technologies that drive the FIRe. As it is, we are already overproducing graduates in FIRe's allied fields like computer science (CS), computer engineering (CE), electronics and communications engineering (ECE), and electrical engineering (EE). There is, in fact, already, and for a long time now, an overproduction of graduates in these fields—in the sense that many fail in the ECE and EE board exams, and many of them do not work even in the general area for which they are trained.

Entirely new programs, whether at the bachelor's or master's level, would take time to get the necessary permit from the Commission on Higher Education (CHED), and would need to be marketed to parents and students who are not familiar with the "new" field. The more sensible approach is to respond very quickly by incorporating a generous number of electives within any of a set of allied programs from big universities, including CS, CE, ECE, mechanical engineering, statistics, mathematics, physics, business, and the like. By way of electives, CS students can reinforce their training in hardware (IOT, computer networks) and in discrete mathematics and statistics. The curricula for engineering, mathematics, statistics, and business programs may be strengthened with courses in algorithms and advanced data structures, advanced databases, AI, statistics, and data visualization. Naturally, the electives can include specific subjects in IOT, data science, machine learning/AI, and other highly specialized topics.

It must be mentioned that at present, most CHED-approved curricula already include a number of allied and free electives. However, in the implementation of the system of electives, some programs negate the expected benefits of these electives by doing the following: (a) prescribing electives that essentially become required subjects, usually to save on cost; (b) offering a seminar-type of subjects that are nothing but a compilation of one-hour lectures from guests and resource persons; (c) requiring electives to be only among the subjects offered by the department, thus precluding any kind of enrichment from other fields in accordance with the original intention of the electives system; and (d) offering the very same set of electives that have become obsolete, which is, again, inconsistent with the intention of using at least some of the electives to train students on cutting-edge and emerging fields.

Focus on one key learning outcome

In place of a futile exercise in trying to pin down the precise number of CS graduates that is needed by 2025 or 2030, for example (not unlike predicting the number of Filipino nurses that will be allowed entry into the rest of the Southeast Asian countries, Japan, North America, and Europe), it may serve schools and universities well if we build in flexibility and relevance in the curricula.

Aside from allocating a generous set of electives, colleges and universities should focus on the capacity of students for lifelong learning. More than the degree titles, and how they sound, the test for relevance in the fields aligned with the FIRe is whether the students, years after graduation, can quickly learn and adapt to new computing platforms, new programming languages, new engineering methods, and the like, and to learn these by themselves. This cannot be left to chance. The curricula must methodically integrate lifelong learning as a "learning outcome" of outcomes-based education.

Note that when focusing on the students' ability to learn new technologies by themselves, these colleges and universities will need to concentrate on the fundamentals, and to make sure that students truly learn about discrete mathematics and statistics, algorithms, electronics, computer networks, and ideally, a solid understanding of machine learning and data visualization. The ability to absorb new frameworks and new technologies, strangely enough, is anchored on a deep understanding of the old, fundamental topics in mathematics, statistics, physics, computing, and EE.

Platform for big data applications

To ensure that students have indeed learned their fundamentals and that the lifelong learning skills are in place, the best teaching-learning strategy is to make students work on real applications, possibly using live, real, big datasets, instead of lecturers spoon-feeding them with the detailed steps of the solution, or with the detailed syntax of existing technologies that are bound for obsolescence soon after the students graduate from college.

The Advanced Science and Technology Institute of the Department of Science and Technology (DOST) or the Department of Information and Communications Technology may wish to invest in an entire center, or at least initially an informal subgroup of full-time personnel, whose only job is to curate, preprocess, clean, and anonymize voluminous data from various branches of government and to promote the use of these data by other government agencies, schools (including senior high schools [SHSs]), colleges, universities, research and development institutions, and the like. This effort must be complemented with continuous nationwide training in AI/machine learning and data science, as well as the setting up of a computational platform that is suitable for such big data applications.

STEM education all the way to college

Science and mathematics education must start early, even as early as in kindergarten. But given what the country already has in place and considering that schools are still reeling from the changes imposed by the K to 12 program of the government, reforms in science, technology, engineering, and mathematics (STEM) education may need to focus on just the JHS and SHS. These may be better seen as a continuation of the reforms induced by the K to 12 program. Among the critical steps are the following:

- A small number of top-performing public science high schools should be encouraged to innovate and experiment, and to come up with several model curricula for STEM in JHSs. Possible model schools can include the Philippine Science High School (PSHS) Main Campus, Quezon City Science High School, Manila Science High School, Makati Science High School, PSHS Davao (Southern Mindanao), PSHS Tacloban (Eastern Visayas), PSHS Goa (Bicol), PSHS Iloilo (Western Visayas), and PSHS Clark (Central Luzon). Other large private high schools, backed by university systems such as those run by the Jesuits, Dominicans, and the De La Salle Brothers, should also be invited to create model (demonstration) curricula that are, at the onset, encouraged to deviate from the curricular framework recommended by the Department of Education (DepEd).

- Instead of taking an entire system of schools (e.g., PSHS system) to design a single system-wide curriculum (which will invariably resort to middle-ground decisions that are rarely exceptional), the better approach would be to encourage each selected school to design what it feels is best for its own campus (and not think of the smaller campuses in its system of schools). Then, create venues for competitions and cooperation to get these schools to learn from each other's experiences within the next 5 to 10 years. Meanwhile, other schools including other private schools and science high schools supported by local government units should be encouraged to select the best features from such model schools—this time with the consent of, and in close collaboration with, the DepEd.
- Create a large national SHS for mathematics and science (PSHS-SHS). This national SHS should recruit from among the best and the brightest coming out of JHSs, whether public or private, the way the current PSHS system recruits from among the best and brightest coming out of grade school. It should be a distinct campus and run independently from the current PSHS Main Campus. This PSHS-SHS ought to have the best mathematics and science resources—in terms of teachers, laboratories, learning resources (digital materials), and advanced campus infrastructure (high Internet bandwidth and extensive WiFi on campus). Teachers in these schools ought to have at least a master's degree, with or without passing the licensure examination for teachers (LET), especially those teaching STEM subjects. A close affiliation with a large university (e.g., University of the Philippines Diliman [UPD] or University of the Philippines Los Baños [UPLB]) is recommended as it could supply prominent professors to occasionally teach as adjunct faculty members, and perhaps for some of the high school research projects to be done in the affiliated university facilities. Given the way education is run in the Philippines, the creation of such a national SHS dedicated to mathematics and science needs an enabling law—particularly in terms of budget, dispensing with the LET requirement for teachers, and perhaps, some aspects of salaries of teachers, curricular offerings, and organizational elements (i.e., to decide whether they are under DOST, DepEd, or CHED).
- Counterpart follow-through programs for graduates of the PSHS-SHS must be offered in selected universities, such as UPD, UPLB, and UP Manila. Possibly patterned after the INTAPS program of the National Science and Development Board (now DOST) in the 1970s and 1980s at UPLB, students may be enticed through redesigned scholarship programs to enroll in high-priority areas, such as CS, electronics and electrical engineering, bio-chemistry, life sciences, mathematics, physics, and possibly new programs in data science and nanotechnology that are oriented toward research. These must be special programs that would provide a seamless transition to university studies without the need for exceptional students to repeat subjects already taken up at PSHS-SHS. And because there are subjects that are skipped once they are in the university, these students will be able to complete the bachelor's program in just three years. As such, the special program for these students perhaps ought to be a research-oriented straight-master's program that can be completed in at most five years.

Tech-voc in the limelight

By the time students are in SHS, programs start to branch out to either tech-voc or an academic track following one of several strands leading to

college/university degree programs. By and large, the tech-voc programs offered by the Technical Education and Skills Development Authority (TESDA) are still seen as an "alternate" to the regular academic track in JHS and SHS that directly lead to college programs.

But the world of AI, data analytics, and big data, and the many skill sets needed by FIRe have all kinds of levels of technical preparation needed and certainly not all about the theories of data science and machine learning. Of course, we certainly need to produce more graduates who are highly skilled in CS, statistics, and electronics. But there are more than a million students entering SHS every year, and only a very small percentage of them will be able to cope with the demands of data science and AI, if these are to be played out at the level of designing and deploying large complex systems.

We need to look more at the other 99.9 percent and how to prepare a good portion of them for the world of mainstreamed AI and the FIRe in such a way that a respectable percentage of them would land in jobs that suit their training and take on careers that make for a decent long-term employment.

Many colleges and universities under CHED are churning out technicians instead of engineers, lab assistants instead of scientists, and bookkeepers and encoders instead of accountants. To a large extent, the rate of wastage in terms of failing to produce college graduates at the expected level of skills is reflected by the thousands of accountancy or engineering graduates who fail the licensure exams. It is more or less the same story whether in teacher education, nursing, medicine, law, pharmacy, and most other programs that require a national board exam.

One of the most important contributions of the shift to K to 12 in the Philippines was the elevation of tech-voc education into the public and administrative consciousness, essentially making TESDA an example of worthy government service, especially among the poor. The air is ready for the public to give TESDA a second serious look. If only there is "more TESDA in CHED", where we actually train technicians, if the students are meant to be technicians, and train bookkeepers if they are expected to do bookkeeping. Some countries have perfected the model of clearly providing a way for university education to take full advantage of partnerships with industry, such as the DualTech programs of Germany. And for many such programs, the academic and tech-voc strands begin to blur. Indeed, to be relevant as a college or university, for the vast majority of them, they really ought to produce graduates who are able to perform the jobs they are prepared for, and with the skills needed for the targeted sectors.

The reverse is also noteworthy. The training offered by tech-voc institutions need not be focused solely on the technical skills. Certainly, there should be room for much more, such as to prepare the students for a modern workplace with various so-called soft skills—so that the welders, carpenters, electricians, or automotive mechanics trained by TESDA can later continue, through some engineering program in college, to become full-fledged engineers, and not get forever stuck in a low-paying job.

Mainstreamed AI, a sneak peek

The FIRe and the mainstreaming of AI have implications that go way beyond academic programs, structures, training, and education policies. Indeed, the mainstreaming of AI, the widespread use of data analytics, the larger adoption of cloud computing, and the ubiquitous IOT, coupled with the fact that the infrastructural, physical, social, and cultural barriers to connecting people wherever they are in the world, have all shaped a cyber-physical world that is getting tighter, closer, and denser.

Not only have more people been interconnected digitally, but much younger and even older people are now on the Net, too. People

with less technical know-how are also now adept with accessing the Web. And, this vast virtual world is also no longer accessible only to those who can afford to purchase their own workstations and personal computers. Although still largely inequitably distributed in terms of ease and speed and capacity of access, the cyber world, all told, is largely accessible to almost everyone on the planet, vastly aided by the fact that the Internet and wireless communication via mobile phones have been integrated.

Again, note that the cyber world not only connects people to people, nor just people to sensors and controllers, the cyber world also allows these "things" (sensors and controllers) to interconnect with each other and decide among themselves as to what to do next. In addition, the promised "fast and furious" wireless 5G communication keeps everyone fixated on what are possible when everything can be transmitted and downloaded at such high speeds, and at very large volumes.

Gadgets connecting to sensors and controllers, and entire complex systems harnessing the power of AI, can make full use of the availability of streamed information as well as rely on stacked knowledge (e.g. database) for what to do next, how to operate under specific conditions, etc. **Give these complex machines the ability to understand human speech, and to produce text messages and even synthesize full human speech—what we get are virtual humans, possibly also connected to the cyber world, interacting with (real) humans.** This leads to "future plots" worthy of science fiction (sci-fi) movie themes.

What all these mean is that the disrupted world of employment brought about by FIRe is not the only driver for a shift in the landscape of needed new skills and professions. The way the world will swirl and move will also drastically change, which may have a greater impact on the education and training landscape than just the disruptions in the manufacturing and service sectors. And it is AI that is powering up a wide variety of applications, from voice assistants and shopping bots, to face recognition in social media, to robots as caregivers, to autonomous self-driving cars.

The implications of mainstreamed AI and the FIRe on education and learning

It must be emphasized that this sci-fi scenario is already happening now, with chatbots making real-world restaurant reservations, avatars talking to children about how they understood a story, digital nurse aid taking care of old patients, virtual poets writing sonnets, photos ala Van Gogh, game playing computers, terrorism analytics, highly accurate face detection, and the prospects of seeing more and more self-driving cars. These developments are all painting a futuristic world which we, humans, will have to share with our digital creations.

The implications on society are vast and complex. In education in particular, we can expect the following to happen in the next five years or so.

1. **Merging of the teacher and the books**: Just direct chatbots toward a specific domain of learning, and the path leads directly to a digital merging of the concepts of a teacher, whether as an expert or as a facilitator of learning, and that of a "book", as a learning material or resource. Children will be routinely conversing with an intelligent digital being, and will learn from it, as part of school time. It is no longer a question as to whether it is theoretically possible. Because clearly, it is. It will be more a question of sociocultural acceptance and economics. Will children embrace this new mode of learning? Will parents want it for their children? Will schools prefer to deploy these digital tutors? How will school fees be shaped by the employment/deployment of intelligent digital tutors? Will the government even allow it? As early as now, the Philippines must carefully assess

this prospect of disruption in the delivery of teaching and learning in schools.

2. **Sensors in classrooms**: Trends and technological advances also point to futuristic classrooms, or learning spaces, where the teacher or the learning facilitator is aided by sensors in the learning space that will signal whether learners are excited, confused, bored, or frustrated. The learning space can thus be adjusted accordingly, or new materials and learning activities can be introduced. For that matter, the academic emotion of learners can be tracked and monitored closely, and intelligent tutoring systems, such as those described above, can deliver differentiated and personalized learning modules according to the learning style and learning progress of the learner.
3. **Heightened experiences through virtual, augmented, immersive reality**: The prospects of having intelligent digital tutors are enhanced with the experiential interfaces that are possible with virtual, augmented, and immersive reality. Museum pieces in far-away Louvre can be seen in 3D within class time; various topics in history can be rendered as a game where a child can be part of history; chemical processes that are too dangerous to be observed in physical chemistry laboratories can be vividly rendered in VR/AR; microscopic organisms and subatomic particles that would usually need expensive equipment can be viewed by children using ordinary tablets. The possibilities are endless; whether in the social sciences, mathematics, medicine, physical and biological sciences, and even, or more so, in the humanities and the arts. Studies must be continually conducted to assess the viability and maturity of these technologies (items 1,2, and 3)—perhaps for some schools to start experimenting on them, and other schools to follow after thorough assessments are made. For that matter, an entire creative and educational digital content industry can be carved out as a niche for the Philippines.
4. **Social media and collaborative learning**: Other than the array of technological breakthroughs that deal with learning materials, pedagogy, and heightened experiential interfaces that can make learning more forceful, more effective, and possibly cheaper to deliver in the long run (than employing teachers who would just transmit facts and figures), education will also be more and more self-regulated and highly collaborative. The availability of information on the Web, and even of entire learning modules that have already been curated and deployed in top institutions abroad, would continue to drive learners to go ahead and learn on their own—pursuing topics assigned to them in school, topics that interest them even if not required in school, and also topics that they need to learn due to specific needs (e.g., health and self-help topics) or by sheer interest (e.g., hobbies, arts and craft, automotive repair, do-it-yourself kits). Learners will also continue what they are already doing at a very young age—collaborative learning in and out of school— largely aided by social media. Thus, the training of our teachers, and of the educational leaders, must be overhauled to consider these technological advances and modern social phenomena.
5. **Data analytics on learning and learners**: Because extensive data can be tracked on a real-time basis, learning sessions can be tailor-made and tailor-fit to students. Furthermore, at an aggregated level, data on entire groups of learners can be routinely collected and analyzed, e.g., English-level performance of grade 1 students in Quezon City; geometry skills of all high school students in the Autonomous Region in Muslim Mindanao; top 10 areas

of confusion about the Spanish colonial period among grade 4 students nationwide. The possibility of tracking the learning progress of students at all levels from kindergarten all the way to college has vast potential for evidence-driven policies, curricular reforms, differentiated programs for different types of learners, and tailor-made learning materials (and intelligent tutoring systems as described above).

Conclusion

The dire employment scenarios for the Philippines in the coming years, brought about by the FIRe, calls for reforms from SHS, to tech-voc, to CHED programs. Instead of herding colleges and universities to join the bandwagon and offer entirely new programs in data science or big data analytics, a more sensible approach would be to build in relevance and flexibility in the existing programs such as CS, EE, statistics, and other allied programs in business, science, and engineering. The key is to make students work on live, real, big datasets from government data that are curated, preprocessed, cleaned, and anonymized. This must be complemented with continuous nationwide training and the setting up of a computational platform that is suitable for big data applications.

Note that with the FIRe, and especially with the mainstreaming of AI, not only will the manufacturing and service sectors be disrupted, for which educational reforms are needed, but the very mode of teaching and learning will be affected as well. The way children and adults learn will be very different—essentially driven by the fact that knowledge is now freely available on the Web, and that learners have learned to extensively use technology to collaborate and learn together. Also, exciting but whose consequences are yet unclear, intelligent digital tutors (well-informed chatbots for specific learning domains) will at some point be viable replacements of the teacher (and the book) in schools and homes; and school time will not be the way it is now. Finally, schools, colleges, and universities will be like the modern manufacturing plants in Industry 4.0—with lots of sensors and data analytics to digitally track and monitor the state and progress of learning in school, at both the learner level and at aggregated levels.

Presentation 4

Facing FIRe with WAATER

Ma. Victoria Carpio-Bernido | Directress, Central Visayan Institute Foundation, Inc.

SUMMARY: In this talk, we focus on how, through solid training and education, economically disadvantaged citizenry could diminish the dread of being swamped by the Fourth Industrial Revolution (FIRe) even as they seek to enjoy unprecedented benefits brought in by such wave of advanced technologies. We highlight the crucial policy choice of cost-effective, efficient, evidence-based educational programs suited to rapid population growth as well as constrained learning conditions. In particular, we look at real-world educational programs and curricula that could produce young people well equipped not only to face the challenges of FIRe but also ready to use it for the advancement not only of self but community and the nation at large. We summarize our education perspective in WAATER: Wide-ranging Advanced Analytics Training and Education Reinforcement.

Let me start the presentation with the context outlined for this conference: *Workers with less education and fewer skills are likely to be at a disadvantage as FIRe progresses… there is a need to adapt to the changing nature of work by making investments in training people to have both soft skills and technical competencies.*

This talk mainly focuses on answering the following questions:

- What critical policy decisions and strategic actions should the country be taking today to get the current and future workforce ready for FIRe?
- What can (and should) be done so that Filipino workers and the young who are now lagging behind in human capital development are able to catch up and move ahead amid global labor market challenges and opportunities?

For this, the following points are highlighted in this presentation: (1) critical policy choices, which involve curriculum depth and content, learning program and materials, and budget optimization, and (2) WAATER: Wide-ranging Advanced Analytics Training and Education Reinforcement, using the prototype of the Central Visayan Institute Foundation (CVIF) experience as an example.

So why are these choices critical for policymakers?

- Poor learning programs coupled with a poor curriculum, even with hundreds of millions of dollars poured into our educational programs, would simply waste human and material resources, with the majority of learners doing poorly in local and international assessments, and having poor alignment of learner skills with labor market demands.
- A good curriculum, but with a poor learning program, even with heavy expense, would only get pockets of good learner development—perhaps, only 1 percent or less of our learners, considering our yearly cohorts of over a million learners per grade level in basic education.
- A good learning program, but coupled with a poor curriculum, again, even with big budgets, would yield selective ability-based learner development, as in the case of dominance of elite institutions, where we have a few who do very well, and are globally competitive, yet depriving hundreds of millions of Filipinos of the opportunity to do well.

So what do we wish to have incorporated in national policy choices? Of course, we would like (1) a strategic learning program—a strong updated national learning program based on evidence and on objective analysis of accumulated historical and contemporary data on learner abilities and actual performance, (2) a strong and rigorous but realistic and updated curriculum, and (3) both learning program and curriculum development implemented with minimal expense and cost for the country so that funds could be channeled to other urgent needs of the nation such as health and welfare. These three considerations are necessary to make the right policy decisions that would assure abundant and inclusive high-caliber human resources for our country.

WAATER: Wide-ranging Advanced Analytics Training and Education Reinforcement

With FIRe, what can (and should) be done so that Filipino workers and the young who are now lagging behind in human capital development would be able to catch up and move ahead amid labor market challenges and opportunities?

Wide-ranging

Education and training of human resources should be wide-ranging in the sense that (1) it is extensive in scope; (2) it covers differences in gender, age, attitudes, behavior, preparation, culture, language, and socioeconomic background; (3) it exposes students to disciplines for long-haul trainings, including science, technology, engineering, and mathematics (STEM), agriculture, humanities, and social sciences—all the disciplines; and (4) it addresses the whole spectrum of learner abilities and proficiencies—providing opportunities for challenged learners to catch up by giving sufficient time and training for them, even while providing opportunities for the gifted to explore and go as far as possible.

In the Philippines, there is a yearly increase of population in secondary schools. Recent statistical data (2014) show a total of 7,171,208 enrollees in secondary schools in the Philippines, which is bigger than the population of Singapore. Happily with FIRe, technology can and will democratize educational opportunities, thus, increasing the potential for countries like the Philippines for catching up with advanced countries in developing human potential. With advanced technologies allowing bypass of the historical need for expensive equipment and material resources, mind power—heavily analytical thinking and creativity—of a greater majority of the youth will be the most essential.

Common problems that have to be resolved in the development of our learners are: (1) boosting interest in STEM courses; (2) sustaining interest

and passing grades throughout a university STEM course; and (3) patching up deficiencies in mathematical preparation (failing in basic and advanced math and science university classes might indicate a gap in the basic education learning program).

According to the Philippine Statistics Authority, only around 38,000 or 1 percent of the students are interested in mathematics, and 16,195 or a little over 0 percent in computer sciences. If we do not want to be swamped by FIRe, we definitely must have a populace who are very much comfortable with the maths, computer sciences, engineering sciences, and all these proverbially tough courses.

Evidently, another problem to address is the gap between rich and poor that translates into gaps in educational and training opportunities. The gap across the globe is widening, even in developed countries. Thus, demographic and anthropologic distribution should be addressed in order to prepare and lift those in poverty for the onset of FIRe. Countries that are able to do this successfully will enjoy the benefits of FIRe rather than be swamped and flattened into bankruptcy.

Advanced

Education and training of human resources should be advanced in the sense that our curricula and our learning programs connect the education from kindergarten all the way to senior high school (SHS) and subsequent rigorous advanced university as well as technical courses. This should not be just for the elite private and public specialized schools, but all schools in Luzon, Visayas, and Mindanao. Whether learners wish to pursue STEM, technical vocational, or business courses, students should be given a strong globally competitive analytical background sufficient to propel them beyond graduate school, professional school, up to having a productive life as a well-trained well-informed citizen.

Analytics training

Math-infused disciplines are necessary for *analytics training*. When we talk about analytics, it is inevitable that our education system should have a strong and solid curriculum in physics, chemistry, biology, and the mathematical sciences in order to allow students to personally go through the advanced analytical processes of these fields. Some countries, highly developed countries included, have made these subjects as electives because of their difficulty. I very much agree with the Philippine educational policy that maintains biology, chemistry, and physics as required subjects. The challenge, however, is to develop a method of teaching that would sustain the interest of students in these disciplines, rather than terrorize and traumatize them.

Even subjects such as economics, political science, sociology, and governance should be at a higher level, thus, strongly math-infused. Otherwise, our students will be left behind. All these disciplines can now be enhanced by data science. We can analyze if there is fraud in the elections, for example, through statistical signatures of fraud. This can be done even in SHS.

Humanities and the arts, as well as sports and kinetics, can also be math-infused as shown by Olympics training programs in advanced countries.

Strong analytics training clearly does not preclude a strong training in soft skills. The young should naturally be honed in social and communication skills and the right attitudes. These are, in fact, already included in all the curricula so far prescribed by the Department of Education (DepEd).

Education reinforcement

Education reinforcement means that we let our young people transition all the way up through the levels of learning we have proposed: starting from visual-kinesthetic level, which means that learners observe, feel, and may talk about a natural phenomenon. This is followed by the higher level of verbal conceptual explanations. We cannot stop

at this stage, however, and accept theories left and right, because as the saying goes, all opinions are born equal in the absence of evidence. For the 21st century, it is very important that we go up to the quantitative mathematical level. This is the reason why disciplines must be mathematically infused. For example, we may have voluminous data, but anybody can have access to that big data, yielding different interpretations. With this, it is inevitable that young people should have an exposure to precision and accuracy in quantitative mathematical interpretation for them to go all the way up to the highest level of quantitative-mathematical synthesis, meaning getting the bigger picture. Moreover, they should be able to deduce from the bigger picture, the details, and have enough predictive power using mathematics. Hence, analytics training may be started at the conceptual level, but should not stop at that. It must also be reinforced by rigorous high-level mathematics including computer science.

WAATER: Web-Adapted Analytic Training and Education Reinforcement

As we are working with FIRe, another education perspective would be Web-Adapted Analytics Training and Education Reinforcement. Earlier, we mentioned that there are some schools and colleges in relatively remote areas. Normally, educational institutions are evaluated based on the strength of their faculty, and many schools and colleges are deprived of teachers with proper training. This is where web-adaptation can help in intervention. The Massachusetts Institute of Technology, for example, has a wide-ranging offering of online courses and open access lectures in mathematics and engineering. Our young people can take advantage of these. The government and private corporations, through their corporate social responsibility funds, could help in giving Internet access or storage of materials for later access in the case when on-demand Internet access in unavailable.

CVIF Dynamic Learning Program (CVIF-DLP)

The CVIF Dynamic Learning Program (CVIF-DLP) uses a systems approach to process-induced learning first applied at the CVIF High School in Jagna, Bohol, in 2002. It is now implemented at the elementary, secondary, and tertiary levels by a number of schools in different parts of the Philippines. We initially conceived the program to improve the performance of the students of our school, the CVIF. Our school is a regular private school, not a science high school, and accepts Grade 7 students coming from mostly public elementary schools—many of them coming from economically disadvantaged families with no good learning materials at home. The CVIF-DLP is meant to give these students a strong globally competitive training in the different areas prescribed by the DepEd.

The design requirements of the CVIF-DLP are as follows: (1) *large-scale enough for state school systems*, but *individualized enough* for each student in any school; (2) *have best evidence-based features for curriculum and didactics;* and (3) *low in cost* that effective implementation is possible for any nation. Such design requirements echo that of Ford's Model T: an iconic disruptive showcase, where the key for its success is process efficiency.

Four essential components of the CVIP-DLP target Learner Disposition: (1) parallel learning groups or simultaneous classes which ensure that only 20–30 percent of the period is for teacher intervention; (2) in-school student comprehensive portfolio; (3) activity-based learning by doing (much student writing of learning activities for independent learning, with no introductory discussion by the teacher for any topic); and (4) strategic rest (absolutely no homework or projects to be done at home, and more time for personal creative and holistic development). These four components are non-negotiable.

Continued implementation of the CVIF DLP at our school as well as in other schools in

the country is based on positive performance indicators, notably remarkably outstanding student cohort performance in in-school and national assessments. Moreover, a number of CVIF alumni have gone on to successful careers and professional development. One example is a former student who is now taking his doctorate degree at the Swiss Federal Institute in Zurich, Switzerland, which ranked number one in the world in the 2018 QS World University Rankings in Earth and Marine Sciences. Another example is an alumna who is now pursuing her Ph.D. studies with the joint Max Planck Institute–University of Dresden program in Germany. Both did their undergraduate and master's degrees from the University of the Philippines after Grade 10 (before the implementation of the new K to 12 curriculum of DepEd).

In conclusion, the choice of (1) a well-designed evidence-based learning program, (2) a strong math-infused but realistic curriculum covering all disciplines, and (3) minimal cost for the government attained with process efficiency and strategic intervention would allow large inclusive cohorts of students of any country to reach globally competitive levels of achievement and productivity.

Open Forum

QUESTION 1

Philip Muncada (University of San Carlos, Cebu City): Have you considered the impact of culture on salaries? For instance, in a first world country like Japan, there is a big difference between the salary of a man and a woman even if it is first world. Women's salary is still lower compared to men's. What is the impact of culture on wage differences?

Elizabeth King: I would interpret the fact that the decomposition of gender-wage earnings difference indicates that the way the labor market rewards human capital is different for men and women. The coefficients gap is more important than the covariance gap—the latter being the returns to the human capital itself. Part of the gender difference is due to the level of human capital rather than the way the human capital is rewarded. The fact that the covariance gap is bigger is due to gender differences in social roles or family roles.

I would say it is because of what you call culture. Also, what we noticed is that the women in post-socialist countries tend to have more of the stronger noncognitive skills because noncognitive or personality traits can be developed. If you have a labor market that does not distinguish very much between men and women, and actually allow women to take paid work and are more likely to be employed than women in other countries, then those women begin to develop some traits that are really valued by the labor market. So I would say those are two pieces of evidence of what you call culture are important.

Alberto Fenix (Fenix Management and Capital, Inc.): What is going to be our response to the future of work and to the future of the economy? To me, what we should be doing is to restructure our education and training system for us to prepare our human resources for the work in the future. Today, it is already depressing. Our problem is that our schools are teaching the way they were teaching 30 to 40 years ago. There has to be a better partnership between education and training institutions and employers as to what skills are needed at the workplace.

We have been working with the Philippine Chamber of Commerce and Industry. I am trying to bring in the dual education training in senior high school. College students can more or less take care of themselves. But, even then, I hire engineers and they do not know the work at my workplace or in my factory. I am already aware of CVIF and what it is doing—that it is teaching in a different way. But today, our education system is still talking about lack of teachers, classrooms, and inaccurate textbooks, instead of talking about how to apply new technologies such as massive open online courses. Why can't these be offered to everyone? Why can't we have free access to the Internet? Companies would have to change their business model: they should give free access to the Internet and make money from advertising, etc. Right now, they make a lot of money from subscriptions to mobile phones, and providing Internet connection, but still we

are one of the countries in the world with the slowest Internet.

Ma. Victoria Bernido: Yes, definitely, we need to make the curriculum relevant but always with some caution. I think I just quickly very briefly mentioned that. Yes, we would like to prepare them for the workforce, but it would be dangerous if we just let the industry dictate what we should take up in the curriculum. Because then, the students might not be equipped for the technology that will be needed in the future beyond what the industry knows at present. So, in the end, it should really be a balance from the whole chain, building the knowledge base we have at the moment that would still be usable even hundred years from now. One example is the vacuum tube technology, which shifted to semiconductors. Semiconductors came about because of quantum mechanics, which is learned in schools and universities. Lasers are another example, with all their applications. Computer scientists ask them, what should the students be strong in? They always invariably say mathematics. They should be strong in that, but that is traditional curriculum. So there should be a balance.

Michael Fung: Although the context in Singapore is different from that in the Philippines, I think there is one strong similarity: that is, education systems are incredibly difficult to change.

So, specific to your question, how do we help high school graduates get the workforce-related skills? Instead of looking at changing the system, we can look at mounting specific programs. We have a program called the Earn and Learn Program. The students start working with an employer but goes back to school once a week. Over a period of 12–18 months, they get a specialist diploma in a certain field that is aligned with what employers are looking for.

Another program that we started very recently is something that has potential in the Philippines. We are working with a McKenzie subsidiary called Generation, and we have started what we called Work-Learn Bootcamp. It is an 8- to 12-week-long program, which can be taken by high school and polytechnic graduates, and even degree holders. During this bootcamp, we train them on specific skills required by the company. We interview companies upfront on what skills they need, then we train these individuals with these specific skill sets. In addition to that, they do upfront training of mindsets, so that learners are prepared for the workplace. Employers can then interview and choose from these individuals.

QUESTION 3

Raul Fabella (University of the Philippines): With the K to 12, how did the CVIF handle the additional years? How do you respond to the question that, perhaps, the phenomenal success of the DLP is due to the Bernido effect?

Maria Victoria Bernido: With our program, the students achieve high level of maturity and content and skills mastery, both soft and cognitive skills, by Grade 10. So when we were mandated by law to also offer Grades 11 and 12, we used this as a spring board for them to do real world research. Our goal now is data accessibility; we do not have to wait for data from DOST, there are so much data available right now. You have data from the Hubble telescope; you have data from particle accelerators; you have data on genes, on proteins, open access, as well as on politics, election results, and so on. Our goal is for the STEM strand to be able to do data analytics on data connected with the humanities and social sciences.

Also, because Bohol is a world biodiversity hotspot, it is considered to be the center of the world's biodiversity, especially in mollusks. So we have also started some research work on diversity, doing some mathematical modeling of shell structure, for example. This October 5 and 6, we

have two guest scientists interested in the DLP. We are conducting a workshop on computational biology, big data, and biology. How do you do data analytics on big data, AI, and basic computer programming using Python, which is a language that researchers also use? Senior high school students will be working on that, so we can bridge the gap to the immediate real world.

Regarding the success of the DLP if it is connected to us, well, the DLP is already being applied in many schools in Luzon, Visayas, and Mindanao, so clearly we are not there; we cannot bilocate, trilocate, and so on. Some schools are doing very well. Some schools have five students passing the UP College Admission Test before; now they are having 31–32 passers.

QUESTION 4

Geneva Frances Guyano (APEC Business Advisory Council of the Philippines): We have mentioned about the fundamentals that we want our students to have like the STEM subjects, data science, and analytics. We are discussing how it is imperative for us to have students who possess the right skills. I would like to get your thoughts on how we should develop our educators, so that they can effectively transmit the knowledge and skills to the students.

Arnulfo Azcarraga: First of all, I just noticed in Dr. Bernido's presentation that they really cut the teachers and lectures by at most 20–30 percent. That is the spirit of intelligent digital tutors. The point there is the active learning that really happens when you give students actual problems to work on. Everything that they need—the math, physics, the fundamentals—they will have to learn on their own. This is why it must be connected to a learning outcome. You basically will need to have the infrastructure and the teachers that will guide them to choose the problem at the right level, ask the right questions, and guide them as they produce the results.

Michael Fung: Changing mindset is another very difficult problem. In the Singapore context, we have continuing professional development for our teachers. But, in addition to that, we now have education and career guidance counselors who are attached to each of the schools. They would also offer additional support for students to make labor market information and relevant knowledge of the industry sector available. We also train and certify adult educators. These educators can deliver government-funded programs. They go through pedagogical training and facilitation training, which includes the use of electronic resources and how to make the instruction more problem-based and more industry-relevant. So, we address that in different parts of the training as well.

AFTERNOON SESSION

WAYS FORWARD

SESSION OPENER

Emmanuel de Dios, Professor, UP School of Economics

In this concluding session, we discuss how various stakeholders can work together to harness the powerful emerging FIRe technologies, achieve accelerated and broad-based socioeconomic development, and prepare for uncertainties arising from the unfolding landscape. FIRe is already redefining what it means to be human and how we engage with one another and the planet. The challenge is whether the technologies we create and use can be channeled to respect and respond to the most urgent human needs and most deeply held human values. This session shall elicit the participants' visions of the country's future in a FIRe landscape and shall recommend policies, strategies, and practical steps to ensure that the Philippines stays on track to achieve its goals of sustainable and inclusive development.

The panelists and participants of this session are expected to share their views on managing both the potential risks and benefits that the FIRe brings to the key areas of equality, employment, privacy, and trust. Attention will focus on the design of sound regulatory and legal frameworks and strong institutions that will ensure that the advances of the FIRe are on track to benefit all.

> "The Fourth Industrial Revolution can compromise humanity's traditional sources of meaning—work, community, family, and identity—or it can lift humanity into a new collective and moral consciousness based on a sense of shared destiny. The choice is ours."—Klaus Schwab, The Fourth Industrial Revolution

Views and Reactions

Fortunato dela Peña | Secretary, Department of Science and Technology

QUESTION: What is the overall strategy of DOST in preparing for the FIRe? What are the top technologies that DOST is focusing on? Given the fast-paced technological change and innovation, what would you change and introduce in the funding of research and development (R&D) in the country? How can we make the partnership in R&D among the government, academe, and industry more effective and sustainable?

I would like to talk about the overall strategy of the Department of Science and Technology or DOST as far as contributing to our development is concerned, and FIRe is just a part of it. We take off from what President Duterte wants to see: the reduction of inequality. For DOST, it means looking at how our regions and provinces are performing in terms of contributing to production and how their productivities compare with one another. Hence, we adopted a regional approach in DOST—whether in human resource development, R&D, and technology transfer, among others. This means we are trying to expand our R&D pool to go beyond the usual, traditional, and exclusive groups of universities and schools that have been benefiting from our grants for many years. What I want to see is how these institutions and our R&D efforts will redound to the benefit of our people and our productive enterprises. So we are trying to capacitate different institutions in the region who know better the needs and opportunities in their areas.

With respect to our approach to upgrade our enterprise, it is not enough to do surveys. You have to see them face-to-face. By visiting them, you will see the varying degrees of where they are in these industrial revolutions. In some cases, enterprises are sill in 1.0. I was in Alaminos yesterday to visit a community that produces salt by cooking. We introduced to them a new value-adding and law-abiding product in iodized salt. They were open to it, but the first thing to do is to improve their basic production facility.

If you look at the cross-section of our productive enterprises, particularly the small ones, there are those that you have to lift from 1.0 to 2.0, from 2.0 to 3.0, and there are those that are prepared to go from 3.0 to 4.0. Those that provide inputs to big companies are prepared—or should be prepared—to move to 4.0. The trick is to understand the situation first.

Moreover, the link with different sectors is very important. More and more firms are realizing that they need to do research, but they do not have the people or the facility to do research. Sometimes, it is because the academe and industry do not trust each other. What we do is we tell firms that if they want a research done, but they do not have the people and/or

facility, the best way is for them to identify an institution—preferably a university that they trust and is willing to do the work for them. When they combine their resource, DOST will augment their funding. This strategy is gaining a lot of traction.

As far as FIRe is concerned, we are preparing ourselves by having the facilities that they need for better services and opportunities, as well as to make our services more accessible by using ICTs, artificial intelligence, and others. We will not be left behind, but we need to consider the status of our different firms. We cannot tell industries in remote areas that we will bring them into 4.0. They will not understand it. We need to be realistic.

Views and Reactions

Eliseo Rio Jr. | Acting Secretary, Department of Information and Communications Technology

QUESTION: Explain the critical role of ICT in the FIRe. What are the policies and plans of the DICT to ensure that the country's ICT infrastructure is FIRe-adapted? How should we address technological risks on security and trust, such as cybersecurity, the unethical use of data by both state and private actors for intrusive surveillance and mind-conditioning, as well as the overuse of technology for building and deploying new weapons?

DICT is the newest department of the government, created in June 2016. We are now in the midst of FIRe. Is DICT ready for FIRe? No, we might get burned. Our ICT infrastructure needs a lot of improvements. When Jack Ma came here a few months ago, the first thing he did was to test our Internet access. He said it was not good, directing his comments to DICT. This is our priority now: How do we improve our infrastructure?

All of our ICT infrastructure is invested or owned by the private sector. The government has almost no investment in ICT infrastructure. Imagine if all the road networks in the country were built by the private sector, we will need to pay toll fees every time. This reality defines our ICT infrastructure (i.e., it is financed by the private sector, so it is slow and expensive).

The government has to pitch in. We are now putting up critical infrastructure in ICT environments. This project has five components, one of which is on international gateway facilities (IGF). Right now, all IGFs are owned by big telecommunications companies (i.e., Globe and Smart); the government has none. But we signed a tripartite agreement with Facebook, so the government can have its own IGF, apart from Globe and Smart. Globe and Smart want us to connect to them through their cell sites. Why don't they just put fixed broadband? They are doing that now, but only in a limited fashion, so it would not compete with their mobile data services. For example, in this room, less than 10 percent is connected to the WiFi of this hotel. The rest of us are connected to either Globe or Smart.

To summarize, the only way for us to be ready for FIRe is to improve our ICT infrastructure.

Views and Reactions

Diwa Guinigundo | Deputy Governor for Monetary and Economics Sector, Bangko Sentral ng Pilipinas

QUESTION: What are the macroeconomic and financial sector implications of the FIRe? How can leaders in the banking and entire financial sector embrace digital transformation innovation and how quickly should they do so? Is the FIRe technology in finance a force for inclusion or exclusion? What specific risks to the public, if any, are posed by the rapid or late adoption of FIRe technology in finance? The BSP is considered a model regulator in its ability to respond to fintech and other new technologies: what lessons can be learned from BSP's experience that will help other regulators in improving FIRe adaptability in their own sectors?

I would like to thank PIDS for inviting the *Bangko Sentral ng Pilipinas* or BSP to this very important gathering. A lot of things have been said about FIRe, and we are all excited about it. But FIRe could also be a perfect storm. With excitement on how FIRe can bring about change, and for change to be meaningful, we need to be aware of the possible risks that we may face.

The challenge to policymakers is not just to walk with the technology but also to anticipate what the next move will be. In fact, we need to be at pace with technology, as we anticipate challenges. We need to be responsive and, if necessary, ingenious to the demanding needs of our time. Otherwise, even central banking may be obsolete or irrelevant.

While there is ongoing work being done by various field experts to address the challenges of FIRe, the future is still under construction—for all intents and purposes. In other words, we are still navigating in uncharted territories. And in this crucial time, the point is to be prepared and to be anticipatory.

With respect to central banking, I can mention three areas where FIRe is most relevant. One is on dealing with fintech companies. The second is on regulation and supervision, or what they call "regtech" and "suptech". The last is the issue of cryptocurrency or virtual currency.

Fintechs are disrupting the financial ecosystem in the sense that they are able to disband, unbundle, and reassemble financial services without necessarily using their balance sheets. They have been providing intermediary services that provide solutions to many customers—whether households or corporations. This adds complexity to the role of regulators, even in terms of the conduct of monetary policy.

This is because technology prompts a shift in banking distribution channels from brick and mortar branches of commercial and savings banks, as well as smaller rural and cooperative banks, to Internet and mobile services. Here, traditional financial institutions have realized that

collaboration may be the best path to long-term growth. In short, we are building a small ecosystem where FIRe is most felt.

Most fintech innovations are on the payment system. They allow peer-to-peer value exchange without the involvement of trusted third parties like banks. The evidence so far suggests that while fintech companies are very useful, they can also bypass the services of banks and, possibly, create incentives for shadow banking. So the synergy between fintech companies and banks is something that we need to promote. This is so the financial transactions between these two entities will still be under the ambit of the central bank.

The second point is the regulatory approach to fintech. The BSP has established a regulatory environment that allows innovations to flourish but, at the same time, ensures that risks are effectively managed. Here, our approach is three-fold: (1) regulations should be risk-based, proportional, and fair; (2) maintain active multistakeholder collaboration; and (3) ensure consumer protection. So, basically, our approach to fintech is via a regulatory sandbox. This is what we considered when the issues of G-Cash and Smart Money arose in 2004. Five years later, we found that the experiment was successful, and appropriate regulations were established to govern the use of e-currency or e-money in the financial system.

Views and Reactions

Peter Draper | Executive Director, Institute for International Trade, University of Adelaide

QUESTION: What is the implication of FIRe on globalization and regional integration? How important is an open trade and investment regime in the FIRe era? What are the opportunities and risks associated with increased cross-border flows of data?

Thank you to PIDS for inviting me here. The answer to one of the questions—is an open trade and investment regime necessary to support FIRe?—is yes. It has to be. What it encourages is the flow of people, goods, services, and knowledge. It is the nexus of these things that promotes technology uptake and development. Of course, it has risks. But, at the end of the day, I think FIRe is inevitable anyway.

FIRe also raises the question of how all of these will be regulated at the global level, as well as at the regional level. At the global level, there is probably only one game in town, and that is the World Trade Organization (WTO). Just a couple of observations about WTO: first, it is in trouble. I think we all know about that. This is something we can pick up on in the next conversations (i.e., why is it in trouble, what can we do about it). Second, the WTO does not cover all the regulatory demands that FIRe requires and represents—and that, in itself, is a challenge that the WTO must face.

This brings us to the regional level. Obviously, there are different models for regional economic integration. You can see that in the Asia-Pacific, as well as in the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP), which I think is the closest to the kind of regulatory arrangement that FIRe or its uptake requires simply because its regulatory ambit goes the furthest. It has a chapter on e-commerce and covers a whole range of FIRe-related technologies. We also find the Regional Comprehensive Economic Partnership, Free Trade Area of the Asia-Pacific, Association of Southeast Asian Nations, and a range of other free trade arrangements in the Asia-Pacific region, but which of these models is most appropriate? For me it is the CPTPP model. Of course, with the US pulling out, there are question marks about the future of this particular arrangement.

We should not forget the national level, as we are talking about trade governance.

What nation-states do at home matters a lot. This brings me to a broader question: How is the system as a whole evolving? And, here, there are forces of integration: technology, cross-border value chain, and consumers. However, there are also forces of disintegration, and these are becoming more apparent in recent months. On the technology side, we are seeing a weak signal toward on-shoring prospects (e.g., labor-intensive industries, 3D printing technologies). These could represent challenges to labor-intensive manufacturers such as the Philippines.

Likewise, political forces of disintegration are becoming more apparent recently. We hear about inequality driving populism, particularly in developed countries like the US. We also have geopolitical issues, such as the US-China relations.

Where does all of this go? The media sector rarely focuses on trade wars. In some sense, the term 'trade war' is a misnomer. It should actually be 'investment, technology, and trade wars'. We might be entering a new normal of hypercompetition manifesting as protectionism.

Views and Reactions

Christopher Bernido | President, Central Visayan Institute Foundation, Inc.

QUESTION: How can we best prepare the Filipino youth and entire citizenry for the FIRe to ensure that prosperity becomes more inclusive? What are the important implications—both positive and negative—of the FIRe for the education sector and what is the appropriate public policy response? What changes do you foresee, if any, for the role of family, peers, and community in the education of youth for skills, ethics, and citizenship?

I would like to thank PIDS for the invitation. Everybody seems to be wondering how to prepare our workforce ready for FIRe, as well as the next generations of workforce. In the face of the complexity of FIRe, we should go back to the fundamentals; go back to basics—things that we are already familiar with, things that are under our control.

What type of workforce do we really need in the face of FIRe? We need individuals—not only in management but also in the rank and file—who are analytical thinkers. But how do we develop individuals or workers who are capable of learning new skills every five years because the skills they know can become obsolete? How do we develop analytical thinkers?

I will answer this in two ways. Firstly, analytical people are logical thinkers. They know how to analyze the cause and the effect. But where do you really first learn logic? You first learn logic in your elementary and high school math. It means when you violate a rule, you will not arrive at the correct answer. By going back to fundamentals, students should learn their math and science well. Besides, when you ask any computer scientist about the best preparation for computer science, they will say mathematics. Even if you teach someone how to code, if he or she does not think logically, the program will not run. He or she does not even know what to solve or what the endpoint is.

I have to make a warning. Different teaching methodologies have different outcomes. I would be remiss if I will not talk about the CVIF-Dynamic Learning Program (DLP), which is available even for economically disadvantaged schools.

Secondly, all new technologies are based on science, which was discovered hundreds of years ago. It is the same science that has made fast-changing technologies possible. If you want a new technology, it should be a technology that cannot violate the laws of science and nature. Same goes for innovation.

The point is you need to learn your math and science well. This is the best way to prepare a workforce that will thrive in FIRe. If you want a critical thinking workforce, the first place to learn it is in school, where we can control it. We should not be afraid of FIRe.

Views and Reactions

Winston Damarillo | Executive Chairman, Amihan Global Strategies

QUESTION: Compared to our ASEAN neighbors, how ready do you think Philippine firms and workers are to embrace the FIRe? What challenges do they face? What specific elements are crucial but missing in the current business and regulatory environment that would nurture technopreneurs and foster greater innovation and technology-adoption among incumbent firms?

Thank you all for having me here today. When we introduced FIRe or Industry 4.0 in Davos, there was a great concern whether that move is more suitable to industrialized economies. There was a bigger concern about what that would bring to emerging economies like the Philippines.

What is exciting is that for the past two years, we have only seen FIRe elements to bring about something different and new for us. FIRe brought inclusion and more equitable wealth distribution to emerging countries. When I look at the impact of FIRe on the Southeast Asian region, I look at three vectors: (1) ability of our industry to transform, (2) cultural adaptiveness of consumer practices, and (3) ability of the ecosystem to sustain the movement of FIRe.

I am happy to report that the Philippines is probably among the leaders in FIRe when you compare it to the ASEAN region. Industries are also taking FIRe into heart, and they are actually implementing it. For instance, the *Bangko Sentral ng Pilipinas* or BSP, being concerned about inclusion, has been opened to fintech as a model and blockchain as a fair game. It opens up the mindset of the banking sector to adopt technologies that not only improve profit but also improve the way they provide services. We see this in our everyday lives today.

In the region, there is a massive movement toward a cashless society. You are going to see more and more QR codes in supermarkets very soon. It is going to be more prevalent because we have decided to standardize our technologies. Lending and microlending, which are the heart of capitalization for micro businesses in the country, are also becoming more prevalent and will be sustained by technology. Simple technologies we use everyday like chatbots or messengers will now be engines to lend 5 million people small amounts of money to capitalize their cottage industries.

The Philippines, indeed, is doing quite well compared to its neighbors. Where we think we lack—and where we can improve upon—is in the area of creating an ecosystem for sustainable success. Not only do we need to increase the velocity of sharing our best practices, we also need regulations that can help—not just in funding our entrepreneurs but also enabling connectivity

between small entrepreneurs and large businesses. It is easy to build technologies, but it is hard to find consumers. If there is a way to connect our largest industries to our smallest, most innovative start-ups, we should be able to do that.

Furthermore, the Filipino culture in adopting new technology is superior compared to our neighbors. We adopt technology far faster than anybody else in the region. We also tend to accelerate the transformation of the way we do business based on technology.

The prognosis for FIRe transformation in the Philippines is very good. It should be heralded or led by the government, such as the BSP, in creating regulations. In a similar fashion, DOST and DTI can put together a collaborative environment setup that helps our traditional entrepreneurs transform from regular shoemaking to technology-aided shoemaking, or pushing for something that the Philippines is really known for: up-cycling technology from trash to extremely great bags, and bringing it down to the masses.

What we need is a more unifying strategy and a more visible strategist. Filipinos have a lot of ideas, but we need to point out to someone with passion, goal, and metric that says we will succeed when we get there. FIRe is proving to be a great platform for progress in the Philippines. We have a good future ahead of us.

Views and Reactions

Alvin Culaba | Academician, Philippine National Academy of Science and Technology and Full Professor, De La Salle University

QUESTION: The Philippines is among the most vulnerable countries to climate change. How can we harness FIRe innovations to address environmental issues? As a scientist/ inventor and policy adviser, what is your assessment of the overall governance of science and technology (S&T) in the Philippines? What role do you envision the Philippines playing in the S&T landscape in the next decade or so? How can that role be improved and which actors should be involved?

FIRe technologies have already been there. It is just a matter of using them to address environmental problems. We still have the same environmental problems since the 1990s. These problems are because of us. That is why it is imperative that we solve it ourselves. It is primarily because we are using a linear economy. In a linear economy, products are made, we buy them, and then we dispose them. It has probably led to the climate change phenomenon.

We need to think of using the life cycle perspective: look at things from the whole value chain—from when you acquired raw materials and brought them to production, usage, and disposal. Now we have to embrace what we call the circular economy, which is being done in Taiwan and South Korea, for example.

We need to capitalize on these technologies and find alternative ways to be more resource-efficient. We have artificial intelligence, machine learning, deep learning, and the Internet of Things to gather data. Using these, we need to come up with something new, rather than dispose of materials or products at the end of their economic life. There can be some other uses for these products.

We also have to draw a number of information and data. With cloud-based computing, we can access data anytime, anywhere. This is one way that these technologies can address environmental issues.

On the question of overall governance of S&T, while it is true that DOST has the mandate on matters that relate to it, there are also other agencies that are engaged in research and development, such as DOH, DA, DENR, and even DND. There has to be some kind of whole-of-government approach in dealing with environmental problems.

To further involve the S&T community, we have to follow a quadruple helix, where it is not only the government, industry, and the academe working together (i.e., triple helix). We need to engage and involve civil societies, the community, and ordinary people. We need to engage them in the discussion to come up with solutions.

Open Forum

QUESTION 1

Rafaelita Aldaba (DTI): Physical infrastructure is crucial in building the innovation and entrepreneurship ecosystem. When is the entry of a third player going to materialize? What is the current status?

Eliseo Rio Jr.: The President wants it before Christmas, or maybe early December. By December, we will have a third telco. We are now finalizing the terms of reference (TOR). By Thursday or Friday, the final version of the TOR will be published. By law, we need to have it published for 15 days before it becomes effective. Once effective, contenders can buy the bidding documents. The third telco must be able to compete with Globe and Smart, which both have 130 million subscribers. To compete, the third telco must have both the financial and the technical capability. We will give the contenders one month or so to come up with their bidding documents.

The bidding date will be on the third week of November; the latest would be on the first week of December. Definitely, we will have a third telco before the end of the year, or we will be kicked out of government service.

QUESTION 2

Soc Bansuela (PAKISAMA): The first three industrial revolutions failed to promote an agriculture system that allows for better health, environment, and prosperity. In fact, they promoted a monoculture industrial agriculture that brought us to where we are now. Most of our farmers remain poor. We are not healthier. One out of 11 Filipinos is diabetic. Given these, how can FIRe possibly harness or change the trajectory of agriculture to achieve better health, better food system, and better agriculture practices? How can FIRE address inequality in agriculture? How can FIRE help in the transformation from monocrop to polycrop? How can FIRE hasten the inclusion of young farmers and women farmers in agriculture?

Fortunato dela Peña: First, I think our various production sectors are too much regulated, making them unattractive to investors and workers. Secondly, we should encourage our young, educated people to go into these areas. For instance, a farmers' association in Iloilo was led by a graduate of the Philippine Science High School, which made a lot of difference in the way the association is being managed and in the way technologies are introduced. He attracted three more Philippne Science graduates to work with them. What did I see? They focus on a particular product; they just produce colored rice, which is commanding a higher price in the market. The members who are graduates of Electronics and Communications Engineering were designing robots that can remove weeds in the farm.

Likewise, to encourage the youth, we added a new program in DOST called the Patriot Program. We immersed the youth in situations where they will really devote time for the country—and not just think of how much they will earn.

Winston Damarillo: From the entrepreneurial side, a well-articulated demand always fixes supply problems. This is promising for the Philippines, especially for the food and agriculture sector. If you notice, we have more restaurants now that are more conscious of where their food is coming from (e.g., farm-to-table food production, organic farming, single-origin coffee). These are the ones that attract the passion and attention of the millennial population. We now care about what we put in our bodies.

We need to change the mindset of people. We do have our disadvantage because our lands are small. Our ability to produce massive amounts of rice is challenged. But we have this ability to re-factor the demand side. The more we talk about that, the more the imagination comes back to innovation. We need to be innovative. Innovation is not mandated; it is not a policy, unfortunately, but innovation is inspiration. Once we connect inspiration to day-to-day realities and the technology necessary to make that reality the case, you will find your own passion to discover it.

Diwa Guinigundo: Aside from FIRe, there is another dimension to mitigating the challenges in the agriculture sector—that is, access to finance. FIRe can definitely enhance access to finance by having a more inclusive financial system. FIRe is a very good instrument to bring this about. BSP is ensuring our financial system is more inclusive. It is important for people to have access to bank credit or bank finance.

Session Synthesis

Emmanuel De Dios

Let me go to a few general points. One is potential. There is now a millennial market that is highly receptive and adept to FIRe technologies. In terms of technopreneurship, there is interest among large segments of Filipinos who have a cultural advantage in taking up new technologies. But, at the same time, we need help to put up infrastructure and the regulatory environment.

FIRE is dependent, to a large extent, on an open global environment, which is now being threatened by certain trends. But the overall assessment is that the forces of integration will ultimately prevail.

We talked about the importance of regulations and an ecosystem that is conducive to entrepreneurs. Here, we are not starting on ground zero. We have some good models, the *Bangko Sentral ng Pilipinas* (BSP) being one. We can cite its calibrated openness, for example, to bitcoin technology. The BSP's regulations are sufficiently experimental so as not to hold back new technologies, but prudent, at the same time, so that public interest is protected. This is an approach that can be tried, tested, and customized by other government agencies. The more dangerous impulse from government is overregulation, which can prevent the entry and adoption of new technology.

Even as we see the potentials of new technologies and the necessary conditions to fully tap into them, we should not forget the fundamentals or prerequisites. In education, for example, th is means attending to the quality of math and sciences as taught in elementary and high school, as well as history, philosophy, and social sciences. If Filipinos are to aspire for those analytical jobs that are least likely to be disrupted by FIRe, there is a need to address the education at the most basic level not only at the apex. At the higher levels, however, what is needed is to facilitate high-level exchange to nurture the STEM culture. Another fundamental requirement is infrastructure, a particularly evident hindrance to hosting advanced information and communications technology (e.g., the quality and access to the Internet).

Finally, all of this is happening in a country characterized by large disparities in technology literacy, wealth and income, and infrastructure). This implies that the impact of new technologies is also likely to be unequal. Managing this inequality to maintain and improve the inclusiveness of the Philippine society and its respect for human values is a challenge to all of us.

But, this is obviously not the end of the conversation—just the beginning.

Closing Remarks

Benjamin Diokno | Secretary, Department of Budget and Management

Good evening, everyone.

First of all, I would like to congratulate the Philippine Institute for Development Studies (PIDS) for a successful forum. This is a very important topic, one that presents itself with much urgency despite its recent nomenclature.

The Fourth Industrial Revolution (FIRE) is not anymore an idea; rather, it is a reality that promises a lot of possibilities in addressing the social problems that we face today.

We live in an age where artificial intelligence plays a big role in our day-to-day activities. The gadgets that utilize this intelligence have become indispensable—from smartphones to Smart TVs, and even robots that can mimic human behavior.

During my younger years, I thought the fax machine was the best thing that could ever happen. I'm not kidding. Let me explain. I was writing op-ed commentaries for several broadsheets then, and I would have to drive to the publisher myself to submit my articles. When the fax machine came, it was a huge relief. It became easier to send documents to anyone.

In comparison to our generation, those who are entering the workforce today will be stumped if we take away their smartphones and computers. Gadgets have become extensions of ourselves. In 2014, Brookings Institution argued that we might all be cyborgs–as the devices we carry in our pockets, or wear on our wrists, are no less part of our being than they would be if implanted in our bodies.

Earlier this year, I caught a glimpse of the FIRe in practice when our economic team visited Alibaba Univesity in Hangzhou, China. As you may know, Alibaba is a multinational conglomerate that specializes in e-commerce, retail, artificial intelligence, and technology.

During the visit hosted by the Alibaba group, we witnessed a "smart" supermarket that showed the future of retail. Transactions were cashless; payments were made through a digital platform called Alipay. Goods could be delivered in your doorstep in less than an hour. By collecting and leveraging big data from customers, Alibaba was able to grasp consumer habits, as well as producer practices, to ensure an efficient supply chain and logistics network.

But despite this great promise of the FIRE, there are certain caveats. One of these is the issue on privacy and security, as big data capitalize on information, some of which may be personal. Still, perhaps the most pressing challenge is the anticipated labor displacement in certain sectors of the economy.

As mentioned, the FIRE is primarily about artificial intelligence, which may replace human work in sectors like hotel and restaurant services.

In the United States, for example, a group of graduates from the Massachusetts Institute of Technology came up with a restaurant that replaced human chefs with seven automated cooking pots that simultaneously whip up meals in less than three minutes. In Japan, there is a hotel where

guests check in with robots which also deliver their luggage to their rooms.

This phenomena is a concern for the Philippines, since we rely heavily on our services sector. If you take a look at this graph, you will find many jobs in the services sector at risk for automation.

The future of work has taken over many discussions among policymakers and industry and business leaders. Make no mistake, we are very concerned. But, perhaps, some of our anxiety from this, as the Asian Development Bank would have us believe, may be overblown.

Technological change will bring jobs also. But the kinds of jobs the new industrial revolution will require us to prepare our workforce for are for an increasingly knowledge-driven and technology-intensive economy.

Of course, we have to acknowledge that we have our weak knowledge infrastructure. We have limited human capital in science and technology, low levels of research and development investment, and weak networks where these are concerned.

Hence, there is little optimism as to our capacity to innovate and create the products that will advance the FIRE. But with the right mix of policies and investment priorities, we can hopefully catch up and benefit from this new industrial revolution sooner rather than later.

Allow me to discuss opportunities available as regards this new industrial revolution insofar as our policy environment and government investment are concerned.

Human capital development

Consistent with the government's aim of developing the country's most important resource—its people—we continue to give education the highest allocation of the budget. We also provide huge allocations to the K to 12 and the Universal Access to Tertiary Education programs.

From PHP 470.5 billion in 2018, the budget for the K to 12 program is increased to PHP 528.78 billion in the proposed 2019 budget. Meanwhile, the budget for the Universal Access to Tertiary Education was increased from PHP 44 billion in 2018 to PHP 51 billion in 2019.

Science and technology investment

Acknowledging the rapid changes brought about by technology, part of our administration's 0+10 Socioeconomic Agenda is the promotion of science, technology, and the creative arts to enhance innovation and creative capacity toward self-sustaining, inclusive development.

To ensure the achievement of this goal, the budget for science and technology has been increased from PHP 19.5 billion this year to PHP 19.8 billion next year.

About one-fourth of this budget will go to expenditures for scholars of Philippine Science High School and Science Education Institutes.

Closer to home: BTMS, Virtual Store, DIME

Finally, and this is me bringing it a bit closer to home, I would like to talk about a number of key reforms in my department, the Department of Budget and Management (DBM), that are important steps for modernizing government.

It is difficult to imagine that until recently, our Public Financial Management (PFM) System remained highly decentralized and, therefore, technology used for different PFM activities, including accounting and fiscal reporting, varies across spending units.

There were attempts in the past to create a fully automated centralized system for all PFM transactions. However, they all failed. As a result of more careful planning, we have successfully rolled out our Budget and Treasury Management System (BTMS) in the DBM and the Bureau of Treasury. By subjecting expenditure items in the budget to the BTMS, a rigorous, automated control regime, the executed budget will better reflect the budget law that was approved by the legislative.

This October, we are launching a virtual store for procurement. This online store will serve

as a platform for online purchases of common-use supplies and equipment. With the application, payment can be done using the user agency's e-Wallet for ease in transaction. Delivery will be made within three days for agencies within Metro Manila, but goods can also be picked up from the nearest depot. This is a key feature of the modernized Philippine Government Electronic Procurement System (mPhilGEPS), the single, centralized electronic portal that serves as the primary and definitive source of information on government procurement.

Finally, and perhaps inching closer to our FIRE aspirations, we also have the Project Digital Imaging for Monitoring and Evaluation or Project DIME. A partnership between the DBM and the DOST, Project DIME makes use of satellites, drones, and computers, to monitor projects real-time. Project DIME is expected to curb corruption in the form of ghost projects, especially the hard-to-monitor infrastructure projects.

With the exception of DIME, most of what I have discussed will perhaps sound like business as usual. Admittedly, government policy and legislation is barely catching up with the rapid pace of technological growth, and will unlikely catch up in the near future.

Of course, we are no less bullish in laying the foundations to prepare for a new industrial revolution as we are in solving our present-day problems. Fortunately, we have institutions like the PIDS that remain relevant and forward-thinking.

At the onset, this radical shift in our industrial technology is sure to create winners and losers. Again, the government cannot address the challenges FIRE will bring about by itself. We must all work together to ensure we usher in a new era of productivity that is inclusive and broad-based.

The private sector is instrumental in this pursuit. After all, this is the playing field of innovation—the industries and individuals that pave the way for industrial revolutions. We in the government, however, are not complacent of the role we can play to stimulate innovations. It is our job, of course, to incentivize and support them to invest in such undertakings, or simply get out of the way of innovation.

Trust that we in the government will work with you should you have policy proposals that will aid in the transition to this new industrial revolution. I, for one, am keen to gather your insights from this forum.

Again, thank you, PIDS, for organizing this timely and relevant event, and thank you everyone for participating.

Key Takeaways

The Fourth Industrial Revolution (FIRe) differs fundamentally from previous revolutions.

It builds on the Digital Revolution and introduces cyber-physical systems (CPS) that allow technology to be used pervasively in societies and even embedded in the human body. Its technological breakthroughs have transformed and even created whole new fields, including advanced robotics, artificial intelligence (AI), nanotechnology, quantum computing, big data, blockchain, biotechnology, innovative materials, the Internet of Things (IoT), 3D printing, virtual reality, and energy capture, storage, and transmission. FIRe is expected to create a smarter, more connected world. It will affect all disciplines, economies, and industries, and challenge ideas about what it means to be human.

FIRe has spread not just in the advanced economies. It also promises new approaches and powerful tools to overcome seemingly intractable problems of developing countries. The following are examples:

- Vision-based artificial intelligence analytics software for traffic and transport applications.
- Cloud-based computing, machine learning, and the IoT for greater resource efficiency promoting a circular economy model of development.
- Sensitive sensors in plants or blockchain technology in production and supply chains to promote polyculture in our agriculture and food systems.
- Digital technologies and mobile devices to achieve financial inclusion. Even simple technologies like chatbots or messengers are being tapped to provide micro enterprises with small amounts to finance cottage industries.
- Big data analytics that allow businesses and governments to understand market needs and address data gaps affecting those who are left behind.
- Web-adapted training and education that provide learners from remote and poverty-stricken areas with access to courses in mathematics and engineering.

If technology solutions are to be effective, however, the problems to be solved must first be well articulated and behavior of the users understood.

Whether for public or commercial use, the novelty and genius of a technology alone will not guarantee its successful adoption. From the entrepreneurial side, it is already established that a well-articulated or anticipated demand is the key even before supply problems are tackled. Innovation means being able to fill an unmet demand or satisfy a need by introducing a new product. But a more far-sighted consideration of consumer behavior and social acceptance is needed when developing and introducing innovations. Object lessons can

be learned from the various privacy, security, and ethical concerns that have lately attended such technologies as facial recognition, social media, and gene-editing, just to cite a few examples. It is important to engage intensively with consumers, gain insights into their behavior, and develop a sense of the society's ethical foundations when commercializing an innovation.

To take advantage of the opportunities brought about by FIRe, society must adopt a global perspective and encourage deeper and wider local participation. Emerging technologies must be continuously and systematically monitored and innovation leaders sought out.

FIRe requires an open trade and investment regime that encourages the flow of people, goods, services, and knowledge. It is the nexus of these things that promotes technology uptake and development.

In particular, the country needs an environment that encourages foreign investment. Foreign investors bring with them not only their capital and know-how but more importantly also their technologies and their customer base. The country needs to find ways to tap more intensively and deliberately into global networks. By attracting global companies that are science and technology (S&T)-intensive and by encouraging linkages between these and local value-chain partners, we can develop the country's S&T ecosystem. Attracting these types of investments can fundamentally change the nature of training and the expertise of our workers.

To produce a future-ready workforce, we must change our approaches to education and training and our view of learning more generally.

Filipinos need to be well equipped not only to face the challenges of FIRe but also to leverage opportunities for the advancement of self, community, and the nation at large. We must not forget to look at the fundamentals (i.e., math and sciences, languages, history, philosophy, and social sciences in basic education) and use technology as leverage for better productivity such as incorporating computer programming in the basic education curriculum. In terms of the set of skills needed, both cognitive and noncognitive skills are important.

We need to find, test, validate, and improve upon the critical building blocks in a "LEGO-like" education and training system that equips students to deal with FIRe. For any level beyond secondary, (i.e., tertiary education as well as voc-tech education and training), industry engagement will be critical. Rapid changes in technology require greater education and training and industry collaboration to shorten the cycle of training and adoption of emerging technologies. Industry must involve itself both in curriculum development and delivery. The use of novel university/industry education and re-education models must be encouraged and the financing models must be found to encourage and sustain such initiatives.

Lifelong learning will be the norm. "The illiterate of the 21st century," as Alvin Toffler stated, "will not be those who cannot read and write, but those who cannot learn, unlearn, and relearn." Other countries have demonstrated the importance of inculcating the mindset that learning for life is a personal responsibility—not the employer's nor the education system's alone.

To ensure that FIRe is inclusive and that domestic capacities for innovation are supported, the availability and quality of digital infrastructure is most critical.

Digital connectivity must be significantly improved. The central role the Internet plays in new technologies makes it essential to develop a nationwide broadband backbone and other ICT infrastructure, first because the new technologies cannot even be effectively deployed without it, and second so that more Filipinos across the country can be part of and benefit from FIRe.

ICT infrastructure is bound to rise to the level of importance of basic infrastructure for electricity supply and transport.

Digital platforms can also be considered new forms of infrastructure. Digital platforms bring together different market participants more efficiently and serve as magnets for entrepreneurs. The government should level the playing field in the market and ensure that the promise of FIRe benefits not just the biggest companies but also the small players in the country. It should allow the private sector to put in the capital and take the risks.

FIRe features the ascendancy of CPS, where connectivity and computational elements become tightly integrated with physical infrastructure and the built environment. These systems take advantage of advancements in sensing, communications, and computational capacity to generate data that are used for closed-loop feedback, which in turn, brings about enhanced performance in terms of accuracy, throughput, reliability, and resilience. Embedded computers, ubiquitous connectivity, and storage are enabling pathways for rapidly increasing data creation and for these data to be fused and processed into actionable information. To support local scientific research and development (R&D) that enables the FIRe and the thrust for a data-driven society, the science infrastructure for data creation, storage, computation, and connectivity supported by government is essential.

Given the speed of technological changes and the uncertainty they create, flexibility will be key to riding the wave of FIRe disruptions.

All spheres of economic activity are being disrupted by technology requiring flexibility to respond and adapt. Skills and competencies developed in school should be like LEGO blocks, which can be used to create different figures using the same building blocks. Built-in flexibility and relevance in the college curricula should be advocated to avoid possible mismatch in skills and jobs.

In labor markets, nontraditional forms of work have increased with technological change and globalization requiring greater agility for both firms and workers to survive. The existing legal and regulatory framework must be updated to help both firms and workers face the increasing risks imposed by digitalization. They should be nimble and be given greater elbow room to stay competitive. Regulating the labor market should not curtail flexibility, but policies must make sure that workers do not bear all the risk.

The social protection systems of the future must be based on policy principles that ensure universal and adequate coverage and sufficient adaptability to new requirements. These principles include universality of and accessibility to social protection systems, adequacy, transferability, transparency, gender equality and inclusion, and good governance, ensuring that the social protection systems are financed in sustainable and equitable ways.

As for industry regulation, adherence to outdated procedures and requirements will not promote consumer welfare. The goal of regulation should not be parity of regulation but rather parity of protection. Regulators need to balance risk with the need to support innovative business models and services. Regulators should be guided by the "innovation principle" not the "precautionary principle" through appropriate types of regulation that do not hinder innovation. Needed are adaptive regulatory frameworks and regulatory sandboxes to enable businesses to test new products, services, and models.

Government must redefine its role in the era of FIRe.

To nurture science, technology, and innovation, government should work with the private sector to improve human capacities for the labor market and to systematically increase the S&T workforce. It should increase support for S&T with proper consideration for what R&D institutions can

actually absorb. Finally, government must also remove regulatory barriers and burdens to innovation and doing business.

Government must be forward-looking. Its attitude must be to encourage innovation, not stifle it. At the same time, appropriate policy interventions are critical to ensure that new technologies serve economic and social development. Government must ensure that citizens are protected against cybercrimes, unintended job losses, greater inequality, and disillusionment as the nature of work changes. There is a critical role for the public sector in providing social protection that is fiscally, economically, and socially sustainable.

We need a unifying strategy and a visible strategist.

Various strategies adopted in other countries can be useful for the Philippines. These include developing formal national digitalization strategies and particular strategies for the deployment of AI, IoT, and other technologies; making the digitalization of manufacturing a national policy by providing small and medium enterprises with tax credits to facilitate equipment upgrades; developing smart-manufacturing workforce training/credentialing programs and supporting investments in these by enterprises; deploying next-generation digital infrastructure (e.g., 5G); and making digital literacy a central objective of public education and adult workforce retraining systems. Other countries have shown the importance of an integrated learning system. Regardless of where people start or pause, they should be able to keep coming back in the system for upgrading and reskilling.

The Philippines' new industrial strategy called the Inclusive Innovation Industrial Strategy (i^3S) focuses on innovation to help the country prepare for Industry 4.0. The overall goal is to grow and develop globally competitive and innovative industries with strong forward and backward linkages. The six elements of the i^3S are (1) innovation policy and commercialization, (2) building of industry clusters, (3) funding and finance, (4) cultivating an entrepreneurial culture, (5) government-academe-industry collaboration, and (6) human resource development for innovation-ready workforce. This new strategy also seeks to promote collaboration and closer coordination among different government agencies at the national and local levels to conduct research, provide physical innovation infrastructure, develop human resource, provide funding, and conduct innovation policy monitoring and implementation.

Other programs and initiatives exist in both the public and private sectors. An industry leader makes a positive prognosis for FIRe transformation owing to Filipinos' readiness to embrace new technologies. What the country lacks is an ecosystem for sustainable success. What we need is a more unifying strategy and a more visible strategist in the national leadership—someone equipped with the passion, the vision, and the metrics who can lead, inspire, and motivate people to act.

Ultimately, FIRe must be harnessed to achieve inclusive and sustainable development.

These developments are occurring in a country still characterized by large disparities in income, education, and technological competence. But FIRe will not wait for the country to resolve its socioeconomic disparities. Therefore, the impact of new technologies can only be expected to be unequal and to exacerbate existing inequalities. The poor lack the resources needed to adapt and upgrade their competencies to changing market demands arising from FIRe. This can lead to greater inequality, displacement, exclusion, social division, and political instability. Managing inequality to maintain the inclusiveness of Philippine society and its respect for human values is a challenge to all and demands a response that includes strategies for social adaptation and mitigation.

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HARNESSING THE FOURTH INDUSTRIAL REVOLUTION: CREATING OUR FUTURE TODAY

Proceedings of the Fourth Annual Public Policy Conference 2018

The advent of the Fourth Industrial Revolution (FIRe) has dramatically changed the world we live in. The FIRe, characterized by the fusion of the physical, digital, and biological worlds, is radically transforming businesses and poses risks that may highly impact our society.

To better understand its potential socioeconomic impacts and benefits for the country, the Philippine Institute for Development Studies dedicated the Fourth Annual Public Policy Conference (APPC) held in September 2018 to the discussion of this topic through the theme "Harnessing the Fourth Industrial Revolution: Creating Our Future Today".

This volume compiles the proceedings of the APPC 2018 to provide a useful reference for our leaders and policymakers on the opportunities and issues associated with the FIRe. It covers evidence-based policy studies, articles, and commentaries written by esteemed international and local experts in the fields of engineering, computer science, physics, agriculture, economics, governance, and business, to name a few. It likewise contains recommendations to mitigate the risks and reap the benefits brought by FIRe to further advance Philippine development.

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