The Adoption and Inhibition of Robotics Technology in the Philippines

Jo-Ann Magsumbol, Ronnie Concepcion II, Alvin Culaba, Elmer Dadios

Abstract

Robotics significantly impacts the way we live and work nowadays. It will positively and negatively disrupt every sector of our society, economy, and the industry. Robotics will definitely transform lives, work practices, raise efficiency and safety levels, improve the quality of service, and create new jobs. Its impact will grow over time as well as the interaction between robots and human beings. However, the adoption of technology has also disadvantages to the workforce as human resources are needed to be trained for this new industrial capability. With these, the government need to provide initiatives to combat the negative effect of robotics.

***Keywords* — Fourth industrial revolution; robotics adoption; robot density; robot diffusion; Philippines**

I. Introduction

Robotics is one of the very promising technologies that could disrupt the way we live nowadays. It will alter the quality of life, productivity, security, salary, and competition of manufacturing firms in terms of production efficiency [1]. According to Oxford dictionary, robot is a machine that has the ability to do multiple and complex tasks automatically and is programmed in a computer. It is a field of study which includes mechanics, physics, mathematics, control engineering, electronics, and computer science. [2]

According to International Federation of Robotics, the global robotic system installation is around 422, 271 units, amounting to $50B in 2018 which is equivalent to 6% higher as compared to the previous year. The average global robot density is 99 robots per 10,000 workers. Statistics shows that in the manufacturing industry, Singapore, which has 831 robots per 10,000 workers leads the robotics adoption worldwide. It is followed by South Korea and Germany with 774 and 338 robots respectively [3]. Philippines started its robotic adoption in the middle of 2016 with 3 robots and have increasing number of applications in different sectors such as agriculture, bomb disposal, and aerial monitoring [4]. With the dawning of Industry 4.0, also known as Fourth Industrial Revolution (FIRe), intelligent robots will eventually upgrade every sector of the society especially the ones with low adoption of robotics technology. Countries that will prioritize less the robotics adoption in their industry has a high tendency to be left behind in the global economy as robots are known in speeding up repetitive processes in manufacturing plants especially in assembly production.

Technological innovation led robotics to take part in various industries wherein robotic segments include industrial robots and automation, non-industrial robotics, unmanned vehicles and drones, and artificial intelligence [5]. Robotics can provide solution to reverse the decline of productivity in manufacturing economical products [6]. Although, high adoption rate has already taken place in developed counties, still, there are several problems encountered by new implementers of this technology such as high cost of initial robot implementation, technical training of personnel, system maintenance, and fear of job displacement. Therefore, to increase the robotic system adoption, it is vital for the government to take the initiatives to provide information the benefit of utilizing the said technology. In the same manner, provide necessary policies, laws and tax incentives for companies that will embrace robotics technology.

The goal of this study is to present the current status of robotics technology adoption in the Philippines and its impact to the economy, industry, employment, and society.

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II. TRENDS IN ROBOTICS

Among the Fourth Industrial Revolution Technology, robotics experienced notable progress in the past several years. For the past two decades, robotics diffusion has significantly increased three times. It is projected that the global stocks of robots will increase more rapidly to around 20 million by 2030. Asia is the growth engine of robotics adoption with China is predicted to have 14 million out of the 20 million robots in 2030 [7].

Most of the time, artificial intelligence (AI) and robotics are being interchange, but they are actually two different entities. Artificial intelligence makes use of computers in developing models that has the capability to mimic human intelligence, whereas robotics are pre-programmed machines that do routine tasks. The emerging type of robot at present is an intelligent robot that is being controlled by AI programs. This combination of artificial intelligence and robotics (Figure 1) [8].

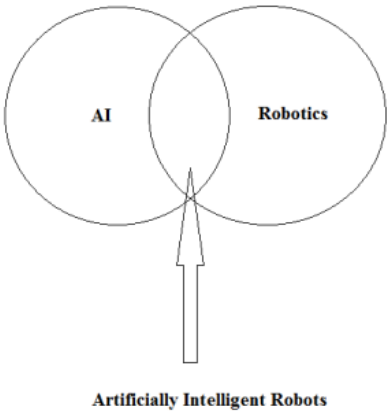

Fig. 1. Cross-link between artificial intelligence and robotics [8]

Robotic is a fast-growing technology. Robotics started a revolution in the manufacturing sector and in the past decades, industrial robots in factories are very evident and useful, and it keeps on getting attention due to their efficiency and effectiveness. Trends in robotics will be seen together with other technologies such as Internet of Things (IoT), cyber security, big data, open automation architecture, virtual solutions, and collaborative robots revolutionizing every process down to community level [9]. Presented as follows are the global and local trends of robotics.

A. Global Domain

Robots had evolved in 5 generations, namely industrial robots, service robots, ubiquitous robot, genetic robot, and bio robot, respectively [10]. Recent technological advancements were observed in robotic machines like drones, medical robots, and service robots. Various involvements of robotics are in the following industries: electrical and electronics, automotive, metal and machinery, rubber and plastics, food, medical, manufacturing, agriculture, biotechnology, and defense. Robotics technology is expected to improve both productivity and Gross Domestic Product (GDP) of a country. Figure 2 presents the trend of robotics technology showing that majority of the emerging economies has low robotic adoption whereas developed countries have high adoption rate that led to better productivity [11].

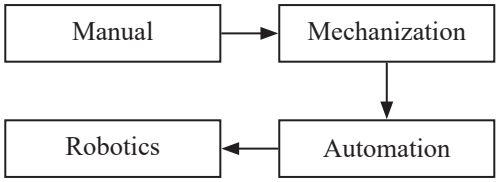

Fig. 2. Trend of improvement of robotics technology from manual to fully autonomous robotic system [11]

Every country may have its own robotics roadmap and development plan to help private and government thrusts in this area. The aim of the Robotics Industry Development Plan (2016–2020) of China is to make robot use tenfold by 2025[12]. According to World Robotics, in 2018, among the top 5 main users of robots, namely China, Japan, US, South Korea and Germany, China is the largest user of industrial robots, with 154,000 units (Figure 3).

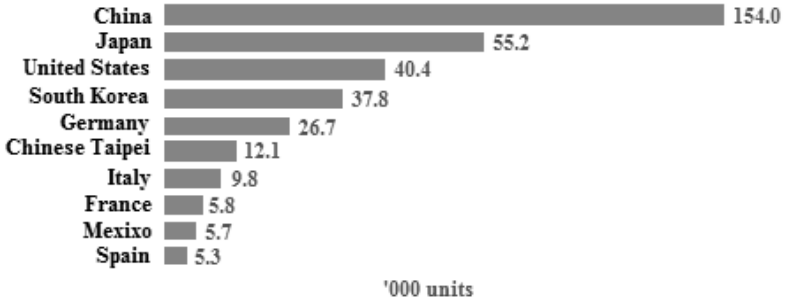

Fig. 3. 2018 Annual installation of industrial robots exhibited by leading countries which adapted robotics technology in their industrial mainstream [1]

US has updated their roadmap, entitled "National Robotics Roadmap: From Internet to Robotics", where its target is to support their manufacturing industry [13]. In 2014, Japan has launched its national goal of "new industrial revolution driven by robots," whereas Korea has "Intelligent Robot Development and Promotion Act" [14].

ASEAN region has been experiencing tremendous economic growth in the past several years, and it is forecasted that in 2050 this region will be the fourth strongest economy of the world. The adoption of ASEAN 4.0 in their respective countries is one of the major factors for this economic boost. The result of this technology adoption is an approximated annual economic gain of USD 216 to USD 627 by 2025. In 2018, Malaysia, introduced the "Industry4ward Policy" where its government has initiated an Industry Digitalization Transformation Fund amounting to RM 3 billion for automation and modernizations of manufacturing facilities. Thailand has its 5 S-Curve industries namely digital, robotics and automation, aviation and logistics, biofuels, and biochemical, and medical hub. Also, Indonesia has its version of Industry 4.0, called "Making Indonesia 4.0", which focuses in five areas of economies: food and drinks, automotive, textile, electronics, and chemicals. [15]. In Vietnam, robot industry is very young, but has a great opportunity of expansion for adopters [16]. Singapore, one of the strong adopters of robotics technology, financially supported the National Robotics Programme (NRP) for a three-year period in which a USD d450 million was given to NRP to encourage the implementation and improvement of robotics in the following sectors: healthcare, construction, manufacturing and logistics [17].

Table 1 shows the summary of robots density in the South East Asian region with corresponding government efforts in the adoption of robotics technology.

B. Local Domain

The Philippines is a novice in the robotics technology and as a new adopter, its impacts and outcomes are expected be noticeable in a decade time. Mc Kinsey Global Institute (MGI) states that around 48% of workers' tasks, roughly 18.2 million jobs, are automated. In the Philippines, the biggest contributor of this automation is the agriculture sector, and this is equivalent to 6 million jobs. Also, retail and manufacturing sectors has 3.4 and 2.4 million automatable jobs, respectively. Figure 4 shows the sectors of the Philippine economy that is a potential for automation [18]. The agriculture, forestry, and hunting sector has the highest number of non-automatable jobs and on the other hand, together with manufacturing, transportation and warehousing, finance and insurance, real estate and rental and leasing they exhibited an index value greater than 1 which signifies the ratio of automatable and non-automatable jobs.

Philippines government has been aggressively supporting digitization efforts, and one of this is through "Inclusive Innovation Industrial Strategy (i3s)" program. The goal of this project is to improve the quality of the industrial, agricultural, logistics, and commercial segment of the economy [19].

According to Harmonized National Research and Development Agenda (HNRDA) 2017 – 2022 of the Department of Science and Technology, from Section IV of the framework which covers the Industry, Energy and Emerging Technology, robotics is an emerging technology [20]. The said project is in connection with "AmBisyon Natin 2040," having three pillars: Malasakit (enhancing the social fabric), Pagbabago (reducing inequality) and Kaunlaran (increasing potential growth). Robotics diffusion is anchored under the pillar of "Kaunlaran" [21]. The government had integrated the Agenda 2030, the Sustainable Development Goals (SDGs) which is also known as the Global Goals and the Philippine Development Plan (PDP) 2017 -2022. SDGs have two principles: sustainable development and no one left behind. It is a 15-years program with 17 goals, 169 targets and 232 indicators. The ninth agenda of this program is Industry, Innovation, and Infrastructure, where robotics technology comes into picture [22].

Table 1
Robot Density of Southeast Asian Countries and Government Initiatives for its Implementation in Agriculture, Medical, Transportation, and Manufacturing Industries

ASEAN Country	Government Program	Robot Density in Manufacturing (As of 2018)
Singapore	National Robotics Programme	488
Malaysia	Industry4ward Policy	34
Thailand	5-S Curve	45
Indonesia	Making Indonesia 4.0	5
Philippines	Inclusive Innovation Industrial Strategy (i3s)	3

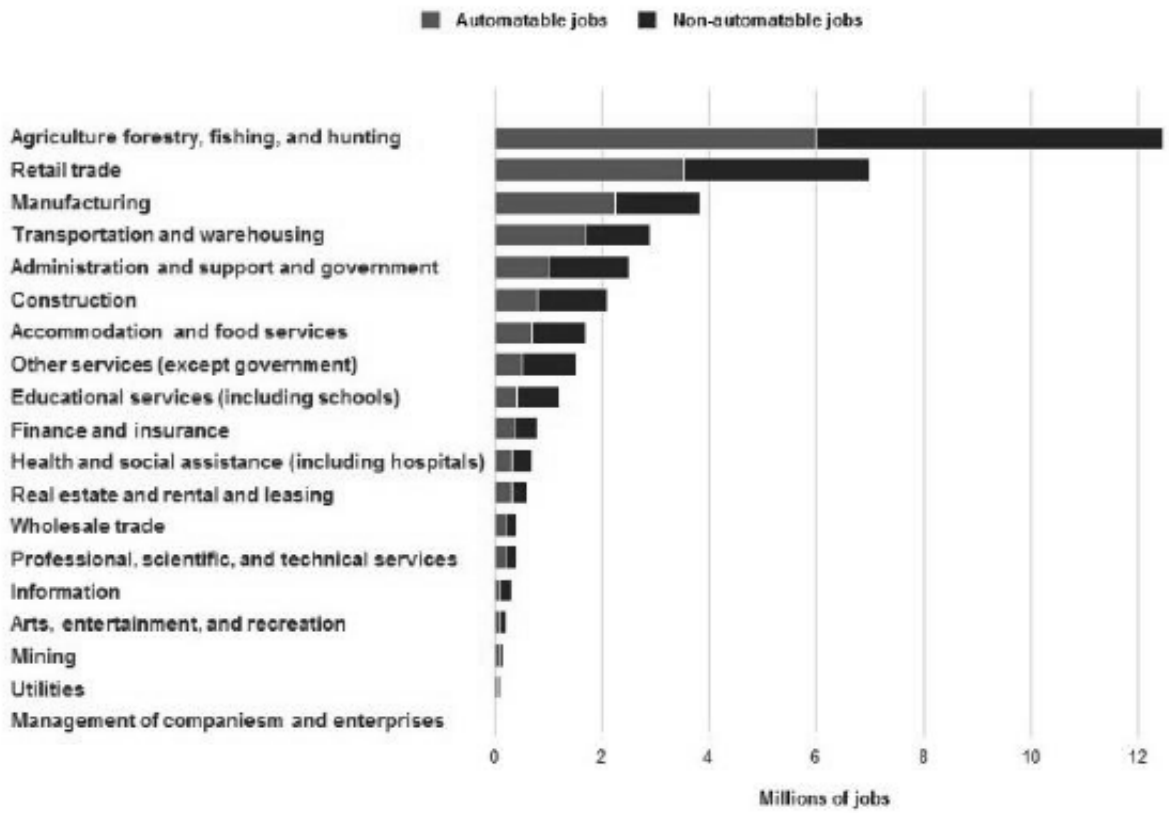

Fig. 4. Sectors of the Philippine economy that have potential for automation [18]

II. Applications of Robotics

Robotics is one of the emerging technologies of the Fourth Industrial Revolution (FIRe). It is used for doing boring, hazardous, and unclean industrial tasks [23]. Robots can be categorized based on their applications as follows: industrial robots, domestic or household robots, and medical robots, military robots, space robots and humanoid robots (Table 2) [24].

Manufacturing industry is one of the first adopters of robotics technology where the nature of work is preliminary dull, dangerous, and dirty. Robots work hand in hand with human workers to accelerate speed of production without compromising quality of products. In military, robotics is used to upgrade battlefield activities and to reduce human exposure to dangerous environments [25]. Due to high risk of exposure to hazardous scenarios and life-threatening conditions by military men in action, the use of robots in the field was are now being accepted. They are used in surveillance and patrolling and in discarding bombs. Drones are type of aerial robot that is widely used in military activities, such as assessing areas of conflict, hazardous places and disaster incident areas where it can provide real-time data acquisition and feedback information in their respective data centers [26].

In health care, robots have changed the way medical practices and procedures are executed. These robots are now being used in intensive care unit (ICU), common room, and surgery. It is also utilized in laboratories to gather specimen samples and transport where it is needed. The da Vinci Surgical System is an example of medical robot tied up with a health care professional to conduct surgery inside a patient's body. It should be pointed however that robot is not designed to replace medical practitioners, but instead help them ease up their tasks [27, 28].

In agriculture, in order to alleviate crop production and decreasing labor costs and other related expenditures, robotic technology is openly embraced by farmers and now they are using self-guided tractors and harvesters which are manifestation of robotics. Recent development of robot is with sensors to supervise various crops diseases so robots can prune, mow, and remove weeds.

In mining industry, an application of robotics technology is in belt assessment scheme that is used to assist mining workers in fault detection. Another application of this is the caterpillar's vehicle that allows the miners to move towards a deeper location without walking inside caves and mining areas [29].

Food preparation is another milestone of robotics technology innovation. Moley Robotics had invented

Table 2
Sample Images of Robots based on Application

Category	Sample Image
Industrial Robots	
Domestic Robots	
Medical Robots	
Military Robots	
Humanoid Robot	

intelligent chef robots capable of preparing pre-programmed menus using smart phones [30-31]. The ingredients prepared in advance in food containers chosen by the person using their smart phones will be cook by this robot.

IV. Factors Affecting the Robotics Adoption in the Philippines

Robot density refers to the number of robots per 10,000 workers. Robotics density per country depends on the facilitating factors, barriers and constrains of their adoption as discussed in the succeeding paragraphs.

A. Facilitating Factors

Robots are means to raise productivity and the standard of living. This robot adoption is happening globally at a very fast paced. The rise of robotics is unparalleled as it is move by five prevailing factors namely, political economy, national agenda, industry reception, sociological and ethical factors.

B. Barriers and Constraints

Robotics technology offers wide advantages to different industries, however there are also various reasons why certain industry do not adopt this disruptive technology. Automated technology often leads to the following constraints: fear of job displacement, high cost of implementation, lack of skilled workers, insufficient knowledge about the technology, and fast phase technology innovation.

Micro small medium enterprise (MSME) refused to adopt robotics in their businesses due to high cost of initial purchase of robots. Alongside with this purchase of robotic equipment is the need for training and equipping of personnel on how to operate the machines. Since this is still an emerging technology, most SMEs do not have sufficient knowledge about this one. The government has not set regulations for the full implementation of robotics in the construction industry. The country has a very low adoption of robotics, and it might be due to the fact that there are no clear incentives offered by the government for those who will embrace this system. Another concern of adopters is the fast phase technology innovation nowadays which made them fearful that their acquired technology will soon be obsolete without even getting back their return of investment.

V. Impacts of Robotics

Robotics is one of the rising technologies that bring economic growth, higher productivity, and labor reinforcement. This robotics diffusion has both positive and negative impact in the economy, industry, manufacturing and labor and society.

A. Economy

Robotics revolution has turned human imagination into creation. Over the last decades, robot diffusion in the manufacturing sector has doubled worldwide. According to Oxford Economics forecast, a 30% increase in the global robot stock would lead to 5.3% GDP increased by 2030 which is equivalent to $4.9 trillion annually added to the global economy. A 1% raise of robot stock in every worker is predicted to have a 0.1% increase of output per worker in the manufacturing industry while it is estimated that around 20 million jobs globally, will be displaced by 2030 due to robot adoption, as per Oxford Economics [31-32]. Nowadays, AI is being integrated with robots which made it superior over the early types of robots. Sensors and cameras are integrated in robots to make it more intelligent and human-like, expanding the capabilities of these robot machines. From 2009 up to 2017, there was an enormous increased of robot sales with a difference of 321,000 units of industrial robots for 8 years of development and implementation.

In the Philippines, though robotics is at its beginning stage, there are already adopters of this technology. SM Supermalls, EPSON Philippines, Accenture Philippines, are some of the early adopters of robotics technology. St. Luke's Medical City also began using Transoral Robotics Surgery. The Small Enterprise Technology Upgrading Program (SETUP) of DOST aims to support the micro, small, and medium Enterprises (MSMEs) to boost their productivity. Recently, Department of Science and Technology's Metals Industry Research and Development Center (DOST-MIRDC) has inaugurated two private firms namely the Raw Brown Sugar Milling Company Inc., and Sans Rival Cakes & Pastries through Advanced Mechatronics, Robotics, and Industrial Automation Laboratory Project (AMERIAL) to complement the academic sector in improving the robotics sector of the country.

B. Industry, Manufacturing and Labor

Robotics will change the labor demand from labor-intensive, monotonous jobs into semi-automated or fully automated robotics system. Even though the adoption of industrial robots has taken dominion in the manufacturing industry, there is only a minimal share of employment in this sector, compared to 75% of employment from the service industry, according to Oxford Economics. The adoption of robots led to 1.3% decrease in the labor sector, from 2005 to 2014 [33]. It was estimated using the instrumental variable approach, that the effect of this automation is -0.54% and 14% for developed and developing economies, respectively. The advantages of adopting robotics technology in the manufacturing industry results in reduced production expenses, compressed work duration, improved site safety,

and better output quality [34]. Also, there are proposed initiatives for the government to combat the possible job loss effect of the said technology. The government may put investment in training individuals to produce additional technically skilled manpower and to guarantee generation of employment opportunities.

C. Society

The diffusion of robots in the society is crucially affected by the government. One of the impacts of the emergence of robotics to society is the distraction of human lives, knowing that robotics led to "creative destruction" of jobs. It opens opportunities for new jobs, but it also displaces repetitive types of jobs at the same time. Also, as robots continue to be more sophisticated and complex, there is a need for a collaborative work between engineers and sociologist in order to address problems arising from social robots. Another concern for using robots interacting with humans is the data privacy issue, specifically when people perceived robots as social being, then human could reveal confidential data to robots [35].

VI. Policy Recommendations

The implementation of the system depends largely on the standardization and regulation. Standards are vital to guarantee product quality and systems safety during operation process. Also, the set of standards crafted by stakeholders should meet the global requirements of the said technology. In order to have a global market, it is important that every product passed international standards. These standards are voluntary, but regulations are compulsory. These are needed to keep global quality of products. Examples of standard setting bodies are International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC) [36].

Policies, rules and regulations and laws of implementation of the robotics technology will be originating from the government initiatives. Presented as follows are the policy recommendations of each sector of the economy.

A. Labor and Employment

According to Philippine Statistics office, as of December 2019 the Philippines population is 108.1 million and there are 42.4 million employed workers. This number signifies the need for the government to create more jobs for the employment of its citizens. Policy makers are recommended to create policy drafts that will promote deployment of robotics systems nationwide. One of the main purposes of Association of South East Asian Nations (ASEAN) integration is to accelerate economic growth of neighboring countries. To do so, robotics platform can be used to achieve this ASEAN objective. Since robotics technology has the capability to boost productivity, it could impact economic growth of a nation. Currently, the adoption of robotics in the country is still at its infancy stage. Therefore, there is a need for the government to further promote its adoption by different sectors of the society, by starting to implement it in government agencies.

B. Human Resource Development and Education

The mainstreams of technical workers need to be addressed in order to create and prepare pool of skilled laborers equipped to do the tasks. Digital training skills must be honed at this early stage in order to produce a mass of technicians and engineers who are expert in the development and application of robotics. The K-12 program of the government must align its curriculum to include robotics tracks in STEM and ICT programs. Through Technical Education and Skills Development Authority (TESDA), the government can re-skill and up-skill the low skilled workers to adapt to this fourth industrial revolution emerging technology. Distant learning through online subscription can also be capitalized by robotics enthusiasts which strengthens the industry-academe linkage. Knowledge transfer from robotics adopters can be provided to the students, future workforce of the country. Thus, the next generation of human resources will be well prepared.

In general, the robotics knowledge transfer is still broad and liquid. With this, conferences and scientific papers can contribute to knowledge dissemination. Likewise, robotics competition also allows researchers to gain knowledge and benchmark their development [37].

C. Government Policy and Laws

Government has an important role in promoting robotics innovation in the country thru subsidies, military needs, and strategies. In 2016, the Philippines has already partnered with Universal Robotics. It is suggested that the Philippine government should further strengthened its linkages to robotics giants of the world and draft policies and laws that gives tax incentives to adopters of this technology, just like what US has done. The government should also reinforce its scope and capacity of implementing robotics policy in its agencies and sectors on a national level. The government should launch projects that will showcase the advantages of embracing the technology. The AmBisyon 2040 of the Philippine government supports technology adoption, as one of its agenda from sustainable development goals.

D. Research and Development and Innovation

Creating a strong digital ecosystem that could withstand the fast phased technology is necessary for adopters to cope up especially in agriculture [37], automation [38], and manufacturing [39] industries. The Philippines has been preparing for this Industry 4.0. It has prepared its roadmap for the adoption of this emerging technology through the Philippine Development Plan 2017-2022 which is also anchored to AmBisyon 2040 as supported by [40-41].

VII. Conclusion

This paper presents robotics development globally and locally. It discusses the impacts of robotics adoption to every sector of the society. This technology keeps on innovating and developing to meet different needs of humanity. In the manufacturing, electronics, logistics, education, and medical fields, the trends keep on advancing. The government and private firms needs to embrace this technology to stay competitive, globally. The Philippines is still at its infancy stage in this system but is a promising hub of emerging technologies since the government is seriously executing PDP 2017-2020. Drafting of policies in labor and employment, human resources and management, and research, development and innovation are recommended. Hence, the adaption of robotics in the Philippines can be manifested by changing the perspective of the leading people down to the end-users in the community concerning its beneficial impacts in the long run.

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