Seeking Out Opportunities and Gearing Up for Challenges in the Fourth Industrial Revolution (FIRe)

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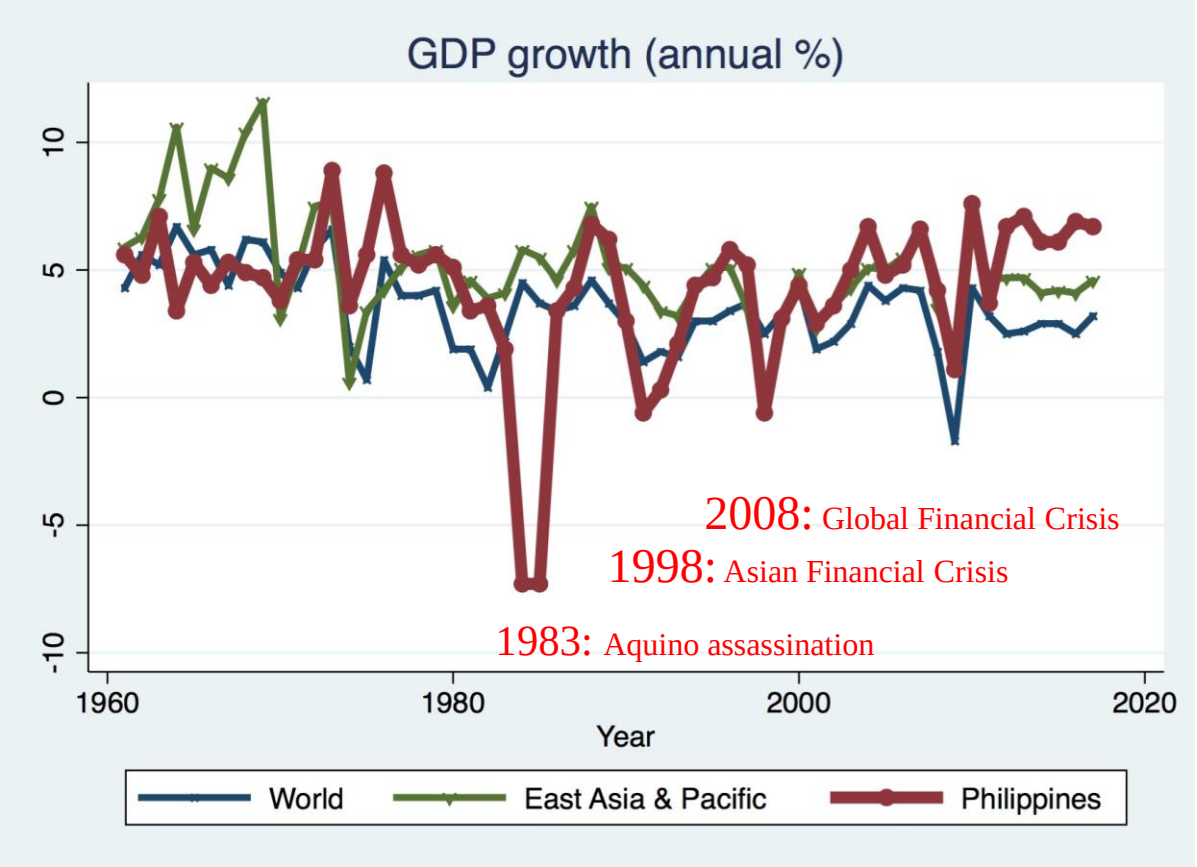
Agenda

1. Introduction
   - Economic Growth and Technologically-Driven Progress
   - What is the FIRe and its Frontier Technologies?
   - Potential Impacts from FIRe Technologies
2. Innovation Ecosystem
   - Readiness for Future Production
   - Innovation Statistics
3. Government as “Gardener”
   - Preparing the Ground (Education)
   - Nurturing the Soil (R&D)
   - Watering the Ground (Support to Innovation)
   - Others : Social Protection, Tax Reform, Whole of Nation Paradigm and Action Agenda

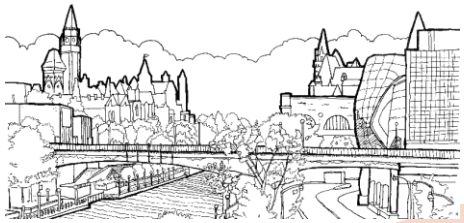
1. Technology and Progress

Since the 1960s, the Philippines has had booms and busts



- Starting 2012, PH economic performance even better than average in East-Asia and the world
- Negative growth in East Asia only in 1998, and across the world in 2009
- Buoyant expectations for global progress in the wake of the emerging Fourth Industrial Revolution (FIRe)

1. Technology & Progress (cont'd)



Fire

Agriculture

Wheel

Cities

Manufacturing & Trade

History of Technological Progress

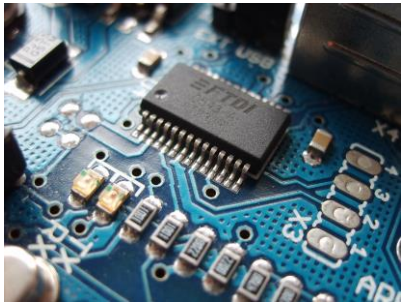
1. Technology & Progress (cont'd)

What is the Fourth Industrial Revolution (FIRe)?

First came steam and water power; then electricity and assembly lines; then computerization. Throughout history, we have improved industry by migrating from established production methods to utilizing cutting-edge technologies

1st Revolution
(1784)
Steam, water, mechanical production equipment

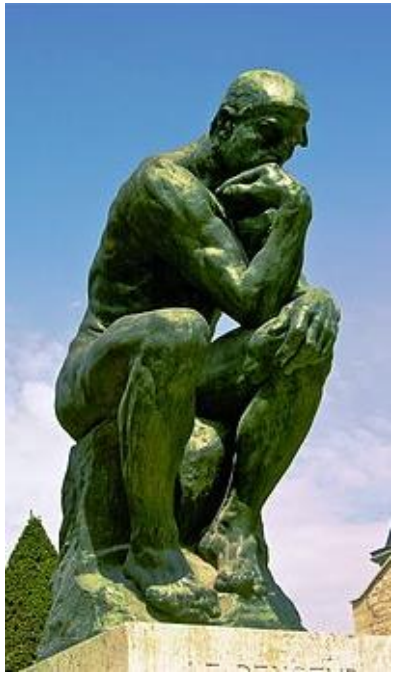
2nd Revolution
(1870)
Division of labor, electricity, mass production, assembly line



3th Revolution
(1969)
Electronics, computers, internet, automated production

4th Revolution
(???)
Cyber-physical systems

1. Technology & Progress (cont'd)



What is FIRe? (cont'd)

"*Characterized by a fusion of technologies that is blurring the lines between the physical, digital and biological spheres.*" – Schwab (2016)

1. Technology & Progress (cont'd)

Frontier technologies

identified by select organizations

(ESCAP, 2018)

- No universally agreed definition of frontier technology

- It shows that the following technologies have been most commonly identified as frontier: 3D printing, the Internet of Things, AI, and robotics

OECD	World Bank	World Economic Forum	McKinsey Global Institute	Institute of Development Studies	MIT Technology Review 2018
Internet of Things	Fifth-generation (5G) mobile phones	Artificial intelligence	Mobile internet	3D printing	3D Metal Printing
Big data analytics	Artificial intelligence	Robotics	Automation of knowledge work	Collaborative economy tools	Artificial Embryos
Artificial intelligence	Robotics	Internet of Things	Internet of Things	Alternative internet delivery	Sensing City
Neuro technologies	Autonomous vehicles	Autonomous vehicles	Cloud technology	Internet of Things	Artificial intelligence for Everybody
Nano/micro satellites	Internet of Things	3D printing	Advanced robotics	Unmanned aerial vehicles/drones	Dueling Neural Networks
Nanomaterials	3D printing	Nanotechnology	Autonomous and near-autonomous vehicles	Airships	Babel-Fish Earbuds
3D printing (additive manufacturing)		Biotechnology	Next-generation genomics	Solar desalination	Zero-Carbon Natural Gas
Advanced energy storage technologies		Materials science	Energy storage	Atmospheric water condensers	Perfect Online Privacy
Synthetic biology		Energy storage	3D printing	Household-scale batteries	Genetic fortune-telling
Blockchain		Quantum computing	Advanced materials	Smog-reducing technologies	Materials' Quantum Leap
			Advanced oil and gas exploration		
			Renewable energy		

Technology	Description
3D printing	Advances in additive manufacturing, using a range of materials and methods, innovations include 3D bioprinting of organic tissues
Internet of things (IoT)	the use of networked sensors to remotely connect, track and manage products, systems and grids
AI and robotics	Devt of machines that can substitute for humans, increasingly in tasks associated with thinking, multitasking and fine motor skills
Big data	High volume, velocity, and variety data from more use of interent (social media, search engines, digital commerce) and sensors
Virtual and augmented realities	Interfaces between humans and computers involving immersive environments, holographic readouts and digitally produced overlays for mixed-reality experiences
Blockchain	Distributed ledger technology based on cryptographic systems that manage, verify and publicly record transaction data
Neurotechnology	Innovations (smart drugs, neuroimaging and bioelectric interfaces) that allow for reading, communicating and influencing human brain activity

1. Technology & Progress (cont'd)

Frontier technologies

Technology	Description
Advanced materials and nanomaterials	Creations of new materials and nanostructures for the development of beneficial material properties, such as thermoelectric efficiency, shape retention and new functionality
Energy capture, storage and transmission	Breakthroughs in battery and fuel cell efficiency; renewable energy through solar, wind and tidal technologies, energy distribution through smart grid systems, wireless energy transfer, and more.
New computing technologies	New architectures for computing hardware, such as quantum computing, biological computing or neural network processing, as well as innovative expansion of current computing technologies (such as cloud computing)
Biotechnologies	Innovations in genetic engineering, sequencing and therapeutics, as well as biological computational interfaces and synthetic biology
Geoengineering	Tech interventions in planetary systems, typically to mitigate effects of climate change by revoming carbon dioxide or managing solar radiation

1. Technology & Progress (cont'd)
Frontier technologies

1. Technology & Progress (cont'd)
Potential Impact of FIRe technologies

	Economic Implications	Socio-Cultural Implications	Political & Security Implications
Robotics and AI	• Technological unemployment • Income Inequality • Disruption of traditional business models and global value chains	• Rise of monopolies and oligopolies	• Political polarization • Instability • Data and access security risks to automation • Espionage, Terrorism, Autonomous warfare
IOT	• Disruption of traditional business models	• Erosion of personal privacy	• Lack of trust in institutions • Cybersecurity problems • Data fraud
3D-printing	• Disruption of existing business processes		• Weapons proliferation • Cyber-sabotage

1. Technology & Progress (cont'd)

Some Technologies of the FIRe

Additive Manufacturing (or 3D-Printing)
Example: Bio-printing organs, prosthetics and drugs

From Medical Futurist : https://medicalfuturist.com/3d-printing-in-medicine-and-healthcare

1. Technology & Progress (cont'd)

Some Technologies of the FIRe

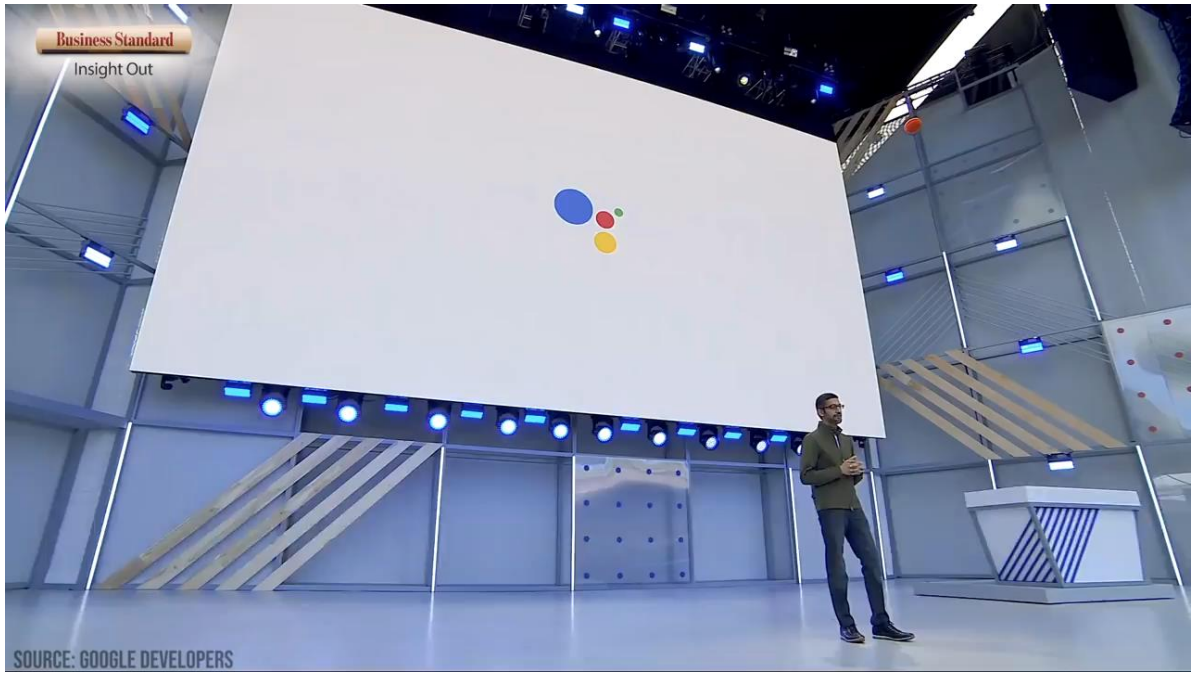
Internet of Things (IoT)
Devices connected with each other and sensors

From Shots of Awe ：https://www.youtube.com/watch?v=bNdLMVYEQKM

1. Technology & Progress (cont'd)

Some Technologies of the FIRe

Artificial Intelligence (AI)
Example: Google Assistant



From Business Standard : https://www.youtube.com/watch?v=d40jgFZ5hXk

1. Technology & Progress (cont'd)

Some Technologies of the FIRe

Artificial Intelligence (AI)
Example: Detecting Diseases in Cassava

From TensorFlow : https://www.youtube.com/watch?v=NlpS-DhayQA

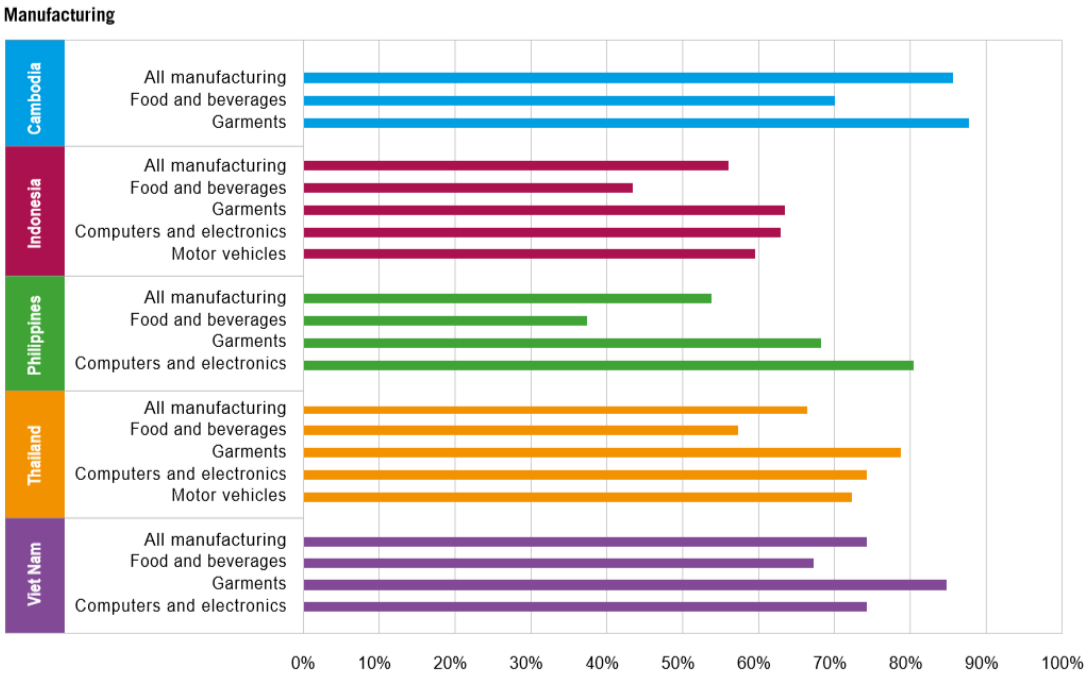
1. Technology & Progress (cont'd)

Some Technologies of the FIRe

Robotics (and Drones)
Example: Drones used in Precision Spraying

From Cool Tech : https://www.youtube.com/watch?v=59ldb4Hf4k4&t=138s

Share of wage and salaried employment in key **manufacturing** subsectors at high risk of automation (per cent).



ILO (2016)

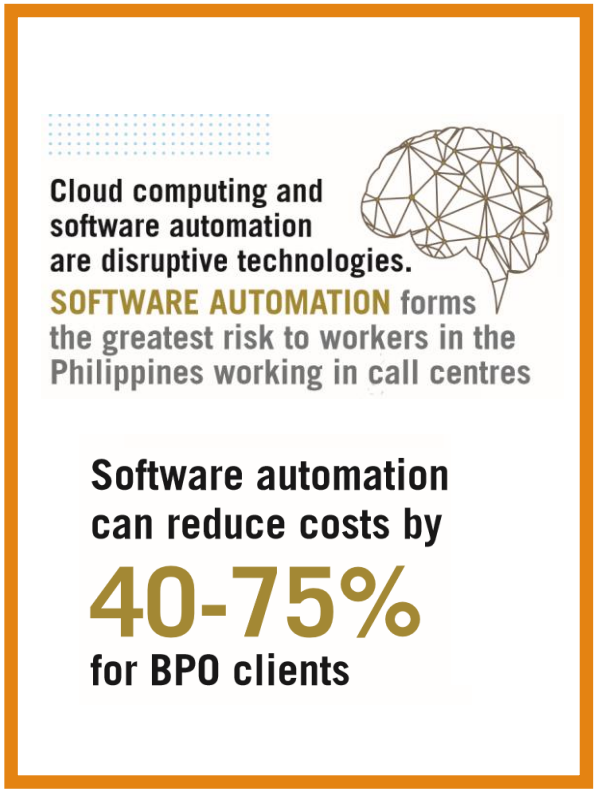
Acc to ILO, in the Philippines:

- nearly half (49%) of wage workers (males: 44%, females : 52%) face a high probability of getting affected by automation
- those working as fishery labourers (580,000), waiters (574,000), carpenters (525,000) and office cleaners (463,000) face a high potential of automation
- around 89 per cent of salaried workers in BPO sector fall into the high risk category of automation

1. Technology & Progress (cont'd)

Potential Impact of FIRe technologies

The Fourth Industrial Revolution will trigger selective reshoring, nearshoring and other structural changes to global value chains (WEF 2018, ILO 2016)



1. Technology & Progress (cont'd)

Potential Impact of FIRe technologies

- Autor (2015) argues that **extent of machine substitution** for jobs tend to be **overstated** by ignoring strong complementarities which increase productivity, raise earnings and augment demand for labor
- Autor adds that **even if automation does not reduce quantity of jobs, it may affect the qualities of jobs that are available**
- Policy implication: **human capital investments** must be at the **heart of any long-term strategy** on preparation for impact of technology on jobs

1. Technology & Progress (cont'd)
General Optimism about FIRe on jobs

1. New tech often automate only some tasks, and not entire job
   - The case of the bank teller
2. Technological feasibility is not adoption
   - The case of the bank teller again
   - Industry 1.0. 2.0, 3.0 persists
   - Pessimistic view (e.g., Stiglitz, 2017) : markets cannot adjust fast enough without massive displacements in jobs

1. Technology & Progress (cont'd)
General Optimism about FIRe on jobs

3. Domestic demand more than compensated for job losses from automation
   - production "reshoring" back to advanced economies did not occur
   - it did not occur ≠ it will not happen

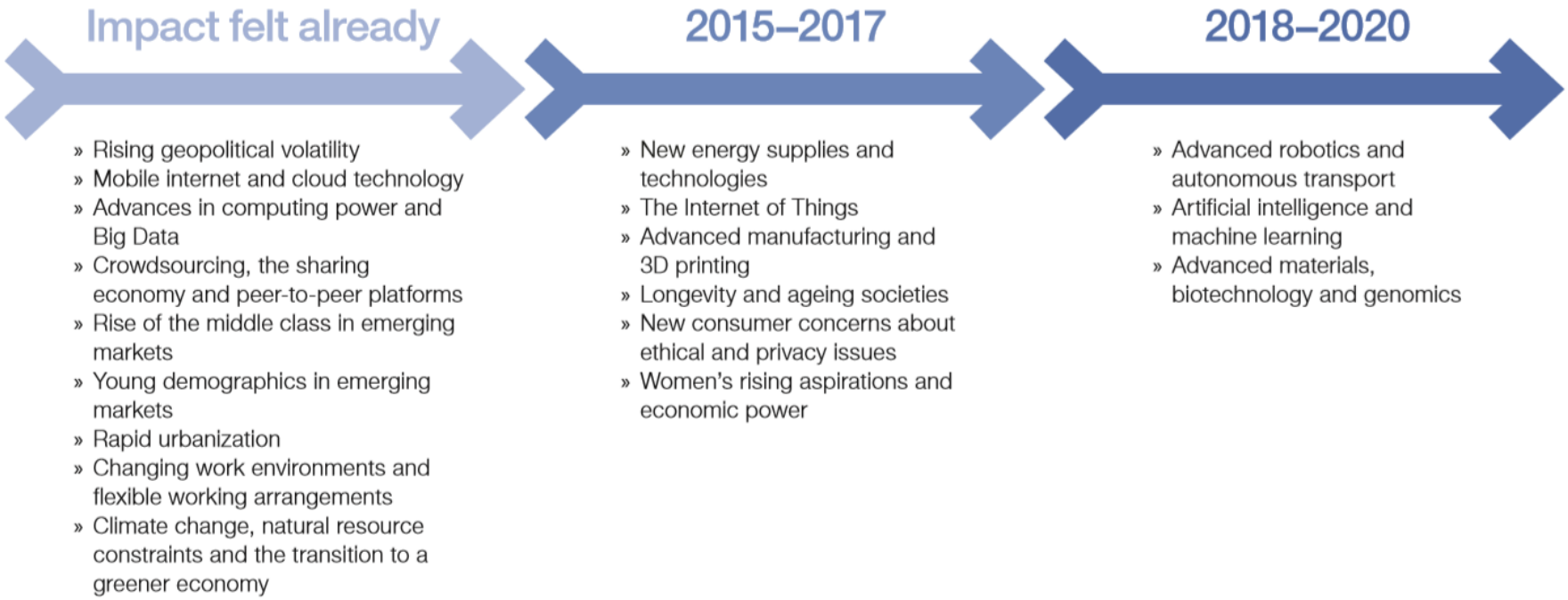
4. Technology creating new jobs, new business models, and new industries

amazon

airbnb

MYKUYA
#YourHelpingHandOnDemand

Timeframe to impact industries, business models



WEF (2016)

Crucial Emerging Technologies for the SDGs until 2030 (examples) (1/2)

Technology cluster	Emerging technologies	Opportunities	Potential Risks/Threats
Bio-tech	Biotechnology, genomics, and proteomics; gene-editing technologies and custom-designed DNA sequence; genetically modified organisms; stem cells and human engineering; bio-catalysts; synthetic biology; sustainable agriculture	Food crops, human health, pharmaceuticals, materials, environment, fuels	Military use; irreversible changes to health and environment
Digital-tech	Big Data; Internet of Things; 5G mobile phones; additive manufacturing; Cloud computing; open data technology; free and open source; Massive open online courses; micro-simulation; E-distribution; systems combining radio, mobile phone, satellite, GIS, and remote sensing data; data sharing technologies, including citizen science-enabling technologies; social media technologies; mobile Apps to promote public engagement and behavioral change; pre-paid system of electricity use and automatic meter reading; digital monitoring; digital security	Development, employment, manufacturing, agriculture, health, cities, finance, absolute "decoupling", governance, participation, education, citizen science, environmental monitoring, resource efficiency, global data sharing, social networking and collaboration	Unequal benefits, job losses, skills gaps, social impacts, poor people priced out; global value chain disruption; concerns about privacy, freedom, and development; data fraud, theft, cyber attacks

Source: UNDESA, 2016

Crucial Emerging Technologies for the SDGs until 2030 (examples) (2/2)

Technology cluster	Emerging technologies	Opportunities	Potential Risks/Threats
Nano-tech	Nano-imprint lithography; nanotechnology applications for decentralized water and wastewater treatment, desalination, and solar energy (nanomaterial solar cells); promising organic and inorganic nanomaterials, e.g., graphene, carbon nanotubes, carbon nano-dots and conducting polymers graphene, perovskites, Iron, cobalt, and nickel nanoparticles, and many others	Energy, water, chemical, electronics, medical and pharmaceutical industries; high efficiencies; resources saving; CO2 mitigation.	Human health (toxicity), environmental impact (nanowaste)
Neuro-tech	Digital automation, including autonomous vehicles (driverless cars and drones), IBM Watson, e-discovery platforms for legal practice, personalization algorithms, artificial intelligence, speech recognition, robotics; smart technologies; cognitive computing; computational models of the human brain; meso-science powered virtual reality	Health, safety, security (e.g., electricity theft), higher efficiency, resource saving, new types of jobs, manufacturing, education	Unequal benefits, de-skilling, job losses and polarization, widening technology gaps, military use, conflicts.

Source: UNDESA, 2016

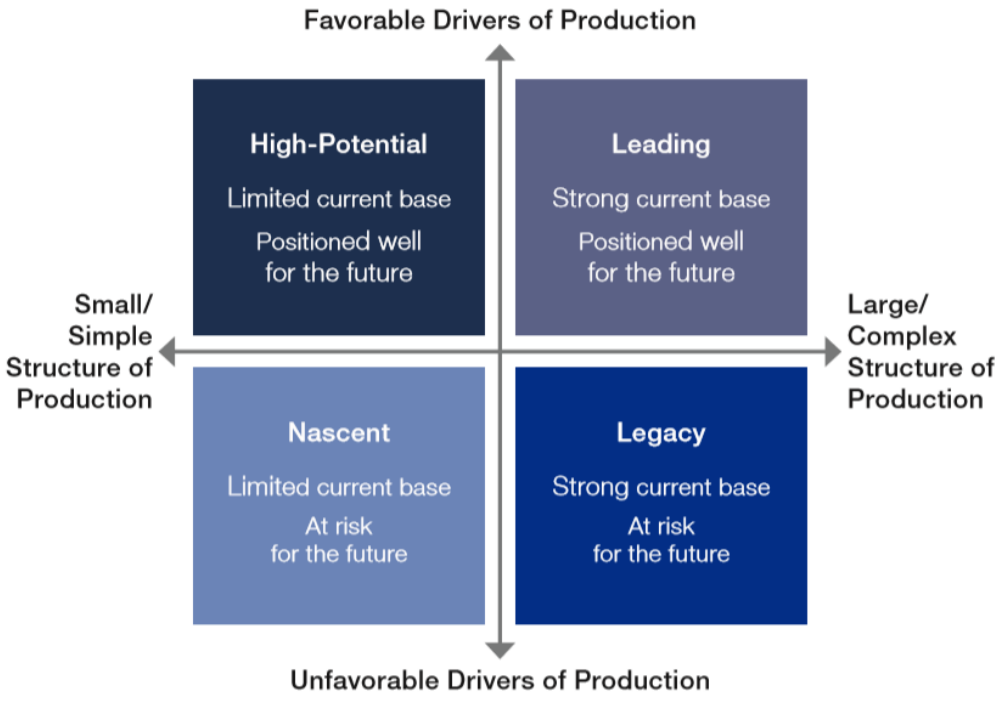
2. Innovation Ecosystem
FIRe and the SDGs

SDG	APPLICATIONS
Agriculture (SDGs 1, 2, 5, 8, 10 and 12)	Recent advances in image recognition allowed researchers to scan more than 50,000 photos of plants to help identify crop diseases at sites using smartphones with a success rate of over 99 per cent
Healthcare (Goal 3)	AI applications have been developed that substitute and complement highly educated and expensive expertise by analyzing medical images. 3D printing produce patient specific prosthetics, orthotic braces and customized medical implants.
Environment and climate (Goal 13)	AI and deep learning can help climate researchers and innovators test out their theories and solutions as to how to reduce air pollution

ESCAP (2018)

2.1. WEF Assessment on Preparations

Country Archetypes



Note: Average performance of the top 75 countries (weighted average driver score, weighted average structure score) is at the intersection of the four quadrants to create the archetype borders.

WEF (2017)

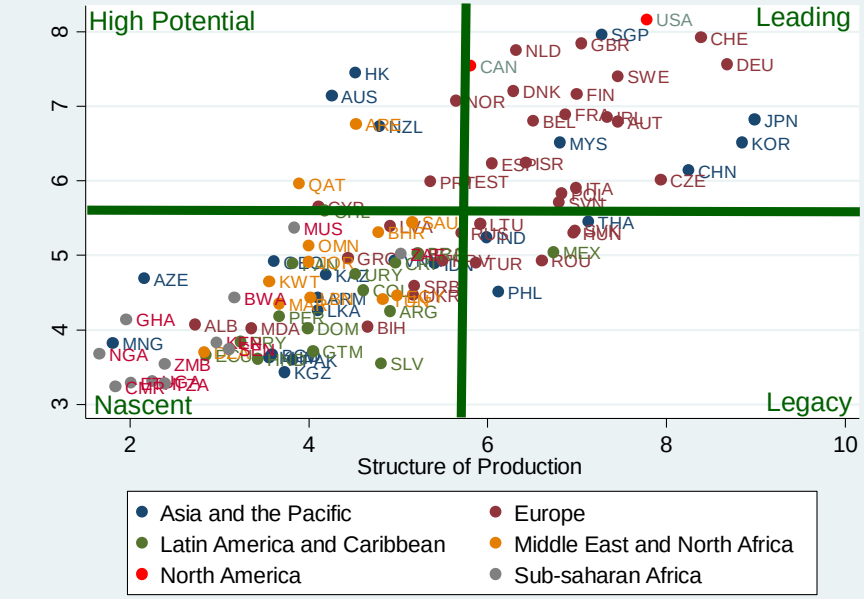
The seven ASEAN countries included in the assessment are spread across three different archetypes: Leading— Malaysia and Singapore; **Legacy**— Philippines and Thailand; and Nascent— Cambodia, Indonesia and Viet Nam.

Legacy country **-** 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.

2.1. WEF Assessment on Preparations (cont'd)

- Investments in R&D, hard and soft infrastructure, as well as capacity dev't of human resources and institutions are complementary factors for Inclusive Development and for **Readiness for Future of Production**

Drivers and Structure of Production



WEF (2018)

2.2. Statistics on Innovation in PH

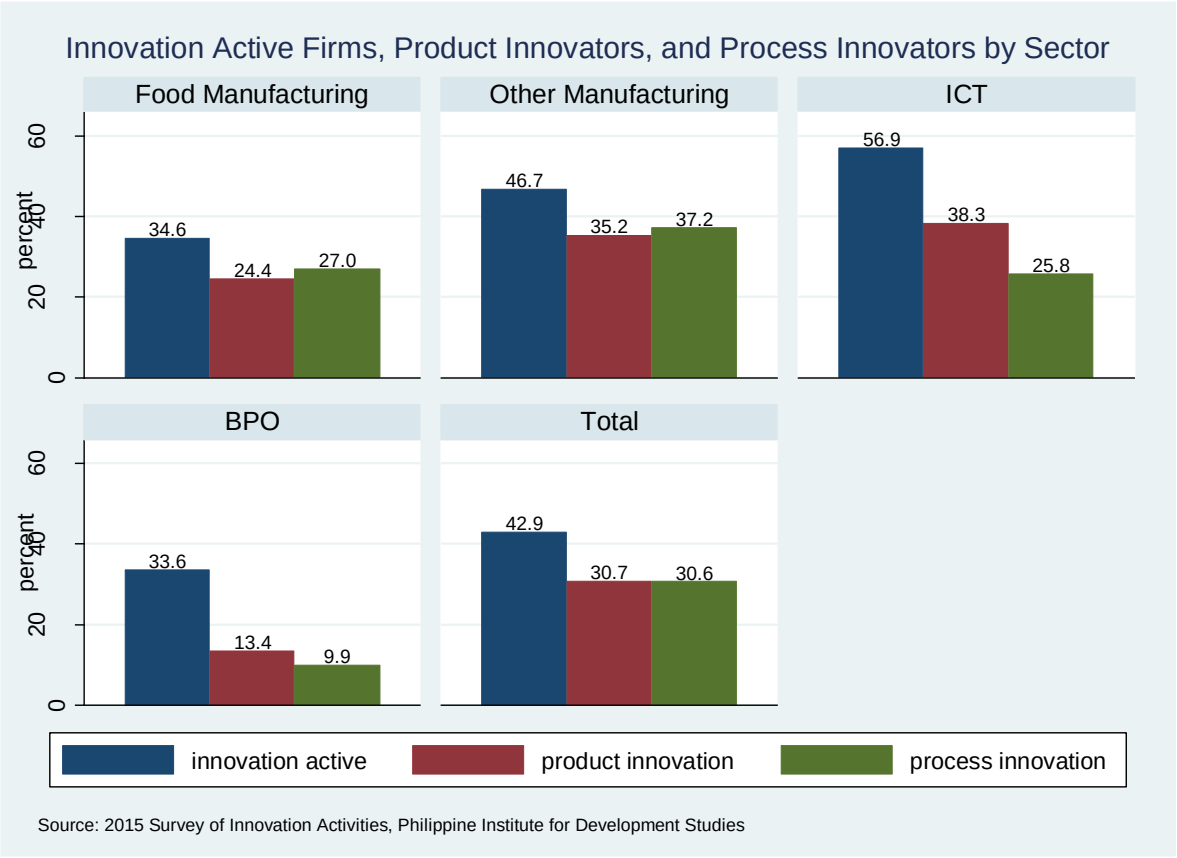
- Innovation is widely regarded as a major driver of economic output, productivity and competitiveness … but not all firms innovate

	PHILIPPINES			ALL COUNTRIES
Indicator	2009 SIA	2015 PIDS	2015 WORLD BANK ENTERPRISE SURVEY	
Percent of firms that introduced a new product/service	37.6	30.7	32.9	36.6
Percent of firms that introduced a process innovation	43.9	30.6	40.9	34.2
Percent of firms that spend on R&D	40.3	26.7	21.9	16.9

2.2. Statistics on Innovation in PH
(cont'd)

About two-fifths (42.9%) of PH firms are innovation active. A third (30.7%) are product innovators. A third (30.6%) are also process innovators.

Innovation varies across sector (and even by size of firm).



Source: 2015 Survey on Innovation Activities, PIDS

2.2. Statistics on Innovation in PH
(cont'd)

Determinants of Innovation: Logistic Model Results

- The practice of **knowledge management** is a **determinant** of product innovation, process innovation and being an innovator.
- Human resources matter: firms with 20 percent or fewer employees having post-baccalaureate degrees are less likely to be innovators than those with at least a fifth of employees having post-baccalaureate degrees.
- Gross sales matters: **higher gross sales** (which correlates with establishment size) is a positive determinant of innovation..
- Location generally does not matter much, except for product innovation

2.2. Statistics on Innovation in PH (cont'd)

Sources of Innovation in PH firms (acc to 2015 SIA)

Information source rated with "high" importance		MSMEs	Large	All Firms
1. Internal	a. Within your establishment or enterprise	9.1	32.3	10.2
2. Market source	a. Suppliers of equipment, materials, components, or software	7.5	16.1	7.9
	b. Clients or customer	14.1	19.8	14.3
	c. Competitors or other enterprise in your sector	8.7	9.0	8.7
	d. Consultants, commercial laboratories, or private R&D institutes	3.5	6.7	3.6
3. Institutional source	a. Universities or other higher education institutions	1.9	3.7	1.9
	b. Government or public research institutes	1.1	2.6	1.2
4. Other source	a. Conferences, trade fairs, exhibitions	5.9	10.8	6.2
	b. Scientific journals and trade/technical publications	2.0	7.1	2.2
	c. Professional and industry associations	3.5	8.7	3.8

Clients and internal sources are regarded as highly important as sources of information on innovation. MSMEs regard customers most at 14.1% while a third of large firms relies heavily on information within the enterprise.

2.2. Statistics on Innovation in PH (cont'd)

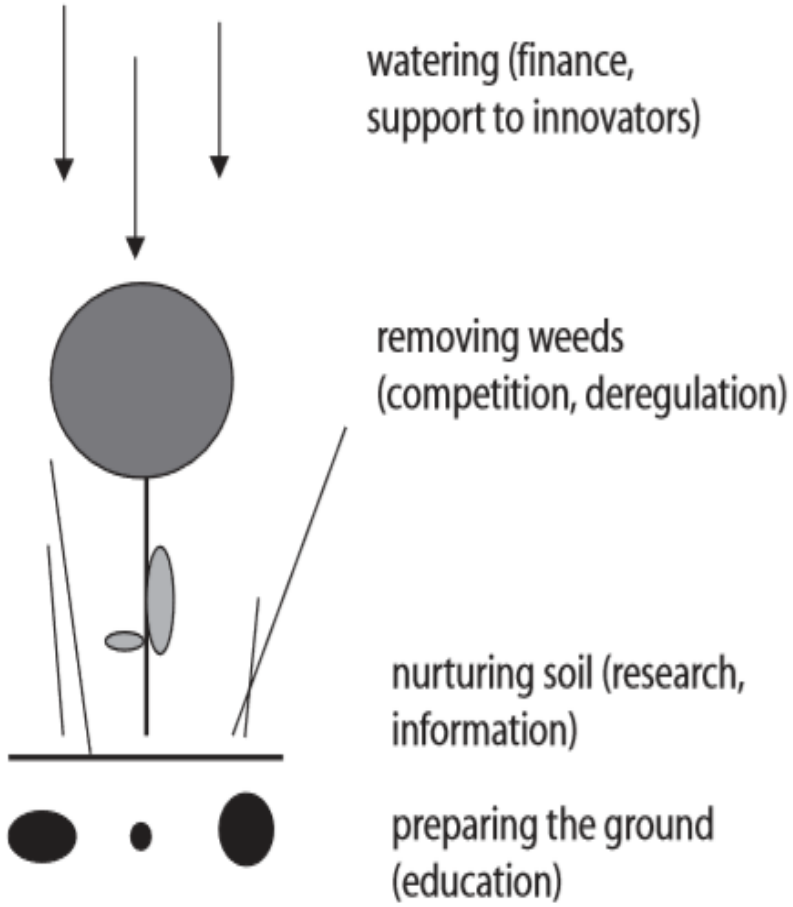
Barriers to Innovation in PH (acc to 2015 SIA)

- **Cost factors** most common issue identified by firms as significant hindrance to innovation.
  - One-fourth of MSMEs , and innovative large firms considered direct costs of innovation being too high
  - About one in every five MSMEs, and innovative large firms cited lack of funds
- One in five firms, especially among MSMEs, also reported **knowledge factors** or **market factors** as barriers to innovation.
  - More than 10% cited lack of qualified personnel as well as difficulty in finding cooperation partners for innovation and uncertain demand for innovative goods/services
  - 16.6% of MSMEs reported market being dominated by established enterprises as a barrier to innovation

2.2. Statistics on Innovation in PH

Global Innovation Index (GII), Global Competitiveness Index (GCI), and Existing Competition Policy

ASEAN Member State	2017 GII Ranking	2016 GII Ranking	2017 GCI Ranking	2016 GCI Ranking	Existing Competition Policy
Singapore	7th	6th	3rd	2nd	Competition Act 2004
Malaysia	37th	35th	23rd	25th	Competition Act 2010
Thailand	51st	52nd	32nd	34th	Trade Competition Act 1999
Viet Nam	47th	59th	55th	60th	Competition Law 2004
Philippines	**73rd**	**74th**	**56th**	**57th**	**Phil Competition Act 2015**
Indonesia	87th	88th	36th	41st	Law Number 5 Year 1999 on the Prohibition of Monopolistic Practices and Unfair Business Competition
Cambodia	101st	95th	94th	89th	**Draft** Competition Law 2016



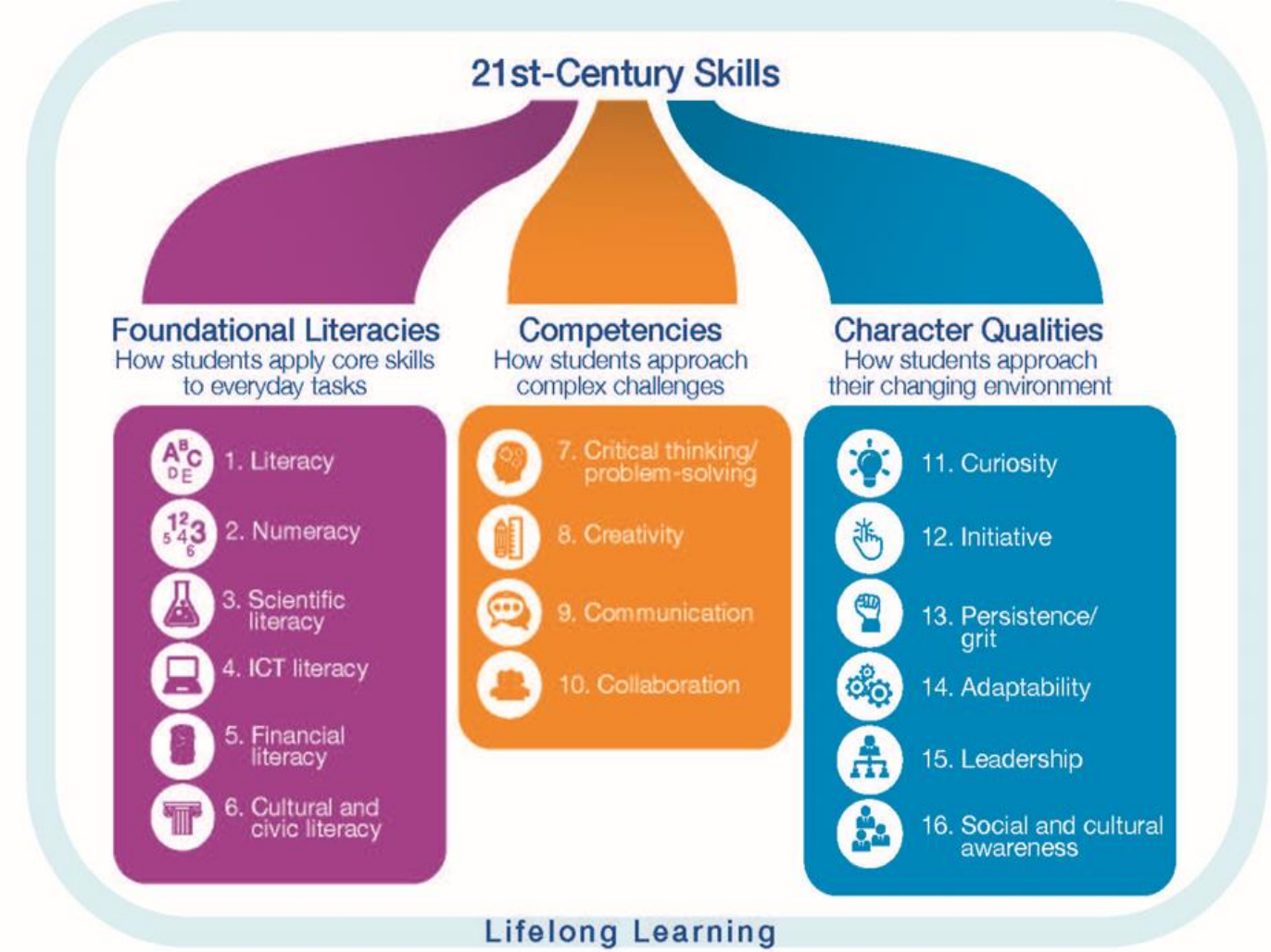
3. Government as Gardener

Source: World Bank (2010)

3.1. Preparing the ground (Education)

- Skills and competencies developed in school should be like LEGO blocks which can used to create different figures using the same building blocks
- Need for lifelong learning, continuous training and retraining; the only way to keep up is to continuously learn, unlearn, and re-learn
  - A key skill that needs to be developed among learners is “learning how to learn.
- Pedagogy should go beyond transmitting knowledge into encouraging reconstruction of knowledge

3.1. Preparing the ground (Education)



Source: WEF (2015)

3.2. Nurturing soil (Research, Information)

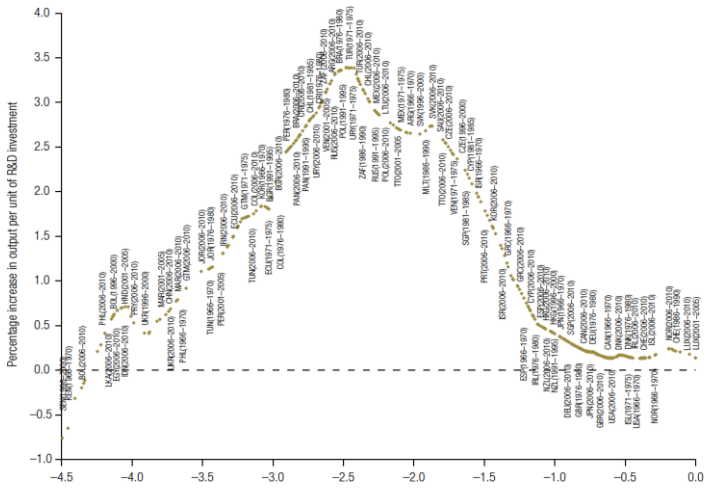
The bulk (60%) of R&D spending across sectors is actually supported by government (Albert *et al*., 2015). While the Philippines has had a slight increase in R&D expenditure to GDP in recent years, this spending is still at less than a fifth of one percent of GDP, which is below the one percent benchmark recommended by the United Nations Educational, Scientific, and Cultural Organization (UNESCO). The country's share of spending in GDP also falls below spending of several ASEAN member states, especially Singapore (2.4 %) and Malaysia (1.3 %), and even including Thailand (0.5 %) and Viet Nam (0.2 %).

3.3. Watering Ground (Finance, Support to Innovation)

- DTI, DOST and CHED working in tandem on Inclusive Innovation Industry Strategy ("i3S")
- DOST programs to boost innovation support
  - Science for Change Program (S4CP)
  - Balik Scientist 2.0
  - SETUP
- DICT
  - Addressing Issues on coverage, price and quality of internet
  - formulating successor to Philippines Digital Strategy 2011-2015, developed National Broadband Plan e-Government Master Plan 2016-2020 (EGMP 2.0),
  - established GovCloud
- Congress : working to establish a National Innovation Council
  - Do we need a new institution or a new paradigm/model?

3.3. Watering (Finance, Support to Innovation)

CAUTION: Returns to R&D Trace an Inverted U-Shape across the Dev't Process



Source: Goñi and Maloney 2017.

Note: Graph uses quinquennials of cross-country data from 1960 to 2010 to estimate the rates of return to research and development (R&D) across the development process: 0 is the frontier, and moving left represents progressively less developed countries.

- ROI on Innovation/R&D Spending rate of return begins to fall and may even be negative for quite poor countries
- Explanation: when countries are far from the technological frontier, the potential gains from "catch-up" increases but when stock of complementarity factors (human capital, firm and management capabilities, financial markets) are missing, returns will be low
- Issues about absorptive capacity

SOURCE: Innovation Paradox

3.4. Removing Weeds (Competition, Deregulation)

- In the most recent *Doing Business 2018* (2018) report, the Philippines ranking slipped from 99th in 2017 to 113th behind Vietnam and Indonesia at 68th and 72nd, respectively. Among the indicators, the Philippines was ranked lowest in "starting a business"
- According to the OECD (2016), foreign direct investment (FDI) restrictions in the Philippines are high by both regional and global standards. Based on OECD FDI Regulatory Restrictiveness Index, the Philippines is the most restrictive economy among the 62 OECD and non-OECD countries included in the database. Compared to other countries (e.g. China, Vietnam, India, Indonesia, and Malaysia) the regulatory environment for FDI in the Philippines has not changed much in the last 20 years.

3.5. Other challenges and issues

- Responsive and adaptive regulation
  - Regulatory sandbox
  - “Whole of Government”
- Labor market and social protection
  - Flexible and forward-looking labor market
  - Strengthening social protection systems: progressive universalism and portable social protection systems
  - universal basic income (???)
- Taxation reform/upgrade (???) : : improve collection of real property tax, provision of excise taxes on sugar, tobacco and alcohol, subsidy reforms, reducing tax avoidance.
- Whole of Nation Paradigm and Action Agenda

Philippine Institute for Development Studies
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Service through policy research

[Thank you]

PIDS Scoping paper on FIRe

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