National Strategy for Robotics

Information and Communication Technology Division
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September 2020

Executive Summary

Unlike science fiction or movie characters, Robots are machines to perform useful tasks for producing economic outputs. Human beings are in a relentless race in producing ideas in getting jobs done better at less cost. One of the focus areas has been in developing machine capability for performing dull, dangerous and dirty (3D) jobs. Which gave birth to Robots. The continued flow of ideas and their integration has made Robots capable of performing productive tasks in a more precise manner than what human can do, causing less wastage and also improving consistency. Instead of being just a mechanical machine having multiple links connected with flexible joints, they have become now intelligent machines, having sensing, perceiving, decision making, and autonomous action taking capability. Unlike human eyes, some of the Robots' sensors can even see through objects. They can also repeatedly perform the same operation with micro meter accuracy, which is not often doable by human. That is often an essential requirement for Bangladesh's export-oriented furniture making. Moreover, they do not contaminate objects like food as they do not breath, or sweat. This growing capability has empowered robots to move out from confined work space in performing 3D jobs to become core production actor in diverse areas, both within and outside factories. The continued growth of comparative advantage in performing productive activities has been placing robots at the center of production, while human workers are being assigned in supporting robots to perform core tasks, and maintaining as well as improving the operation of Robots. Such supporting roles are taking shapes in the form of (i) collaborating with and supervising Robots in performing tasks, (ii) developing improved as well as new capabilities of robots, (iii) motion planning, programming or teaching them for performing targeted tasks, (iv) redesigning workspace and also products for making them robot friendly, (v) installing and configuring Robots, (vi) manufacturing them, and also (vii) repairing them. There has been increasing opportunity of performing productive tasks in more effective and efficient manner by empowering and supporting robots in executing them. As a result, competitive production strategy has been finding robots as an indispensable core building block. The purpose is not just to replace human labor. As we are in search of higher quality at lower cost for improving our quality of living standards, the increasing demand for quality and reduction of wastage among others are making robots as essential machine for human to add value to economic activities. In absence of robots, our ability to drive economic growth slows down, and eventually saturates prematurely, particularly within the given competition space. Even 5 percent wastage reduction due to precision operation of Robots is sufficient enough to determine profit or loss in the globally connected competitive market.

There is no denying that Robotics poses both threats and opportunities to Bangladesh. In reference to different predictions, published by local and international institutions, substantial number of labor centric manual jobs will be taken over by Robotics. As a result, Bangladesh's labor centric value addition in manufacturing faces threat. According to recently released prediction, 5.38 million jobs are at risk in five key areas of Bangladesh by 2041 for the advent of automation. Robotics, particularly the emergence of sewbot, is also posing threat to the offshoring model of ready made garments industry. On the other hand, Bangladesh should keep increasing per capita income taking it from less than $2000 to above $12000 by 2041 for meeting development aspiration. As Bangladesh has very limited scope to increase the per capita income through the exploitation of natural resources, Bangladesh's main option has been to increase the value addition capacity of labor. Robotics offer the option of delegating low value tasks to robots and redeploy labor for higher value added tasks. On the other hand, Robotics opens the opportunity to enter into high precision manufacturing. Robotics also offers the opportunity of increasing yield and reducing wastage in productive activities both within and outside factories, and also of increasing safety in food processing. Emerging robotics also opens the opportunity of improving productivity, response, and safety of transportation and logistics. Telerobotics in the form of industrial internet of things (IIoT) opens the opportunity of high value service export for the remote monitoring, supervision and operation of industrial and service delivery IoTs. Moreover, there has been high innovation and startup opportunities in the broad area of robotics. Bangladesh's challenge is to cope up with the impending threat and leverage unfolding opportunities. This

strategy looks upon this conflicting situation for leveraging robotics to keep driving economic growth of Bangladesh for meeting the development aspiration, while creating jobs.

Basic objectives of this strategy are to: (i) Blend labor advantage with robotics for maintaining as well as improving competitiveness of existing industries, (ii) Open entry of Bangladesh to the manufacturing of high value, next generation miniaturized, complex products requiring assembly adaptability, precision, and reliability beyond the skills of human workers, (iii) Promote creativity, imagination, and innovation among youths, (iv) Support the growth of industry for Robot R&D, innovation, adoption, adaptation, manufacturing and maintenance, (v) Create opportunities for service export through remote collaboration with robots, (vi) Create high skilled manpower for performing tasks in collaboration with robots, programming robots, redesigning work process and products, maintaining robots, and pursuing research and innovation in robotics, (vii) Build robotics industry by maximizing local value addition for meeting domestic demand and exploiting growing export opportunities, and (viii) Leverage fourth industrial revolution in critical areas like agriculture, ahealthcare, and manufacturing.

This strategy development exercise has extensively reviewed available literature. The evolution of robotics in terms of technology capability, and applications have been looked upon. Thematic study papers, produced by Think Tanks, research establishments, international consultancies and government agencies, about the prospects of robotics and likely responses have been reviewed. Country level strategy and policy responses to leverage Robots has been investigated to draw lesson. The unfolding commercial offerings and adoption of robots in Bangladesh, regional countries, China, and the rest of the world has been reviewed for assessing the situation, and predicting likely future for leveraging scope of Robotics. This exercise engaged stakeholders through a series of sector specific consultations. With the given possibility, and importance to Bangladesh's economy, stakeholders of 17 important sectors were consulted having 2-hour long consultation for each of those sectors. Sector specific association members and key players participated in those consultations. Those consultations gathered sector specific inputs from four major dimensions: (i) unfolding robotics technology scenario, and it's adoption in Bangladesh, regional countries, China, and the rest of the world, (ii) emerging threats and opportunities for Bangladesh in the area of economic competitiveness, education and skill development, R&D and innovation, and startups, (iii) Bangladesh's weakness and strengths in the area of the availability of skilled human resource for using, customizing, programming, and maintaining robots in production, capacity of undertaking R&D, innovation and production of robotics solution, start-up capacity for pursuing innovative ideas in the area of robotics, and policy and regulatory framework for coping up as well as leveraging robotics, and (iv) Bangladesh's strategy in the area of intelligent usages of robots for improving competitiveness, human resource development, R&D and innovation ability development, Robot production and maintenance capacity development, and fostering start-ups in Robotics.

The review of literature and extensive stakeholder consultation find that Robots are finding place at the center of competition strategy in productive activities across the world. Regionally countries are responding to accelerate the adoption of Robots. It has already started to penetrate in Bangladesh. Robots are offering the opportunity of improving the quality and reducing the cost simultaneously, in diverse areas starting from food processing to furniture as well as plastic product making. Due to this vital capability of improving quality and reducing cost simultaneously, as opposed to having tradeoff between these apparently conflicting variables, Robotics is an essential strategic tool for maintaining and also improving competitiveness in this globally connected market economy. In absence of robotics, Bangladesh will not only be able to maintain cost advantage by relying on labor only, because in many cases robots are cheaper as they reduce wastage, and improve quality. In certain areas, in absence of Robots in production, producers cannot meet needed precision, and comply with issues like safety, particularly for exploiting export market opportunities. For example, in absence of micro meter accuracy in cut, hole and joint making, Bangladeshi furniture makers cannot expand their footprints in export market, as export requires knock down shipment of products and customer end assembly. Human hands and judgment are not the solution to offer such precision. Moreover, precision jobs being performed by robots also reduces wastage,

consequentially lowers cost. In certain cases, 5% wastage reduction is justified for robots' usages as labor content in production is less than 10% in many productive sectors. For example, it's less than 6% in high-end furniture manufacturing plants in Bangladesh. Wastage reduction and precision are major drivers for adoption of Robots.

Despite the miracle power of improving the quality and reducing the cost simultaneously, Robots are not ready to be deployed in the work environment for deriving the potential benefits readily. It's not like ready to swallow capsule or wear cloths. The technological and economic feasibilities should be assessed to figure out target suitable applications. Robots should be customized, in terms of sensors, end effector tools and software, to make them optimum solution for the performing target tasks. Workspace and also products should be reengineered to make them robot friendly, and robots should be programmed accordingly. Human skill should be developed to work in collaboration with robots, configure and teach robots (often by showing samples), troubleshoot problems, maintain them, and also repair them. To leverage from the evolution of Robots, capacity should be developed for monitoring and forecasting robotics, assessing the feasibility in leveraging the unfolding opportunities in Bangladesh, adapting them for making them suitable in feasible application areas, undertaking R&D for advancing robotics with innovative ideas, and fostering start-ups for pursuing for rolling out innovations. Moreover, capacity should be developed to manufacture spare parts, end effector tools, accessories, and eventually manufacturing robots. Studies indicate that as high as 60 percent local value could be added to imported basic robots. In absence of local value addition capacity and maintaining the operation with local capacity, in many areas Bangladesh will not be able to derive potential benefits. Such reality demands a very well thought out strategy for empowering Bangladesh to derive potential maximum benefits for improving Bangladesh's global competitiveness and creating new jobs. Along the way of being smart user of Robotics for offering higher quality at lower cost, and Bangladesh should also succeed in developing Robotics industry.

Review of literature and stakeholder consultations indicate that Bangladesh should exploit robotics for improving the competitiveness of existing economic activities and also penetrate in new segments, particularly where precision matters. Strategy should focus on intelligent adaptation, as opposed to buy and install readily available robots with the support of foreign consultants. To address multidimensional objectives, the proposed strategy focuses on collaborative (Government, user industry, IT&LE industry, academia & training institutions) approach for (i) technology-economic feasibility analysis of application of Robots in Bangladesh, (ii) demonstration of concepts of potential applications, and (iii) capacity development for exploiting suitable application areas, through (iv) developing human resources for a. usages, b. robot programming, c. software development, d. product and process redesign, e. installation, configuration & maintenance, e. repairing, manufacturing of robots' parts and robots, and (v) seeding R&D for innovation as well as start-ups in sensing, software and end-effectors. In implementing this strategy, Government's role will be to stimulate demand and supply of robotics solutions, supporting human resource development, and seeding R&D for innovation and startups. It's expected that such facilitation role of the Government will lead to the intelligent adoption of Robots in diverse productive sectors, and the creation of local Robotics industry for adding value to imported robots, supporting their adoption, and eventually producing components for Robots, as well as whole robots, for the export market.

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Acronyms

AR/VR	Augmented and Virtual Reality
BBS	Bangladesh Bureau of Statistics
BPO	Business Process Outsourcing
CAGR	Cumulative Average Growth Rate
CT	Computer Aided Tomography
IoT	Internet of Things
IIoT	Industrial Internet of Things
IRO	International Robot Olympiad
M2M	Machine to Machine
R&D	Research and Development
CPS	Cyber Physical Systems
RPA	Robot Process Automation
RAS	Robotics and Autonomous Systems
R&D	Research and Development
RMG	Ready Made Garments
SMEs	Small and Medium Sized Enterprises
STEM	Science, Technology, Engineering and Management
UAV	Unmanned Aerial Vehicles

1. Background, Objectives, and Scope

Robots are Cyber Physical Systems (CPS) having the ability of sensing, perception, and decision making for performing some meaningful, productive physical tasks without the direct human involvement and/or in collaboration with or under the supervision of human operators. Such cyber physical systems are driving the Fourth Industrial Revolution. Although, they are commonly perceived as humanoid, but they emerge in diverse form. Even upon retrofitting sensors, software, and connectivity, a dumb wheel chair, or tractor could be made smart, autonomous or semiautonomous robotic machines. They not only reduce human role in operating those machines, but most importantly, they make dumb machines able to understand the situation and adapt the behavior for increasing safety, improving precision, and reducing wastage. For example, a robotic pesticide or fertilizer sparing machine can adapt the discharge of farming inputs for reducing wastage, increasing yield, and also improving food safety. Similarly, a smart wheel chair can offer higher degree mobility to elderly people and those who are in need of special assistance. The scope of increasing the capability of machines by making them smart has been opening immense opportunity of innovation, which could be harnessed to empower youths and create start-up success stories.

Over the last 50 years, Robots have progressed from simple mechanical assistive devices to intelligent machines. Instead of playing assistive roles helping human in performing tasks, they are growing as the main actors in performing productive tasks. For example, in a state-of-the-art automobile-manufacturing plant, as high as 80 percent tasks in certain areas like body shops is being performed by robots. Robots are increasingly getting more capable as well as less costly than human labor. As a result, comparative advantage in performing productive tasks, robots are taking over labor. It's not only the cost issue, but also the quality and wastage. In certain situation, like cutting metal or paining automobiles, robots can perform the job more precisely than human workers. Such reality is demanding the optimum blending of human labor with robot capability to remain competitive in this globally connected market economy.

With respect to productive usages of robotics, robots emerge in three main forms: 1. Robot manipulators, 2. Mobile robots, and 3. Flying Robots. Although humanoids create excitement, but still to date their usages in productive activities are very limited. Robot manipulators with varying degree of freedom are primarily used in factory works. Mobile robots are autonomous mobile machines such as autonomous cars, tractors, or mining vehicles. Flying robots are often known as unmanned aerial vehicles (UAV) or drones. Robots in all these forms are showing relevance to Bangladesh's economy. Moreover, some of the robotic applications are showing up without having the shape of conventional robots. For example, sewing robots do not have familiar shape. But, the progression of this robot, sewbot, could have significant consequence on Bangladesh's economy.

Strong excitement among the youths: Robotics has created significant excitement among the youths. Arranging robot competition has become an integral part in any major Computer Science and Engineering festivity in the country. Our students are also participating in international competition, and winning awards as well. Among the awards, a Bangladeshi youth won a gold medal and two other students won technical awards in Robo Scholar Challenge Category of International Robot D Challenge in South Korea on September 28, 2019. The Shahjalal University of Science and Technology (SUST) won Nasa's 2018 International Space Apps Challenge. On December 20, 2019, Bangladesh won a

gold, two silver and six bronze medals with one technical award in the 21st International Robot Olympiad (IRO) in Thailand. In 2019, Bangladesh won a gold medal, two highly-commended medals and one technical medal in the event that was held in the Philippine.

On one hand, robots are rising as a mega trend to cause disruption to labor centric value addition proposition in many industries, which are relevant to Bangladesh's interest. On the other hand, the growth of robotic technologies has also been opening innovation and labor augmentation opportunities. Moreover, youths in Bangladesh have been showing high level of interest and demonstrating creativity in robotics. As opposed to waiting for robotics to keep unfolding, and causing disruption to Bangladesh's labor based industrial economy, there appears to be smarter option. That is to predict and prepare to cope up as well leverage robotics. For this reason, the need for developing national robotics strategy has been paramount.

Robotics and automation for Bangladesh's development progression: In order to reaching economic targets set for 2021, 2030, and 2041, Bangladesh needs to keep complementing labor with technology. One of the technologies has been Robotics. Robotics will increase productivity. On the other hand, robotics will allow Bangladesh to enter into high precision manufacturing, food processing and also farming—among others. Through next generation robotics, Bangladesh will also be able to connect labor force to emerging global remote service delivery value chain. Moreover, robotics offers enormous scope for empowering youths to pursue creativity, innovation, and startups. Robotics also poses threat to labor based value capacity of Bangladesh. Bangladesh should also prepare to respond to job displacement effect of robotics.

Competitiveness: Cost, Quality, and Productivity: Producers are continuously comparing options of labor vs Robots in meeting cost, and quality targets. At the end of the day, economics of production dictates the decision. In one hand, robots are getting cheaper; on the other hand robots are contributing to higher quality and lower wastage. Producers are also under pressure to keep paying more to employees. But, customers are increasingly demanding higher quality products at lower cost. Robotics and automation is a powerful option for the producers to meet these conflicting variables. Starting from ready-made garments to plastic products, producers are increasing taking refuge to robotics. Lack of skilled manpower having the capability of working with robots in a collaborative manner is the first constraint. In order to use to robots in existing productive activities, work processes should be redesigned and robots should be programmed accordingly. Producers are facing difficulty in finding skilled people in performing this task for leveraging robots. A robotics technology is progressing, new opportunities are unfolding. Due to lack of local capacity of innovating next generation robotics solutions, producers are also failing to tap into it to outperform competitors. Moreover, the technological and economic feasibility of Robotics does not appear to be intuitively visible at the firm management. On top of it, commercially available robots should be customized and uplifted to make them suitable for target applications for maximizing benefit.

1.1 Overview of Bangladesh's Manufacturing Economy

According to BBS survey on Manufacturing industries 2012, 25 categories of manufacturing industries employed 5.015 million persons; among them 2.762 million were involved in readymade garments, as shown in Table 1. Current employment in RMG appears to be around 4 million. Employment in industry (% of total employment) in Bangladesh was reported at 21.26 % in 2019, according to the World Bank collection of development indicators. Despite having potential in other areas, Robotics will likely have impact in the manufacturing sector. The challenge is to increase employment by leveraging robotics.

Table 1: A snapshot of manufacture economy of Bangladesh

BSIC & Description	No. of establishments	TPE-Total Persons Engaged		
	Number	Both sex	Male	Female
Total	42,792	5,015,936	3,062,009	1,953,928
10 Manufacture of food products	8,441	280,257	216,116	64,140
11 Manufacture of beverages	367	20,448	18,448	2,000
12 Manufacture of tobacco products	487	52,204	35,222	16,983
13 Manufacture of textiles	10,983	805,508	569,868	235,640
14 Manufacture of wearing apparel (Readymade garments)	6,984	2,762,335	1,257,464	1,504,871
15 Manufacture of leather and related products	930	75,524	53,057	22,467
16 Manufacture of wood and products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	302	8,528	7,874	654
17 Manufacture of paper and paper products	902	42,376	38,063	4,313
18 Printing and reproduction of recorded media	904	26,667	25,484	1,183
19 Manufacture of coke and refined petroleum products	19	1,417	1,371	47
20 Manufacture of chemicals and chemical products	563	52,598	46,642	5,957
21 Manufacture of pharmaceuticals, medicinal chemical and botanical products	494	71,380	61,356	10,024
22 Manufacture of rubber and plastics products	1,036	41,139	31,373	9,766
23 Manufacture of other non-metallic mineral products	4,654	471,850	416,787	55,063
24 Manufacture of basic metals	1,205	120,965	117,884	3,081
25 Manufacture of fabricated metal products, except machinery and equipment	1,449	44,462	39,950	4,511
26 Manufacture of computer, electronic and optical products	149	16,390	14,377	2,013
27 Manufacture of electrical equipment	884	44,556	39,520	5,036
28 Manufacture of machinery and equipment n.e.c.	195	10,001	9,120	882
29 Manufacture of motor vehicles, trailers and semi-trailers	137	4,906	4,716	190
30 Manufacture of other transport equipment	276	17,921	16,595	1,326
31 Manufacture of furniture	1,055	33,143	31,442	1,701
32 Other manufacturing	235	9,471	7,487	1,984
33 Repair and installation of machinery and equipment	120	1,558	1,511	47
34 Recycling	21	333	283	50

** The number begins at 10, because that indicates "BSIC code" used by BBS.*

1.2 Objectives and Scopes

The overall objective has been to leverage Robots for economic growth, job protection and creation, improved quality of life, and empowerment of youths. Some of the specific objectives are:

1. Blend labor advantage with robotics for maintaining as well as improving competitiveness of existing industries.
2. Open entry of Bangladesh to the manufacturing of high value, next generation miniaturized, complex products requiring assembly adaptability, precision, and reliability beyond the skills of human workers.
3. Promote creativity, imagination, and innovation among youths for pursuing startups.
4. Support the growth of industry for Robot R&D innovation, adoption, adaptation, maintenance, and manufacturing.
5. Create opportunities for service export through remote collaboration with robots.
6. Create high skilled manpower for performing tasks in collaboration with robots, programming robots, maintaining and repairing them, and pursuing research and innovation in robotics.
7. Leverage fourth industrial revolution in critical areas like agriculture, and manufacturing.
8. Reduce the skill gap by predicting the unfolding robotics technology scenario and empowering the workforce to support the industry to leverage robotics

1.3 Study Design and Methodology

This strategy development exercise has a very significant stakeholder consultation. Such engaging stakeholder consultation serves three major purposes: (1) To create awareness and sanitize target industries, (ii) To get informed about industry level situation, and (3) To initiate the formation of partnership for undertaking collaborative projects for implementing the strategy. Upon review of Bangladesh's industrial and service economy, 19 sectors have been targeted for having consultation. Due to COVID-19 situation, these consultations took place over video conferencing. Industry association leaders, and representatives of major firms of each sector have participated in those consultation, often lasting for two hours. Consulted sectors are shown in Table 2. Detailed inputs gathered from each of those sectors are presented in Appendix A. To guide the consultation, a template has been developed, comprising of issues related to unfolding scenario, adoption pattern, unfurling threats and opportunities, strength and weaknesses, and strategic responses. Adequate literature review has been conducted to assess the global situation in the area of Robotics, and to analyze inputs obtained from stakeholders. Collected inputs have been analyzed within applicable theories for developing strategy to cope up as well as leverage unfolding Robotics threats and opportunities. It is to be noted that some of the consultations took place having representatives from more than one sector. For example, in a single consultation, inputs were gathered from Agriculture and Food processing. Similarly, respondent having expertise in both textile and RMG provided inputs for these two sectors.

Table 2: List of sectors consulted for preparing the strategy for Robotics

sl	Sectors	sl	Sectors
1	Ready Made Garments	11	Elderly Care and Service Robots
2	Textile	12	Search & Rescue
3	High-tech Manufacturing	13	Blue Economy (Ocean & Marine)
4	Leather, leather products, and footwear	14	Food Processing
5	Agriculture	15	Manufacturing, SMEs
6	Constructions	16	e-Commerce (warehouse, logistics)
7	Plastic Products	17	Waste segregation and recycling
8	Furniture	18	Light Engineering
9	Teleportation, RPA, & IIoT for BPO	19	Pharmaceuticals
10	Transportation	20	Healthcare service delivery

1.4 Megatrend of Robotics as a Disruptive Force

Although Robots emerged in the 1950s as a mechanical machine to perform dirty, dull, and dangerous (DDD) tasks, but the feasibility of adding sensing, perception, and reasoning capability to physical machines has been creating mega trend of Robotics. Machines with human like cognitive capability has been expanding the envelope of robotics creating immense new opportunities, and also posing challenge to plain and simple labor based productive activities. For example, Robotic automobiles are opening the opportunity of reducing wastage and fatalities caused by road accidents, while posing threat to millions of driving jobs. For the expansion of usages of robotics, the market of robotics itself has been expanding rapidly as well.

According to McKinsey research, around 50% of current work activities are technically automatable, and 6 in 10 current occupations have more than 30% of activities that are technically automatable. According to Boston Consulting Group's insights of megatrend, the spending of robotics is likely to jump from just over $15 billion in 2010 to about $67 billion by 2025, as shown in Fig. 1 (Sander and Wolfgang, 2014). It appears that industrial application is at the top, followed by the commercial market.

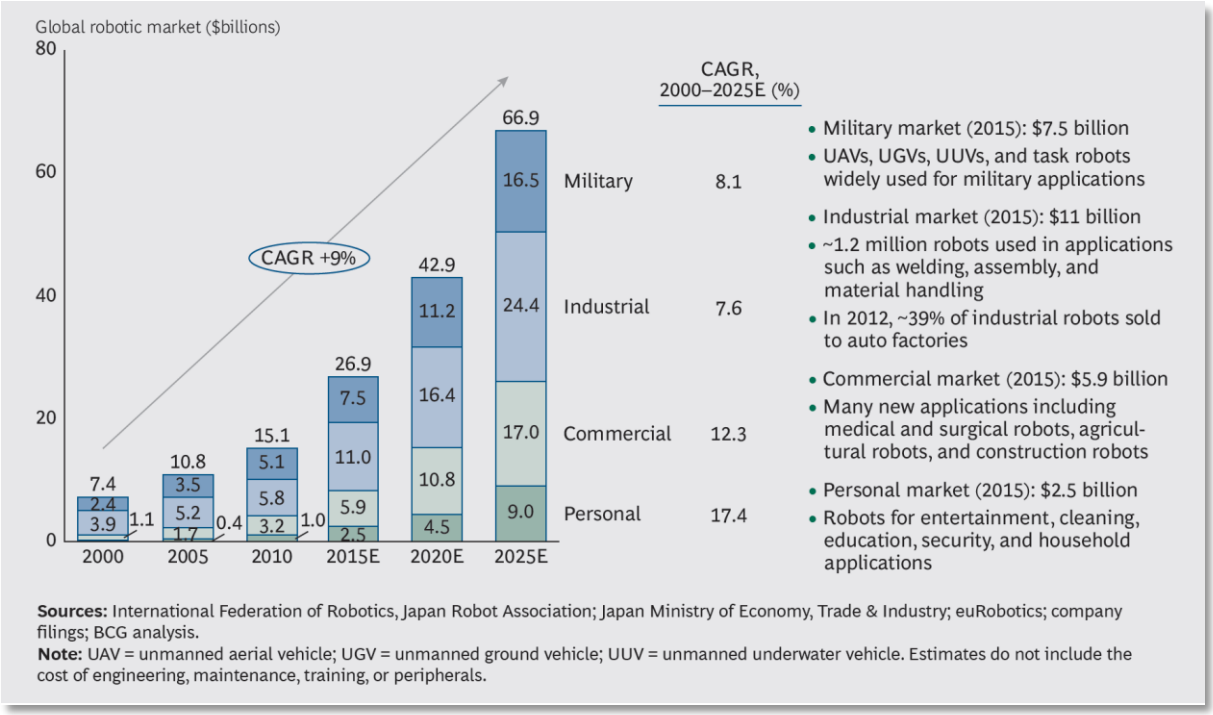


Figure 1: The world wide spending of Robotics is expected to rise to $67 billion by 2025

Among the major segments as shown in Fig. 1, military robotic segment is not within the scope of this strategy. With the growing role of manufacturing, Industrial robots appear to be highly relevant. The robotics has the potential to have both negative and positive consequential effects on GDP produced from manufacture, which steadily reached to BDT25,739 million in 2019, as shown in Fig. 2. In the commercial market segment of robots, increasing complexity and growing budget in construction projects is also creating the scope to benefit from Robotics. Already, UAVs are being used in some

construction projects. The increasing labor shortage is also accelerating technology use in agriculture. This trend will likely move towards making mechanical machinery robotics for increasing precision, reducing wastage, and also increasing the yield. It appears that robots in personal market segment in Bangladesh will rather be slow in near future.

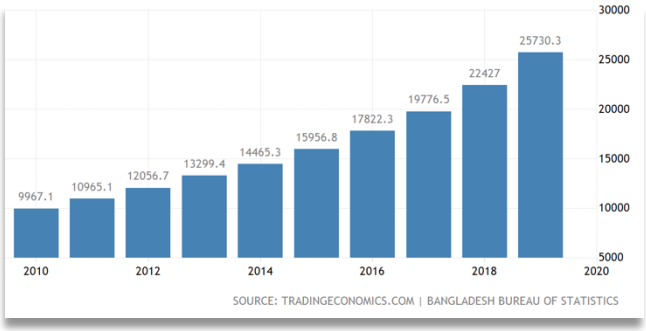


Figure 2: Rising manufacturing GDP of Bangladesh

Industrial Robots: The annual shipment of industrial robots is expected to accelerate across the globe, as shown in Fig. 3. Among the underpinning for such accelerated growth of industrial robots are: (i) Decreasing cost, (ii) Increasing variety of models, (iii) Greater technical capabilities, (iv) Increasing labor costs, (v) Accessible talents, and (vi) Ease of integration. The expansion of verities from from the first electrical, 5 axis, microprocessor controlled robot in 1974 to approximately 300 today is enabling expansion in new applications. Moreover, robots have not only become larger and can handle heavier loads (due to an exponential growth of payload from 6 kg to 1,000 kg). But also they feature more axes and require fewer controllers. In some cases, more than 30 axes can be synchronized by one controller. Greater precision and also mobility are also contributing to ease of use of robotics in precision manufacturing and ware

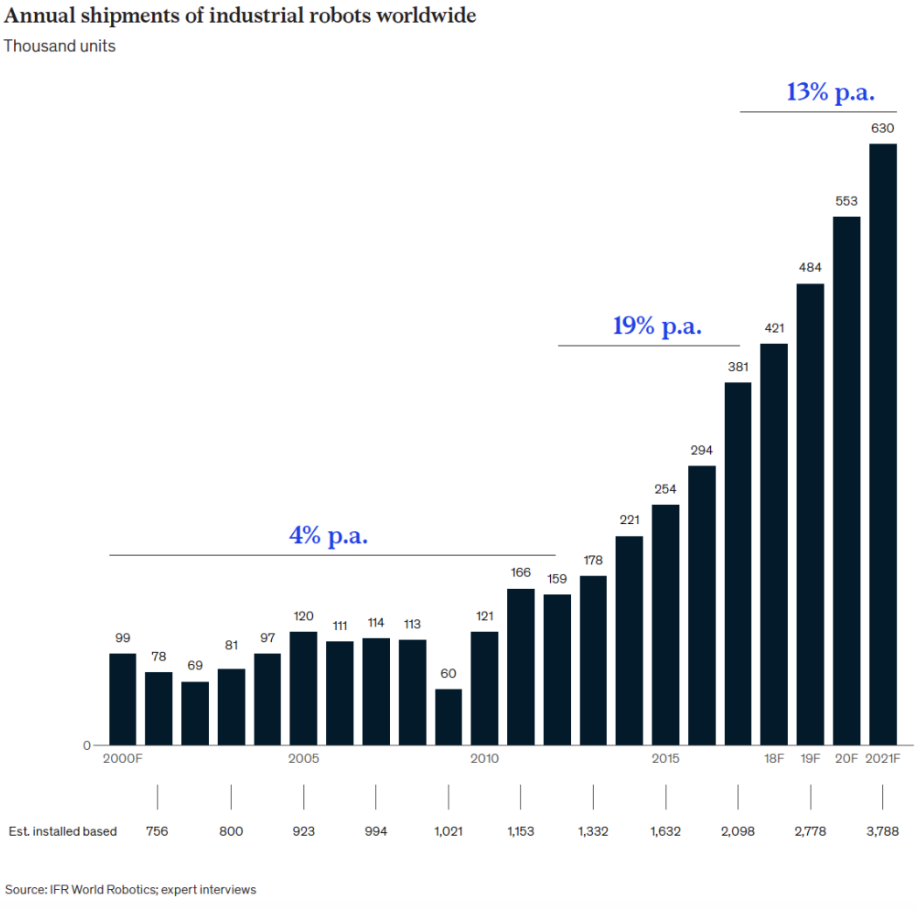


Figure 3: Annual shipments of Robots

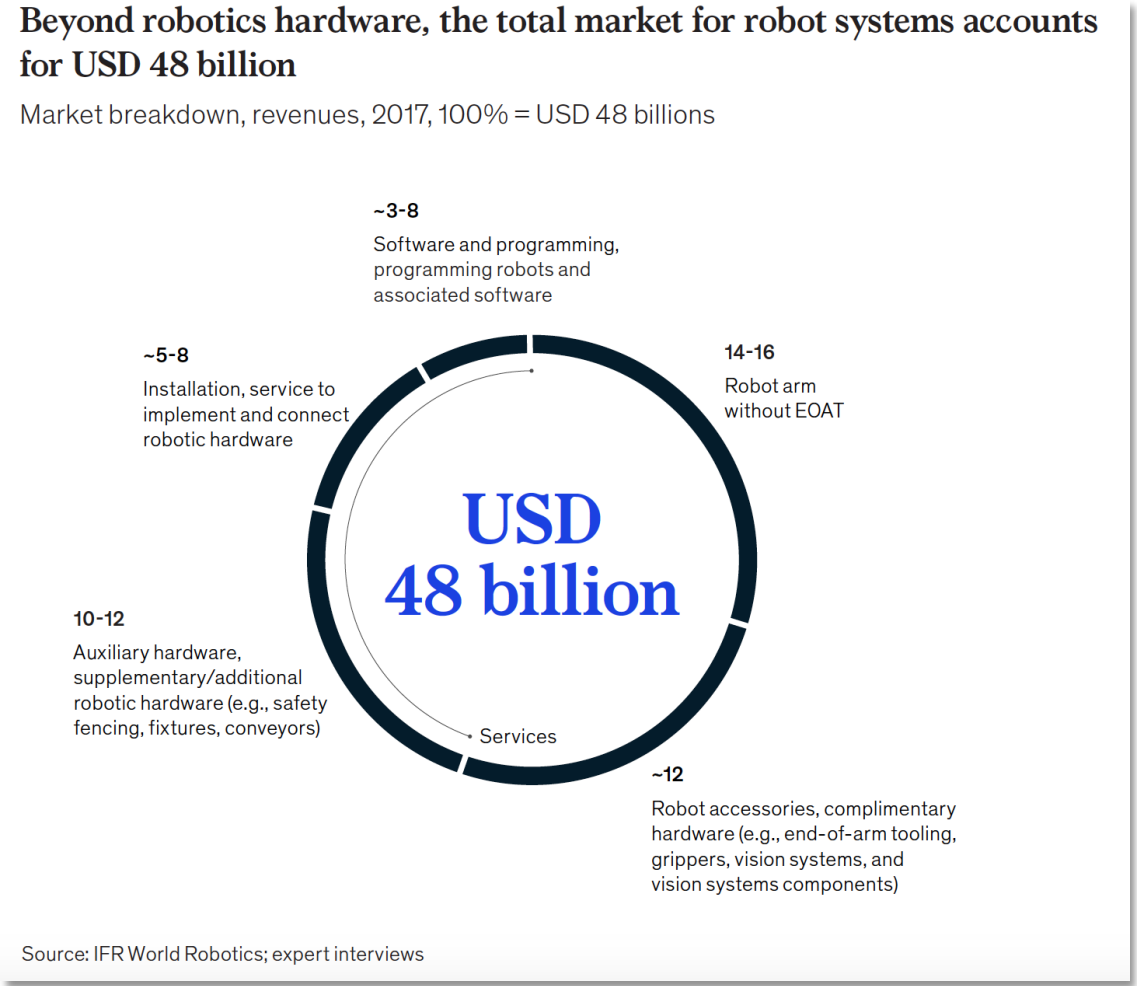


Figure 4: Cost break down in deploying robots in industrial operation

Cost components of industrial Robots: According to International Federation of Robotics (IFR), the market for industrial robot arm, excluding end of arm tooling, already reached 14 to 16 billion USD in 2017. To deploy robot arms in operation, additional service and accessories are needed. As reported by Mckinsey&Company (McKinsey&Company, 2019) in reference IFR, the robot itself creates about 30% of the revenue, accessories make up about 25%, and service (including auxiliary hardware, software and programing, and installation) covers the remaining 45%, as shown in Fig. 4. As robotic arm making requires high precision engineering, Bangladesh may choose to start adding value in task specific programming, associated software, installation, and service. It should be noted that at present Bangladesh is relying on foreign consultants for the purpose of robot programming, installation, and maintenance. Developing human competence in taking over these tasks from foreign consultants would not be pose serious barrier. But progress in this area will open the opportunity of adding almost 25% value. Such local value addition will not only reduce the cost of adoption of robotics, but also create local jobs. Such local jobs will catalyze the growth of local value addition in other segments.

The cost reduction is not the lone driver of increasing adoption of robotics. The quality is the 2nd most important factor for adopting robotics in industry, as shown in Fig. 5. Therefore, for addressing the quality issue, it's likely that industrial economy of Bangladesh will show increasing positive response to robotics. Consultations in some sectors like Furniture and footwear making indicate that precision

cut by robots is often essential requirement for assuring quality for the export market. Health issues, including viruses like COVID-19, are also driving the growth of robotics in food processing and healthcare service delivery. It has been found that robotics adoption growth rate in food processing in the USA is at the top among all other industries due to food safety compliance requirement. Bangladesh will also like feel similar urgency for expanding food export.

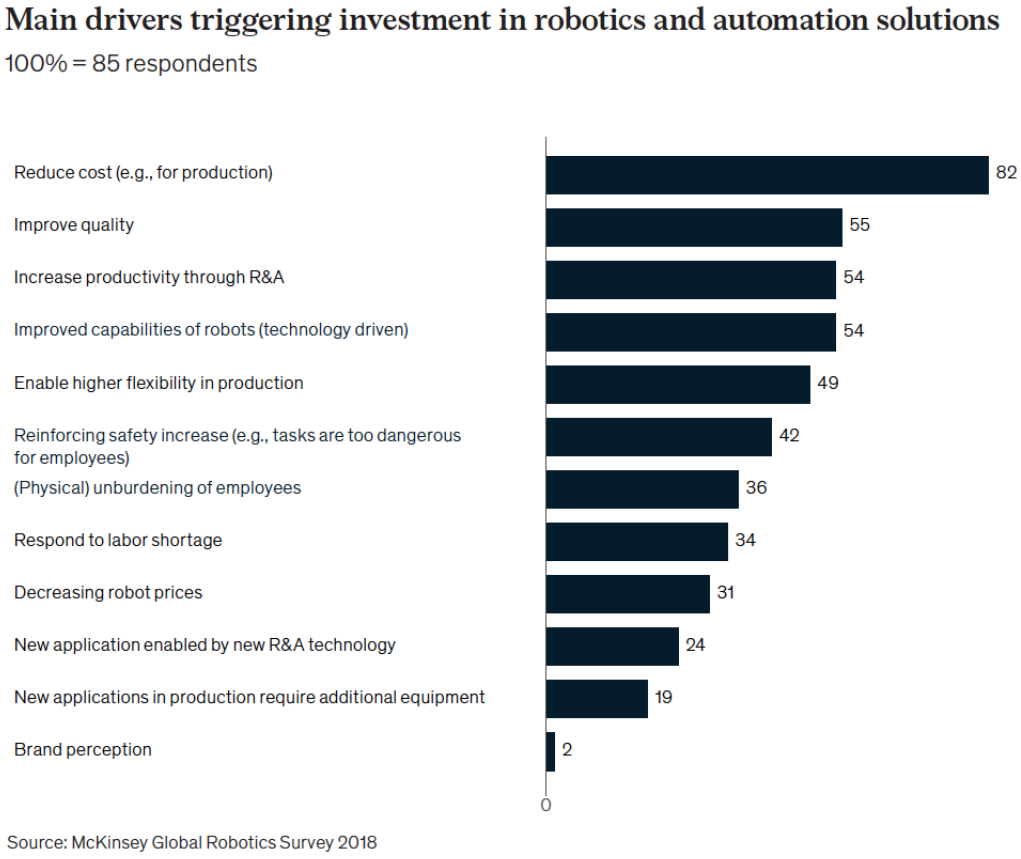


Figure 5: Drivers in creating the pulling effect of Robotics in production.

Key markets and players: Market of robots is segmented into three main sections: Hardware, Software and Service. Among them, hardware is the largest segment, as shown in Fig. 6. Some of the key market players are Mitsubishi Electric Corporation (Japan), ABB Group (Switzerland), Kawasaki Heavy Industries Ltd. (Japan), Rockwell Automation Incorporated (U.S.), and FANUC Corporation (Japan). KUKA AG (Germany), Seiko Epson Corporation (Japan), Yaskawa Electric Corporation (Japan), Staubli International Corporation (Switzerland), Mayekawa Mfg. Co., Ltd. (Japan), Universal Robots A/S (Denmark), and Bastian Solutions Inc. (U.S.). According to some prediction, the global robotics technology market size was valued at $62.75 billion in 2019, and is projected to reach $170.08 billion by 2027, growing at a CAGR of 13.5% from 2020 to 2027 (RTMI-2020, 2020).

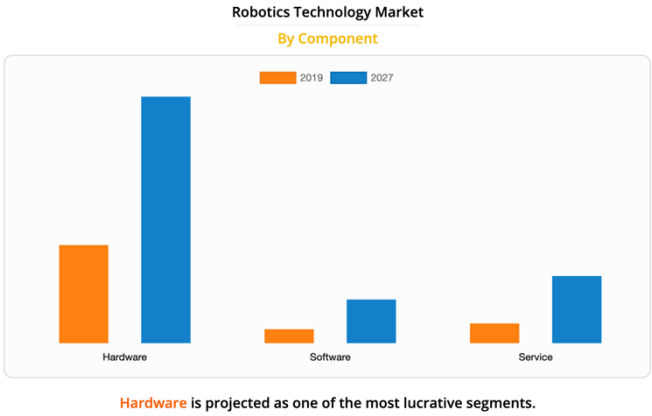


Figure 6: Market segment of the robotics industry

Patent trend in Robotics: There has been surge in patent filling in broad area of robotics, as shown in Fig. 7. In 2013, the global number for published patents in robotics and autonomous machines passed the 5,000. As of 2013, global portfolio of robotics patents stood at about 120,000, which were cleared worldwide over the last two decades. Japan's top position 31 percent of the total robotics patent published is followed by the US claims of holding second place with 19 percent. Other top performers are Germany at 17 percent, China at 10 percent, Korea at 9 percent, France at 3 percent and the UK at 2 percent.

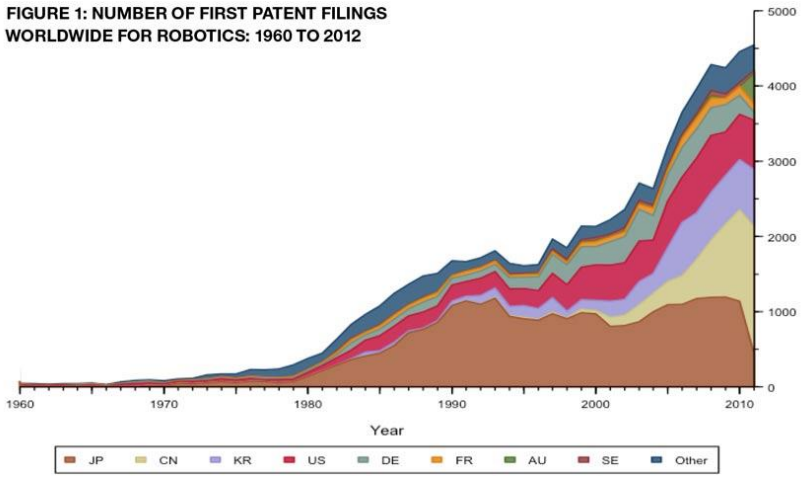


Figure 7: Robotics patent filling trend: Source, WIPO

On one hand, boundary of robotics has been expanding. On the other hand, business interest has been growing. Robotics R&D is longer limited to hardware devices. There has been increasing emphasis on sensing, perception, and reasoning. It's being estimated that the global R&D spending in the robotics industry to keep growing at a CAGR of around 17% during 2016-2020. As a result, search in broad area of AI is drawing increasing interest to Robotics community. At present, Robotics R&D and patent filling is dominated by advanced countries. Both offensive and defensive strategies are in action. The R&D budget requirement for generating meaningful ideas has been increasing. To recoup the growing R&D investment, companies are looking showing growing interest to patent filling. Such patent filling trend bring two important lessons for Bangladesh. The first one is that replication-based strategy for entering into robotics will keep eroding the strength. On the other hand, it gives that signal that there is has been expanding opportunities in robotics through R&D and innovation. In addition to patents, industrial designs that protect a robot's appearance – its shape and form is also an important strategy in helping firms to maintain excludability, and appropriate the returns on their R&D investments.

Robotics innovation systems: Despite high growth of Robotics adoption, it's being observed that R&D, innovation and manufacturing of Robots are highly concentrated in advance ed countries. More importantly, robotics clusters in these countries are typically centered around leading universities. Notable Examples include Boston (United States), the Île-de-France (France), Odense (Denmark), Zurich (Switzerland), Bucheon (Republic of Korea), Osaka (Japan) and Shanghai (China). These clusters thrive on the interface between public and private research, with firms commercializing innovations developed partly through long-term research in universities and other public research organizations. With the exception of China, which hosts some of the fastest-growing robotics companies such as DJI (a drone company), Siasun and Estun, most robotics-related innovation and company startups are found in high-income countries. The system capacity vital for developing robotic clusters as the robotics innovation ecosystem is highly dynamic, and research-intensive. Collaborative among key actors is the key, and it is becoming increasingly complex. It demands an expanding network of

specialists, research institutions, user firms, and technology-intensive firms. They need to bring together know-how from a diverse range of fields to deliver technologically feasible and economically viable innovations, which are often built on the latest developments in materials science, motive power, control systems, sensing and computing.

Global trends of using Robots in high-school: What is the insight in it: four of the 20 best-selling toys on Amazon during the 2018 holiday season were ro bots, robotics kits, or other electronic circuitry kits? Kids are highly fascinated with Robots. It's being reported that Worldwide school spending robotics products and curricula will likely to grow from $146.5 million in 2018 toreaching $640.5 million by 2023. This is a hoping 28 percent annual through 2023 (Robotics. K-12 Education, 2019). Robotics toys bring STEAM concepts to life. They engage students through hands-on opportunities of learning and being creative as they build and program their own robot. Programming of robots make the learning of key concepts in math, physics, coding, and engineering easier, as they're seeing how these principles apply within real-world scenarios. Moreover, such exercises also prepare future workforce to innovate, and build robots, and collaborate to work with them. On top of using robotics in STEM education, AI and robotics are, among other things, catalyzing the creation of new majors, minors, and certificate programs.

Strategy Lesson from this megatrend for Bangladesh: So far Bangladesh was more or less immune to Robots. On the one hand, robot makers kept targeting the automobile and electronic sectors. Bangladesh so far has very low value-added activities in these sectors. On the other hand, robots we not technologically capable to undertake tasks in areas where Bangladesh has labor advantage. But rapid technology progression, as shown in patent filling trend, Robots are getting increasingly smart to perform tasks in varying situation. They are getting capable in handling flexible materials like fabrics or leather. They are also acquiring capability to understand varying work environment and adapting their behavior. Moreover, entry barrier in the Robotics industry itself is expanding from the acquisition of producing precision mechanical parts to undertaking R&D for developing patentable AI capabilities. So far Bangladesh's industry is highly decoupled from R&D and academic research, as they are mostly focusing on replication and labor-based value addition. But the entry in Robotics, both for adoption and production, demands strong collaboration among three major actors: 1. Robot user industries, 2. Academic and R&D institutions, and 3. Robot technology firms. It's also worth taking into consideration that labor based brute forced strategy of replicating parts of robots does not have much merit. High level of precision need often makes reverse engineer of these complex systems practically impossible. Moreover, patent infringement allegations will pose serious barrier for the entry of export market. To prepare future workforce friendly to robots, Bangladesh should also consider of using robotic toys in STEM to high-school students. Although, academic and commercial research and development are important to robotics. However, much of the current robotics R&D spending worldwide is still being directed by national governments as robotics has a key role to play in addressing economic competitiveness.

1.5 Robotics and Future of Work

There has been fear factor about Robotics in Bangladesh, and also across the world. There is no denying that Robotics is a labor-saving technology. But intelligent exploitation of this technology has also the possibility of creating jobs. Some of the possibilities are described below.

Analysis of production factors and comparative advantage based task allocation: In production, two factors such as labor and capital (machinery) share roles in performing tasks in producing outputs: Q = f(K, L); here Q: Output, K: Capital, and L: Labor. In order to meet the growing wage of labor, and offering better quality outputs at lower price, profit-maximizing firms have been improving the role of capital or machinery. Technology is being developed to build machines, better machines to delegate increasing role from labor. As a result, comparative advantage between capital and labor has been continuously shifting towards machine, consequentially reducing the availability of tasks for human workers to perform. Such increasing role of technology also enhances productivity, expands demand, and increases demand for labor (in certain situation). Moreover, technology also supports product innovation, creating new tasks and increasing demand of labor to execute them. The net effect on technology on jobs or total stock of tasks to be performed by human workers depend on aggregation of these multiple implications of technologies on reduction as well as creation of tasks.

A firm as well as an industry, also country as a whole, at a certain point in time is producing a set of products P, consisting of N number of products. Each product $p \in P$ has a set of F, comprising of M number of features. In order to add each feature to a product, a set of tasks T should be executed. Based on the comparative advantage, production factor, whether labor or machine (capital), is assigned to a particular task in adding features to produce products. Moreover, labor is also needed for the consumption of products, such as driving automobiles. The labor requirement in a firm, industry, or a country depends on product set, volume of production, consumption, and comparative advantage of labor and capital.

A task execution complexity demands capacity of production factors. Execution complexity depends on the need of capacity in the form of (i) knowledge, (ii) manipulation, (iii) movement, (iv) communication, and so on. Production factors acquire those capacities through three primary means: (i) innate ability, (ii) training as well as design (codified capability), and (iii) experience, in the form of tacit. Human workers or labor attain the eligibility of performing a task due to both innate ability, and earned capacity through training as well as experience (tacit capacity). On the other hand, machines are built with inanimate materials, which are devoid of task execution capacity (often termed as lack of knowledge about task) to begin with. The technology advancement is being leveraged to build task execution capacity in machines through design. Based on comparative advantage, production factors whether labor or machine (often called capital) is assigned to a particular task.

Robots to augment innate capability: For example, doctors cannot travel through different organs to diagnose disease, and fish farmers cannot look through the water to understand health of fish. Similarly, dairy farmers cannot understand state of mind or body of cows well. Technology stack of the Robotics can support us to innovate to augment human's innate capability to make them play far more important role than before in performing productive jobs. By empowering innate capability of farmers with sensors and artificially intelligent software, we may succeed to increase outputs from

the same unit of land and other farming inputs, expanding production and creating jobs. Moreover, leveraging of this opportunity will reduce wastage.

Effect of innovation on tasks and labor demand: There are three major innovation types, having varying effect on tasks. These innovation types are: 1. Sustaining (incremental) innovation, 2. Process innovation, and 3. Disruptive innovation. *Sustaining innovation* focuses on addition of new features as well as advancement of existing features. Addition of new features invariably introduces new tasks. But advancement of existing features has mixed effect; depending on the feature and nature of advancement, it may kill or add tasks. *Process innovation* invariably focuses on increasingly advancing machines' comparative advantage over labor in performing tasks. *Disruptive innovation* has mixed effect. It introduces new products, consequentially new tasks to make them. But it also destroys the demand of existing products, reducing the demand of tasks in making them. Invariably, disruptive innovation expands the market, expanding the volume of production—thereby creating demand for labor, of different types though.Robotics technology has the potential to drive of these innovations.

Effect of product redesign on tasks and labor demand: Often product redesign leads to eliminating tasks in making products, and task simplification, so that machines can have comparative advantage. To counter the market force, industry has been redesigning products in reducing the demand for labor to make them. Attaining redesign capability out of Robotics technology stack appears to be vital for Bangladesh. In one hand, it will create innovation jobs. On the other hand, it will increase competitiveness of existing products, consequently expanding the trade and creating the demand for labor. Moreover, redesign capability for making high-tech products more appealing by adding Robotics technology features appears to be highly critical for Bangladesh in developing high-tech industry.

Effect of export led manufacturing on task introduction: Export oriented manufacturing often creates the demand of low skilled tasks in developing countries. To organize and support low skilled tasks, some managerial and support tasks are also created. Due to high-level competition among the global brands and multinationals, there have been aggressive R&D activities for labor saving technology for reducing the cost and lowering lead-time. As a result, task content supply in export-oriented manufacturing will keep shrinking rapidly. Export diversification and engaging into those productive activities which demand the demand of Robotics with innate capability could be prudent strategy.

Unfolding remote service delivery opportunity: There is no denying that Robotics has been posing threat to job loss, particularly in developing countries. Among other options, Robotics innovations are opening new type of remote service delivery opportunity. For example, remote supervision and control of semiautonomous IoTs appear to be an emerging opportunity of increasing task supply. Despite the potential, many Robotics innovations starting from autonomous vehicles or elderly care delivery robot nurses will remain semi-autonomous devices during the foreseeable future, requiring human supervision and on-demand intervention. The emergence of low latency cellular connectivity like 5G is opening the opportunity of supervising these unfolding Robotics innovations over the Internet. These opportunities could be exploited for increasing the task supply, connecting youths of Bangladesh though AR/VR gears to the global service value chain of IoT supervision. Moreover, execution of manufacturing jobs through collaborative robotics could also be delivered over the Internet. Such remote coupling of human interface with machines in the age of 4IR could be wonderful opportunity for Bangladesh.

Moreover, there are opportunities of creating jobs for supporting the adoption, adaptation, innovation, and maintenance. As explained before, there is a scope of adding value to robotics, consequentially creating jobs. The strategy focuses on leveraging this opportunity so that local value could be added in programming robots, developing associated software, fabricating end of the arm tools, and providing maintenance, which may lead to designing and producing the full robotic solutions.

2. Review of Country Level Robotics Strategies, and Thematic Studies

Japan is already leader in both usages and production of industrial robots. So far, Robots in Japan are primarily used in manufacturing of automobiles and electronics. In its new Robot Strategy (Japan Robots Strategy, 2015), Japan has been targeting robotics outside factories. Most notable application areas are: (i) Service, (ii) Nursing and Medical, (iv) Infrastructure, Disaster Response and Construction, and (v) Agriculture, Forestry, Fishery, and Food Industry. In these application areas, as opposed to past generation highly specialized rigid robots, japan has been targeting flexible and adaptive robot and tool systems with specialized cognitive capabilities. These targeted applications will require development of underlying technologies like sensing, perception, grasping or manipulation. To address it, Japan has adopted strategy of active collaboration among industry, academia, and government to realize robot revolution in actual fields.The Japanese government has put aside 100 billion Yen (or $921 million) with the pure focus of assisting and funding the projects in emerging applications of robotics like elderly care during its first five years, starting from 2019. The Austrian Council on Robotics and Artificial Intelligence has come up with a White Paper with a title, “Shaping the Future of Austria with Robotics and Artificial Intelligence” (Sabine, 2018).

To leverage Robotics in agriculture and food industry, UK Robotics and Autonomous Systems (RAS) Network has come up with detailed findings about opportunities and necessary actions. It focuses on long-term technology vision encompassing a new generation of smart, flexible, robust, compliant, interconnected robotic systems working seamlessly alongside their human co-workers in farms and food factories (UK-RAS, 2018). According to this report, RAS technologies in agriculture requiring 5 to 10 years to diffuse in advanced countries offers time for Bangladesh to prepare and respond to leverage it. Moreover, it offers the opportunity for Bangladesh to promote collaborative research programs for adapting, advancing and customising emerging RAS innovation to meet unique requirements and labour economics of Bangladesh. It has been reported that the successful delivery of RAS potentials within a sector domain, such as Agri-Food, requires close collaboration between the RAS community actors, including academic and industry practitioners. It’s also being recommended to advance component technologies like navigation, sensing, safe operation, grasping, manipulation, and perception and fuse them to develop appropriate cognitive capability, which could be fitted with conventional electro-mechanical farming and food processing machinery in making them flexible for dealing with variations in precise manner. As a result, wastage would be reduced, yield would be increased, food safety would be improved, and cost would be reduced. UK-RAS has also come up with another white paper (UK-RAS, 2016) focusing on industrial robotics for driving next generation manufacturing revolution in the UK. Human-robot interaction, embedded cognitive capability, and flexibility of smart robotics are targeted for enhancing making UK’s manufacturing sector to meet the requirement of mass customisation, small batch of production, and performing tasks in varying situation in cooperation with human workers.

Often Robotics strategy has been embedded with artificial intelligence strategies. In formulating Machine Intelligence Strategy, it has been stated that the nature of economic as well as social implications brought by Robotics will largely depend in large part on the actions taken by policy makers and Governments today, (Carter, W. and others, 2018). Depending on the actions being taken, unfolding implications will be highly polarized, posing the risk of increasing inequality between firms, industries, and also countries. In a report (OECD, 2018), OECD has observed strong role of industrial robotics in the global organisation of production. It has been observed that Robots play vital role in competitiveness. In addition to labor saving, the use of robots improves the quality. For example, vision-guided robots increase accuracy, precision and safety in a number of areas, particularly when tasks are not repeatable, when the industrial environment is less than ideal, and when avoiding contamination is crucial, such as food production to ensure the quality of raw food. Moreover, vision guided robots appear to highly effective in quality inspection such as whether there is presence of foreign particles on processed food. Particularly, automobile makers and parts producers rely on such robots for detecting quality flaws such as faults in body panels, uneven paint finishes, breaks in adhesive sealants, and irregular welding bead. Through inclusion of flexible and mobile robots, producers also rapidly reconfigure production processes on the manufacturing floor, switching from producing a vintage product to a new good, and thus enhancing the product mix. Such a capability appears to be crucial to react to increasing global demand by innovating faster and leveraging a shorter product lifecycle.

In deciphering China's AI dream Ding, J. (2018) finds Robotics Industry Development Plan of China. It has been revealed that Robotics has been a key technology for China for addressing competitiveness issue. Ray, J. and others (2016) finds that "Chinese state-owned conglomerates, companies, and venture capital firms are actively acquiring and investing in AI and foreign robotics technologies companies, particularly in Europe." Automated machine tools and robotics is a core competence for China for progressing with the Vision 'Made In China 2025'. China has already started showing progress in increase in China's indigenous robot in the purchase of 140,000 industrial robots in 2019. It's being estimated that nearly half of all industrial robots sold in China will be domestically-made by 2020 (Source: IFR). Electronics and Automobile industries are the major users of industrial robots in China, as shown in Fig. 8. In addition to industrial application, China has also been working on developing Smart robots counter-terrorism, disaster relief, healthcare, educational entertainment, and home services (He, Y. , 2017). It's also being predicted that by 2020, the quality of the core components of robots produced by Chinese companies will reach comparable quality levels with their counterparts in the global market.

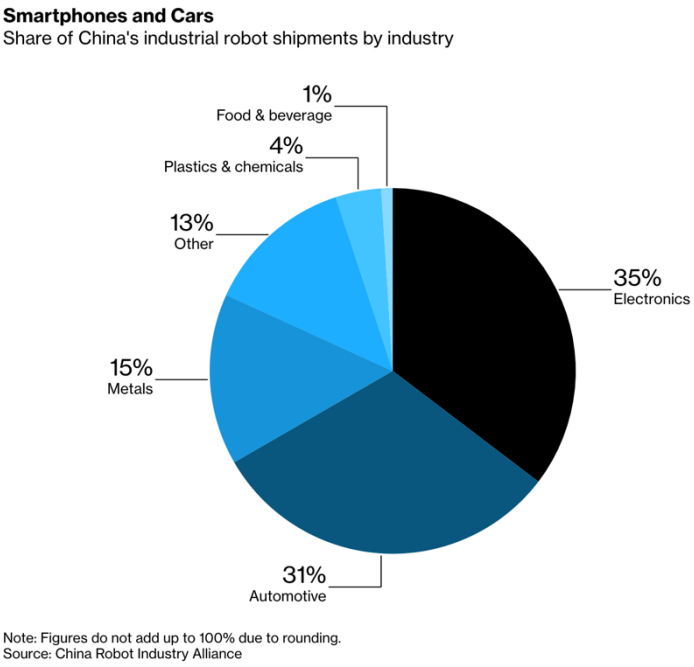


Figure 8: Distribution of adoption of industrial robots in China

SPARC (2015) has developed a high-level strategic overview of the European robotics community and its objectives. It provides (i) a common framework of description for robotics within Europe, (ii) a clear set of goals for market relevant technical development, and (iii) illustrate the relevance of these goals with respect to future market opportunity. This strategic framework establishes linkages of technologies, robotics, and services with application domains. Based on such mapping of technical and market detail, they develop Strategic Research Agenda (SRA). This strategic framework is being updated annually as priorities, technologies and strategic developments shape European research development and innovation. It's being reported that euRobotics (comprising the European Commission and 180 companies and research groups) created this robotics research program SPARC, with investments of €700M from the EC and €2.1Bn from euRobotics.

According to Oxford Economics (Oxford Economics, 2019), there forces are behind the surge of robots. With the progression of technologies, robots are getting cheaper than human labour in many circumstances. The reduction of price of microprocessors, and the scale advantage of software, among other factors, have been reducing the price. Average unit price of industrial robots fell by 11% between 2011 and 2016. On the other hand, industrial labour cost has been increasing in most of countries including China and other developing countries. The technology progression is making Robots evermore sophisticated, in more varied contexts, and can be installed more rapidly. With the support of artificial intelligence algorithm, they can learn from their experiences and make decisions informed by data from a network of other robots, resulting in their deployment in in sectors beyond the automotive industry. On the other hand, demand for manufactured goods increasing and there has been intense competition to deliver higher quality at less cost.

With the rising capability of robotics, decreasing cost, and increasing wages, a recent World Bank publication (Trouble in the making?) has raised concern about the weakening potential of manufacturing led development (HD, Mary. And Nayyar G., 2018). Industrial automation and advanced robotics, digitalization and Internet-based systems integration using factory Internet of Things and additive manufacturing (3-D printing) are growing as significant factors influencing which locations are attractive for production. It appears that advanced countries are aggressive pursuing robotics reverse the offshoring trend. There have been successes, albeit small, to reshore historically labor-intensive manufacturing activities back to high-income economies--closer to the consumers.

South Korea is already global leader as far as robot density is concerned. To augment its position to leverage smart robotics, not only in factories, South Korean trade ministry revealed in 2016 to pump 500 billion won (about $445 million) into its robotics industry over the next five year. It was expected that a big chunk of the funding would help to finance corporate R&D centers for nurturing new talent and to help develop next-generation robotic technology by 2020. This funding commitment was augmented further with the allocation of additional $2 billion for the AI R&D by 2022 (Medium, 2018).

Robotics has been a core strategy in addressing quality and cost issue in producing economic outputs. The strategy has been to support R&D to figure out economically feasible application areas, demonstrate technology potential, advancing technologies to expand application areas, and develop human resource as well as demand through collaborative R&D in partnership with industry, resulting in developing system capacity for adoption, adaptation, production, maintenance and innovation.

3. Unfolding Robotics Scenario

3.1 Technology Prospects and Global Offerings

Robots used to be fixed mechanical manipulators performing dull, dirty and dangerous jobs in restricted environment, like welding cars or painting car bodies. But there has been progress in major building blocks such as sensing, perception, decision making and collaborating making them flexible, smart. Robotics technology has been growing at a rapid space. Such growth dynamics often creates challenges in predicting future scenario and strategizing responses. Robots used to be blind, dumb, and locked into place. On the other hand, we are able to see an object, walk to it, coordinate our movements to grasp it, sense that we are holding it correctly, and make adjustments if anything goes wrong. But technology progression is empowering robots to acquire those capabilities. As a result, robotics has been encompassing many disciplines starting from computer science to psychology. We also need to adapt laws to new technological possibilities, in particular privacy and liability. In order to develop national strategy, such technology progression should be taken into consideration, for assessing unfolding threats as well as opportunities. Strategy development should focus on coping with threats and leveraging emerging opportunities. Moreover, human resource capacity as well as intellectual asset development for leveraging Robotics should focus on multiple disciplines as shown in Fig. 9.

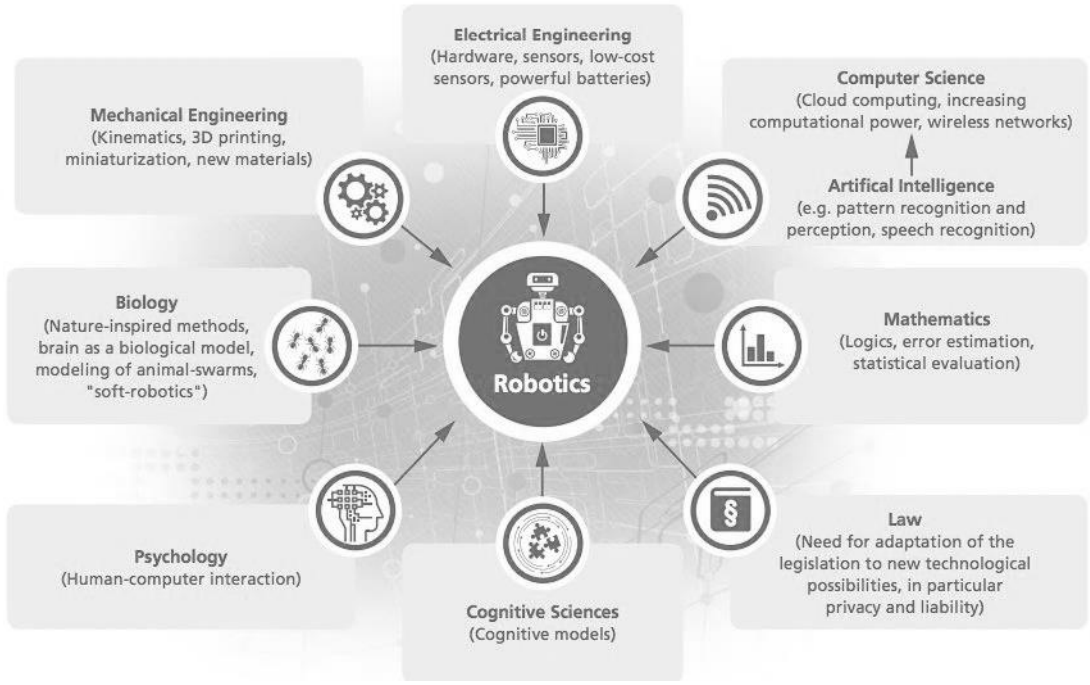


Figure 9: Robotics demand competencies in multiple disciplines

Some of the notable developments driving the envelope of robotic technologies as well as application areas are briefly explained in following sections.

3.1.1 Human-Machine Interface and Collaborative Robots

Figure 10: Collaborative Robotics

Historically, robots were given tasks to perform in isolation. The development of sensors and computing power have become cheap enough to be easily adopted for robot applications, which is resulting in a revolution in control and flexibility of systems in developing robots capability for interactive collaboration with human. A major new application domain has been in the adoption of collaborative robots that can operate side-by-side with humans, as shown in Fig. 10. These collaborative robots or cobots interact with humans in a shared space or to work safely in close proximity. Collaborative service robots can perform a variety of functions, from information robots in public spaces; logistics robots that transport materials within a building, to inspection robots equipped with cameras and visual processing technologies that can serve in a variety of applications such as patrolling perimeters of secure facilities. Collaborative industrial robots enable manufacturers to extend automation to final product assembly, finishing tasks, and quality inspection.

3.1.2 High Precision Manipulation

Even when workers are affordable, the next generation of miniaturized, complex products with short life-cycles requires assembly adaptability, precision, and reliability beyond the skills of human workers.

3.1.3 End Effectors, Hands, and Fingers

Figure 11: Human hand like Robot fingers and hands being developed

Robots having human like hands open new phase of automation and application of robotics. A robotic hand with four autonomous fingers and a thumb that can do anything our own flesh and blood can do, as shown in Fig. 11. That is still appears to be the stuff of fantasy. Upon sensing, perceiving and deciding, the next challenge for robots is to execute the tasks, like grasping an egg, or handling knife. Many of the tasks being performed by us require our hands to grasp, lift, manipulate and release objects. In comparison to our hands, so far robots' hands are primitive in nature, as far as sensing and dexterity are concerned. The progress in making robots' hands similar to ours will significantly contributes to improving comparative advantage of robots over human in performing numerous tasks, starting from stitching tissue to handling fabrics. For example, research is taking place in developing robot hand having as

high as 129 sensors and 24 joints, with very similar movements to those of humans, including the thumb or even the flexion of the palm to move the little finger. One of the emerging areas of technology progression and innovation in robotics will be likely building human like hands.

Sense of touch of robots' fingers will enable robot to take over many service jobs from human (Fig. 12). For robots to qualify service jobs like serving food or taking care elderly people, touch, combined with sight, is crucial for tasks such as picking up objects—hard or soft, light or heavy, warm or cold—without damaging them. Despite having significant progress in robotics technology, we are far from having human finger like sense of touch of robot fingers. Adding the sense of touch could remove uncertainties in dealing with soft, fragile and deformable objects, consequential opening new set of comparative advantage for robots. Good thing is that progresses are being reported. For example, recently, researchers from MIT and Harvard have developed a scalable tactile glove and combined it with artificial intelligence. Sensors uniformly distributed over the hand can be used to identify individual objects, estimate their weight, and explore the typical tactile patterns that emerge while grasping them.

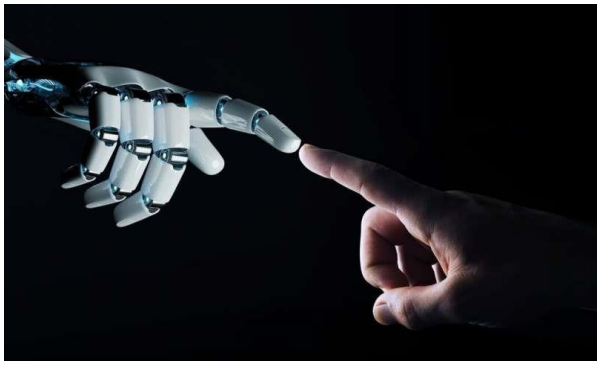


Figure 12: Sensing at the tip if finger is useful for many potential tasks

3.1.4 Robots' Skin

So far, robots do not have human like skins sensing temperature, or pressure. The lack of feel and respond to physical contact is limiting applications of robotics, particularly in areas which require them to come in increasingly close contact with people, like in elderly care or hospitality service delivery. Although 13,000 sensors that enable tactile sensation is insignificant to human beings' 5 million skin receptors (Fig. 13), but it's far better than having no sense of touch at all. Such progress will enable robots to have human like touch sensing capability, opening new application areas, as touch enables safe robot operation, by detecting contact with unseen obstacles and giving the possibility to apply the correct force for achieving a task, without damaging objects, people and the robot itself.

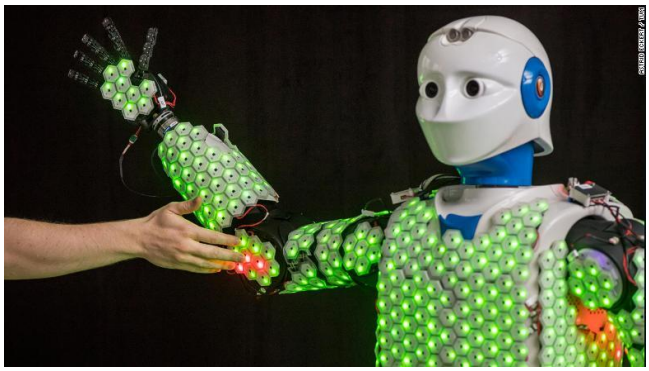


Figure 13: High resolution Robot skin being developed for expanding the scope of Robotics

3.1.5 Sensing and Perception

Stereo vision for 3-D bin picking: Robots for random bin picking is getting closer to human skill. The human hand still beats the robot when it comes to picking, but the gap is closing fast. Starting from e-Commerce, segregating office wastes to many other applications, robots could be great help for sorting objects. Although we perform random 3-D bin picking in an intuitive manner, but its a very complex task for robots. For a robot to be able to effectively pick random objects from a bin, it requires a point cloud map (Fig. 14). To create a point cloud map comprising of millions of data points of object space, progress based on stereo machine vision camera generating a 3D depth map is being reported. It appears that 3D-bin picking with machine vision capability will enable robots to take over increasing tasks from human.

Figure 14: Robots with stereo vision are in operation of picking objects

X-ray and CT imaging: Day by day, sensing and perception capability robots is getting deeper, even crossing the limit of human's innate capability. It's being reported, "The first robot takes X-rays and a CT scan of the carcass, which generate a 3D model of its shape and size. Based on what the system sees in the model, another bot drives rotary knives between the ribs and cuts through the hanging carcass, using the spinal chord as a reference point." Unlike human, real-time (high speed) x-ray and CT scan equipped robots can see through carcass (Fig. 15). As result, robot butcher can perform the job in a more precise manner, addressing the quality issue. They also maximize the yield of production of different meat products from the same carcass. Moreover, they not only reduces cost, but also they improve food safety by reducing human touch and presence. Among 25 million people in Australia, 30,000 are butchers (0.12%); and these jobs are under threat. All across the western world, the number could be significant. Due to food safety, and productivity, these robot butchers will also enter developing countries like China, and India. As a result, robot butcher alone will kill millions of jobs.

Figure 15: X-ray imaging-based 3D vision capability is being developed for Robot butcher.

High-Precision surface perception: Precision and productivity are key performance indicators in installing floor tiles. It has been demonstrated that Robots can lay tiles more precisely than human workers can perform. And instead of 24 seconds needed by human worker to lay each tile, technical solution that is deemed feasible and capable of reducing this time to about 10 seconds. Mobile robot with omni-directional locomotive capability, and stereo cameras and light-striper for sensing is showing the possibility of repacking human workers in laying tiles (Fig. 16). High-resolution imaging is needed to identify tile seams and edges, assess the quality of automatic installation, and locate where the next tile should be placed. Navigation and positioning are performed through an algorithm of laser-based triangulation system, and by detecting, counting, and dead reckoning off of tiles placed on the floor through high-resolution image processing.

Figure 16: 3D laser imaging based robotic applications for laying floor tiles

Teaching through showing: Teaching through showing is an important progress in making robots recognize diverse objects. Particularly, such technique is very useful for trash sorting. Trash-sorting robot opens the opportunity of greener environment. By showing samples, robots are being taught to separate glass bottles from plastic ones or metal cans. It opens the possibility of deploying robots in sorting office trash destined for compost, recycling or landfill. Progress could be made further in making robots as viable solutions for dealing with growing wastes. Such robot possibility also raises the necessity of taking steps in education, skill development, R&D, innovation, and start-ups.

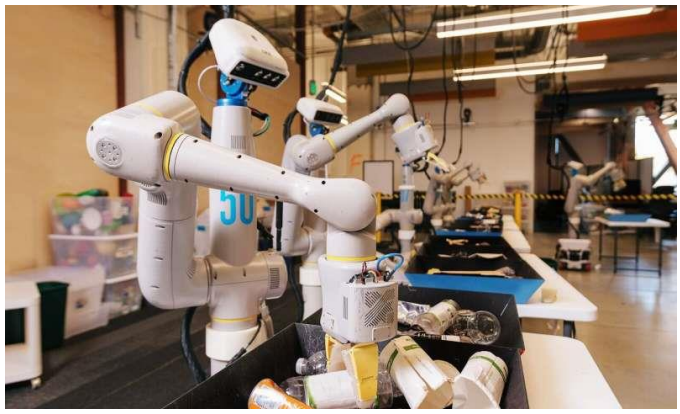


Figure 18: Computer vision and learning algorithms are empowering robots to learn from

3.1.6 High-Speed Hand-Eye Coordination in handling Flexible Materials

For dynamically aligning pieces of fabrics in feeding to swing head, very precise and rapidly varying hand-eye coordination is essential. It's being reported that success has been attained in developing a specialized camera capable of capturing more than 1,000 frames per second, and a set of image-processing algorithms to detect, on each frame, where the threads are in real-time, without slowing down the speed (Fig. 19). Such high speed, also high-resolution vivid image

Figure 19: Robots with the capability of handling fabrics and performing sewing

frames allow the computer to pick out individual threads in the fabric. As a consequence, any distortion to the fabric made by each punch of the needle can be measured extremely accurately. As reported by the Economist, these measurements are a vital achievement in allowing the "feed dog", which gently pulls the fabric through the machine, to make constant tiny adjustments to keep things smooth and even. This success appears to be sufficient enough to mimic required human hand-eye coordination in handling fabrics-making sewing steps human-free.

3.1.7 Remote Service Delivery and Tele-robotics

In the era of Industry 4.0, Teleoperation and Telerobotics in Industrial Internet of Things (IIoT) is an emerging area of Robotics. A concept is shown in Fig. 20. Robots and remote control systems enable various industries to control real machines/equipment by virtual object through remotely operable master controlling interfaces. While much of the focus is on industrial automation in a manufacturing, there are many industries expected to benefit from IIoT robotics including healthcare, agriculture, and more. Such of the likely benefits may range from guaranteed machine up-time on factory floors, actual amounts of energy savings in commercial buildings, guaranteed crop yields from a specific parcel of farmland. According to some market research findings the overall Robotics Market for IIoT will Be Worth $45.73 Billion by 2021. Advanced IIoT systems will also utilize Digital Twin technology to enable next generation teleoperation. IIoT applications are supported by ICT infrastructure including broadband communications, sensors, machine to machine (M2M) communications, and various Internet of Things (IoT) technologies. 5G and mobile edge computing will enable Teleoperation anywhere there is 5G coverage, enabling many new consumer and industrial automation scenarios involving robotics. Coupled with Haptic Internet technologies, Virtual Reality (VR) and low latency 5G connectivity, the teleoperation and tele-robotics market will take a major leap as user interfaces improve further offering seamless virtual presence.

Figure 20: Industrial internet of things, semiautonomous collaborative robots and AR/VR based user interface are opening a new era of remote service delivery

3.2 Adoption in Bangladesh

Among other sectors, Bangladesh's manufacturing and light engineering sectors are facing the urgency of improving productivity, enhancing quality, and reducing wastage. It appears that blending of robot with labor could be a useful solution to address such a pressing need. Upon seeing the productive improvement prospect with collaborative robots and successfully venturing into the Indian and Sri Lankan markets, a Danish collaborative robotic arms maker, Universal Robots, started its operations in Bangladesh in 2017. It's being reported that the company's latest collaboration with an SME in India resulted in 300-percent boost in production over a brief period of eight months, according to a statement of Universal Robot. Leveraging of robots to empower already employed 3 million manufacturing workers by equipping them with smart manufacturing solutions, which involve the utilization of collaborative robot technology and automation, has the potential to improve competitiveness of the manufacturing sector of Bangladesh.

Robots for Improving the Utilization Factor of Capital Machinery: Among several reasons, local firms are increasingly embracing robots for replacing human role to increase throughput of expensive capital machinery. It takes one minute to make a chair by automatic machine and another 30 seconds to bring out the product from the machine manually (Fig. 21). But a robot can take the product out within 10 seconds, saving 20 seconds on each chair, according to industry insider. As a result, utilization of machine increases. It's being reported that country's one of the major plastic good makers has 50 robots that are used to take out plastic chair, table, bucket and various other household items. Robots are also being used in Hatil's furniture manufacturing plant. The use of robots in the finishing section has increased quality and reduced the material wastage. Moreover, high-end PLC based automation is in use in many sections of the furniture maker. It's being learned that accuracy, consistency and reduction of material wastage are the major drivers of automation in the furniture sector of Bangladesh.

Figure 21: Robots are being used in loading and unloading

Robotics in Furniture Making: Robots have started to penetrate export-oriented furniture making. It has been found that Robots are improving precision and consistency in one hand. On the other hand, robots are reducing wastage of resources like chemicals, and other materials in finishing furniture as shown in Fig. 22. Stakeholder consultation reveals that robotics and automation are indispensable for assuring consistent quality, and precision in exporting furniture in knock down form. To them, human labor is not substitute to Robots, as they are required to micro meter precision in wood cut, and hole position.

Figure 22: Robots are in action in finishing furniture in local factory.

Robotics in Plastic industry: Bangladesh's plastic industry has been using high-end production machinery, being controlled through embedded programmable logic controllers. They are seeing the possibility of using robots for increasing the throughput and reducing labor requirement, particularly for the operation of the plastic injection molding machines. One of the applications is, 'a robot can lift a moulded part out of one injection moulding machine and place it into another for the over-moulding process.' As a result, it will reduce labour and assembly costs, and improves the quality, reliability and integrity of the end product. In plastic industry, Robots are also used to perform insert moulding that involves encapsulating an 'insert' in moulded plastic, as shown in Fig. 23.

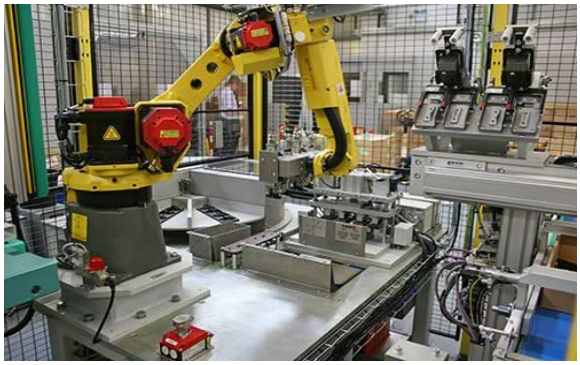


Figure 23: Robots in plastic industry

3.3 Adoption in Regional Countries

To increase the quality of production, and to cope up with the labor cost, virtually in every country of the industrial world, robot density has been growing. Two Asian countries, South Korea and Singapore are the at the top having 710 and 658 robots per 10,000 workers in 2017.

India: Robot population in India grew 39% year on year: robot is getting better alternative to the least costly factory labor of the world. Although India's robot population is far less than China, but it has been growing rapidly. India reached a new record of 4,771 new units installed in 2018 (Fig. 24). Robots are not only getting cheaper than the least costly manufacturing labor force of the world. In certain situations, quality of job done by robots is better than being performed by human workers. For example, in welding or painting cars, robots perform better than human workers. In this globally connected competitive economy, robots are not only labor saving devices. They are increasingly playing vital role in offering desired quality, and also reducing wastage. With the given increasing role of robots, every developing country should have carefully thought out role of robotics in building their industrial economy.

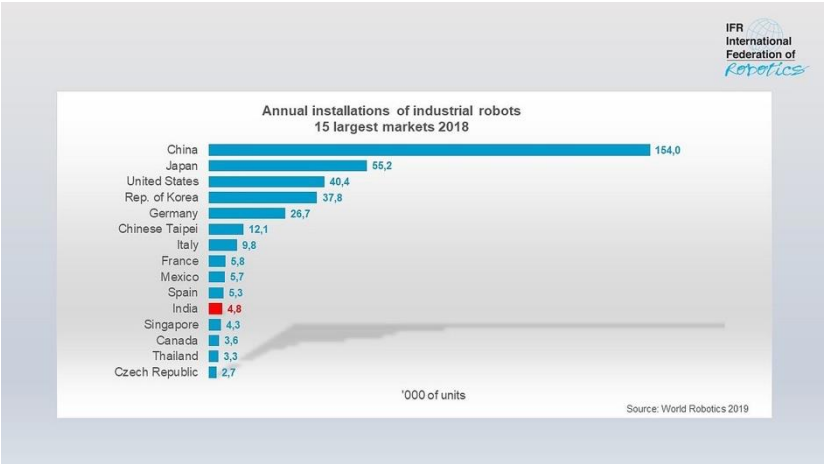


Figure 24: Rise of Robots in India

Vietnam: Robots in Vietnam are on rise, turning it the 7th largest market. Vietnam has been focusing on modernizing manufacturing for improving the competitiveness. Such smart factory move has ramped up the robot demand, reaching 8,000 in 2017. The robots are used in various fields, such as electronics, automobiles, foods, beverages, and consumer goods. Primarily the entry of multinationals in manufacturing landscape of Vietnam has boosted the demand for robots. Among the six major foreign suppliers, ABB is at the top with sale of 5,000 robots in 2017. Low cost labor advantage is no longer sufficient for developing countries to maintain competitiveness in the global value chain of manufacturing. They need to have very well thought out strategy for leveraging robots as a complement to labor to develop as well as maintain low cost edge. Moreover, robots also improve the quality as well as predictability of outputs--which are vital in global market.

3.4 Adoption in China

Cheng, H. and Others (2019) finds that China has emerged as the World's largest user of industrial robots. It's also learned that by 2020, China will be also producing half of those Robots. The growth of sales of Robots in China from zero in 1995 to 87,000 in 2016 is shown in the Table 3. Rising wages, increasing demand of China made products, decreasing costs of Robots and increasing capability drive tis massive growth of Robot adoption in China.

Table 3: Rise of sale of Robots in China and the World

Annual Robot Sales in China and the World

Year	*World (1,000 units)*	*China (1,000 units)*	*China's share in the world (%)*
1995	69.3	0.0	0.0
2000	98.7	0.4	0.4
2005	120.1	4.5	3.7
2010	120.6	15.0	12.4
2011	166.0	22.6	13.6
2012	159.3	23.0	14.4
2013	178.1	36.6	20.5
2014	220.6	57.1	25.9
2015	253.7	68.6	27.0
2016	294.3	87.0	29.6

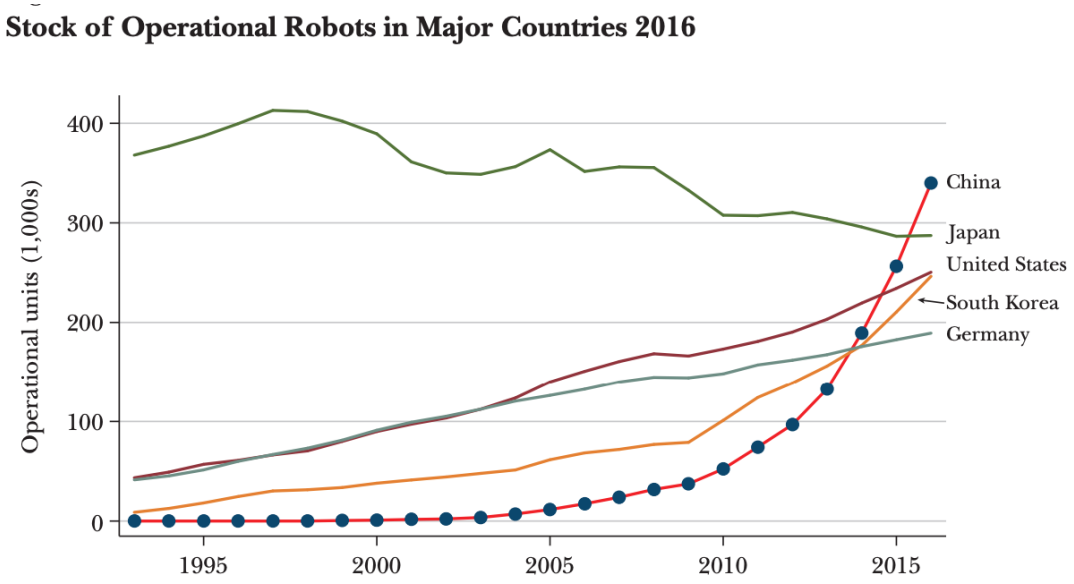
Source: International Federation of Robotics (2017).
Notes: This table shows the rise of China in the world robot market, especially after 2013.

To implement Chinese Government's Vision of "Made in China 2025", by 2020, China will be producing 150,000 industrial robots an annular. According to this strategy, China aims to be competitive in advanced manufacturing. And Robotics has been a core tool to implement this strategy. The Chinese government is supporting robotics start-ups in key industries including automobile manufacturing, electronics and logistics. In addition to tax relief, subsidies are being provided in R&D. As a result, the number of companies involved in robotics manufacturing has sharply increased from 800 in March 2017 to almost 6500 at the end of the same year. This is also a lesson for Bangladesh for attaining the vision 2030 and 2041.

Outside conventional strongholds like Automobiles and Electronics, Chinese companies are leveraging Robotics in logistics and warehouses. A smart warehouse developed with a fleet of more than 300 robots, the owner company is reporting the performance of reducing the use of manpower by 70% and increasing the efficiency by 30%. Chinese e-Commerce companies are also investing in autonomous delivery Robots. A golf cart sized robot equipped with cameras and sensors are capable of navigate their surroundings to deliver goods within a 5 kilometers radius. To meet the vision of "Made in China 2025", the Guangdong province is currently investing $150 billion into industrial robots and new automation centers.

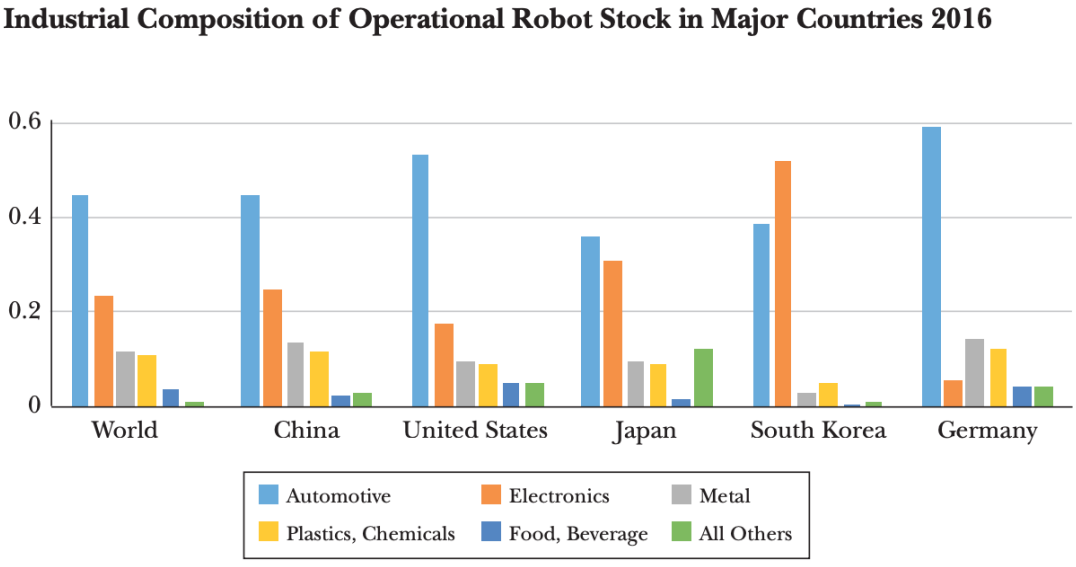
3.5 Adoption in Advanced Countries

It seems that China's growth has outperformed the rest of the world, as shown in Fig. 25. Major industries using Robots in advanced countries are Automotive, Electronics, Metal, Plastic, Chemicals, Food, and Beverages as shown in Fig. 26.



Source: Data is from International Federation of Robotics (2017).
Notes: This figure plots the operational stock of robots in the five major markets. China exceeded Japan

Figure 25: Rise of Robot's population in the world is led by China



Source: Data is from International Federation of Robotics (2017).
Notes: This figure plots the share of robots across industries in the manufacturing sector by countries. China is not dramatically different from the other countries, suggesting that the supply of the technology matters in explaining which sectors use robots more.

Figure 26: A few major industries dominate Robot usages in the world.

3.6 Robots in Healthcare and in Dealing with COVID-19

Precision is an issue in healthcare service delivery. As early as 1985, the idea of using robotics for increasing precision, particularly in surgery and sampling, was introduced. In contrary to using robotics in many other applications, particularly in automobile manufacturing, robots are assistive devices doctors and nurses. It's envisioned that robots will keep gaining momentum expanding both the breadth and depth of applications in healthcare. Some of the notable benefits, purposes, and application areas of robotics in healthcare industry are i. Improving accuracy ii. Precise diagnos, iii. Remote treatment, iv. Augmenting human abilities, v. Supporting mental health and daily tasks, vi. Auxiliary support services. It has been learned that robots for handling samples in diagnostic laboratories are already being used in Bangladesh. Moreover, robotics surgical tools are also in use for minimally invasive intervention.

Pharmaceutical industry: In the global pharmaceutical industry, automated inspection and packaging is increasingly gaining importance. Benefits of automation in the pharmaceutical sector includes efficiency, saving workers from hazardous environments, eliminating human error, increasing repeatability and reproducibility, and in cleanrooms, removing the potential for human contamination. Some of the major application areas of robots in the pharma sector are i. Robots for filling, inspection, and packaging, ii. Robots for filling, inspection, and packaging, iii. Cleanroom robots, and iv. Robots in the laboratory. For meeting compliance issue, already automation in place in Bangladesh's pharmaceutical industry. It's predicted that the trend will continue for reducing human touch further.

Robots in fighting Coronavirus: Across the world, in more than two dozen ways, robots are being used during the COVID-19 pandemic. It's application spans from health care in and out of hospitals, automation of testing, supporting public safety and public works, to continuing daily work and life. A research conducted at Texas A&M university, based on review of 120 press and social media reports from China, the U.S. and 19 other countries, indicate that both ground and aerial robots are playing important role in almost every aspect of managing the crisis. A summary of this research finding is shown in the following figure 27 (Murphy, R. and others, 2020). There was also interest to use, and also develop robots, in fitting the corona virus. It was reported that police used unmanned aerial vehicles for monitoring social distance.

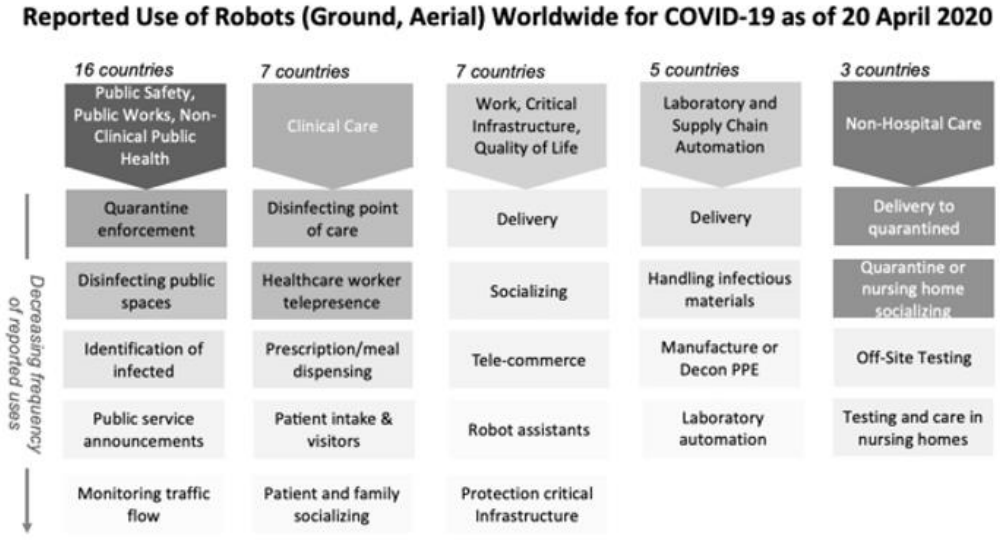


Figure 27: Example of usages of ground and aerial robots in fighting COVID-19 crisis

3.7 Robotics in Transportation, and Logistics

One of the major developments of robotics in the transportation sector will likely be autonomous vehicles. Already, concept vehicles are in demonstration. Robots are being increasingly used in shipping and logistics. Global market of robots in logistics is expected to increase from $1.9 billion revenue in 2016 to to hit more than $22 billion in 2021. For expanding the role of robotics in handling logistics tasks, like container loading and unloading, robotic systems are being developed with 3D laser vision and machine learning software. So that they van 'see' various products in a container, figure out the best loading/unloading sequence and execute the process with a large degree of precision.

It's being predicted that more than four million jobs will likely be lost with a rapid transition to autonomous vehicles across the globe. Driving occupations are under threat. Particularly, it would be a significant issue in Bangladesh. On one hand, autonomous vehicles are offering the opportunity for reducing road accidents. On the other hand, there is an issue of job loss. Bangladesh should carefully monitor the situation, and take necessary measures for making the transition as painless as possible. Although, at this point in time, robotics in the transportation and logistics is not a major issue in Bangladesh. But the future demands Bangladesh to be ready with it. Moreover, the unfolding future scenario has also the possibility of creating remote service delivery jobs for providing assistance to autonomous vehicles, and also robots being used for logistics. Bangladesh should also into this unfolding scenario, and take necessary measures to leverage it.

3.8 Robots in Key Sectors of Bangladesh

A series of consultations took place to gather inputs from sector specific stakeholders. For each sector, inputs were gathered in five major areas. These are i. Unfolding robotics scenario, and adoption pattern in Bangladesh, regional countries, China and advanced countries, ii. Unfolding opportunities and threats for Bangladesh, iii. Bangladesh strengths and weakens for coping up threat and leveraging opportunities, iv. Recommended strategies for responding to unfolding robotics scenario, and v. Responsibilities for the implementation of the strategy. Summary if sector specific inputs are provided in the Appendix A.

4. Robotics Posing Threats and Opportunities to Bangladesh

4.1 Competitiveness: Cost, Quality, Productivity, and Compliance

Consultation with stakeholders reveal that there are opportunities of using Robotics for reducing the cost and improving the quality simultaneously. It has been learned that in BPO industry with the support of RPA, efficiency could be increased by as much as 40% in certain service delivery. Similarly, the cost could be reduced by as much as 50%. It has been reported that in food processing, adoption of robotics has the potential of reducing cost and improving safety. For example, high-end robotics sensing could be used in detecting trace materials like presence of lead or pesticides. Construction industry also offers the opportunity to benefit from Robotics, particularly in repetitive tasks such brick laying, laying of railway tracks, and also laying tiles and doing plastering. It has been gathered that Robotics offer the means of compliance issues in food processing, sorting, and packaging. The e-Commerce sector expects to befit form Robotics in Wearhouse operation. Robotics in the form of customized automation of task after task appears to be have potential in all major sectors, particularly in the leather, footwear, and leather products sector. It has been learned that despite the salary of workers in China in the range of $500 to $600 in the leather products and footwear sector, the cost of production in China appears to be lower in China than Bangladesh. One of the reasons appears that Chinese factories are benefiting from continued uplifting of their production processes from manual to semi-autonomous to automation through incremental progression in adopting robotics and automation. On the other hand, role of robots for precision operation in certain sectors like export-oriented furniture, leather products, and footwear production is vital. There has been strong urge that cost of production should continuously be reduced in all consulted sectors. Robotics is an emerging technology option to address this burning issue. The focus should be on continuous cost reduction and quality improvement through stepwise adoption of robotics, as opposed to having a big jump. To exercise this strategy, local capacity for sector value chain analysis, techno-economic feasibility analysis for identifying target tasks to be automated, selection of suitable robotics solution, robot programming and customization, operation of robots, maintenance capacity, and R&D for innovation should be developed.

4.2 Transformation of Jobs: Loss and Creation

There is no denying that certain labor demand in certain tasks will be lost. Due to the intelligent adoption, quality of productive activities will likely go up and cost will come down. As a result, local industry will expand at a faster rate, both for import substitution and export. Faster expansion will lead to increasing jobs creation. However, in absence of adoption of robotics, Bangladesh's competitiveness will likely keep eroding, resulting in job loss. Therefore, it may not be unfair to state that the Robotics has the potential having net positive effect on labor market of Bangladesh. In addition to it, the adoption of Robotics will create jobs for supporting robots to operate. Moreover, growing labor shortage in certain industries, like construction, food processing and Agriculture could be addressed with Robotics. Safety critical operations like constructing high rise buildings could significantly benefit from Robotics. The exploitation of value addition scope in Robotics through programming, software development, or fabricating the end effectors have also creating jobs. It has been learned that light engineering sector has some firms with the capability of producing mechanical components of Robots.

4.3 Education, Skill, R&D and Innovation

Leveraging of Robotics will demand education, skill development, R&D and innovation services. Educational program for producing human resources for programming robots, and developing software will be needed. Similarly, skill development training will be needed for producing work force to work in collaboration with next generation Robots. Skilled human resources will also be required for installing, commissioning, trouble shooting and repairing robots. Consultations revealed that there would be demand of significant skill development training to benefit from Robotics. R&D and Innovation will play vital roles for developing new sensing, perception and manipulation capabilities of robots so that Robots could be used in expanding areas. As explained before, as high as 70% value could be added even to imported industrial robotic arms through the development local human resources, R&D and innovation capability. Moreover, in absence of local capacity of developing human resource and R&D capacity, Bangladesh will be required to pay for foreign consultants and technicians, which will increase the cost of adoption of robotics and loss of opportunities of creating jobs for the citizens of Bangladesh.

4.4 Opportunities for the IT and Light Engineering ndustry

IT industry: Leveraging Robotics would create demand for the IT industry for providing associated application specific software, developing new sensing and perception algorithms. Those algorithm developments will demand knowledge associated with machine intelligence, image processing, computer vision, and data analytics among others. IT company y should acquire needed capacity to tap into new opportunities likely to be created in applications of Robots. As mentioned before, as high as 10% value cloud be added to Robots through programming and developing associated software. By the way, to leverage this opportunity IT firms need to update their conventional capability. Conventional IT expertise like programming in C++, Java or Python, cloud computing, data analytics, and web technologies would not be sufficient. They need to acquire capacity in the area of sensors, lighting, reading data from sensors, and processing those data to extract information like geometric measurements, and quality of printing or alignment. Moreover, as it has been mentioned there has been surge in patent filling in Robotics, particularly in AI. Aspiring IT companies can look into this opportunity.

The adoption of Robotics for improving IT education will also require development of associated software applications. Such software applications will be vital for using basic Robotics Toys for demonstrating STEM concepts and enabling students to program them at high level. This is an opportunity for IT companies to develop such software applications. It has been learned that some industrial sectors are already using high end PLC based production machinery. Often software tools are used for diagnostics and programming such controllers. In many cases, foreign technical expertise is sourced for this purpose. Local IT firms has the opportunity to expand their services for tapping into this market.

Light Engineering: Often robots are sound as science fiction characters, having artificial intelligence capability. But more than 30% value in robots is in mechanical components. Some of the common components are base, links, gears, end-effectors, gripper, chains, joints, sensor and motor mounts,

couplers, shafts, sprockets and chains. For the light engineering sector, this could be a new market opportunity. It's understood that some of the firms in the light engineering sector are already performing precision operation with CNC machines.

4.5 Youth Empowerment and Start-ups

It could be an example of Silicon Valley's excesses that a robot pizza startup could be worth $4 billion. But SoftBank pumped $375 million into Zume just last year (2018). It seems robotics startups offering wearhouse automation is drawing high interest among investors. Recently, Vecna Robotics gained $50 million in a funding round, the latest investment in a surge in venture-firm backing for warehouse automation. Crunchbase maintains a database containing the list of startups in the robotics space provides data on their funding history, investment activities, and acquisition trends. As of Jan 2020, this database has the history of 1247 robots startups. In 2706 founding rounds, 4169 investors fueled these startups with $21.8b (till Jan 2020). Some examples are in Table 4.

RobotUnion claims to be the first pan-European acceleration program fully focused on robotics. They are a diverse and balanced team of accelerators, investors, business platforms, research & technological centres and corporations in the robotics startup ecosystem. A few of the supported Robot startups by RobotUnion are shown in the following Table ??. In its recent round of selection, each of the winners, selected among 204 applications from 32 countries, received up to €223,000 in equity-free funding, alongside acceleration and mentoring services. Investors are showing high interest in Robot startups.

Table 4: RobotUnion Supported Robot Startups and their Relevance to Bangladesh

sl	Name	Countries	What do they do?	Relevance to Bangladesh
1	Tendo	Denmark		
2	Scaled Robotics	Spain	It builds mobile robots that navigate construction sites to collect 3D maps. These maps are uploaded to the cloud to track the progress of a job and the quality of the construction to find potential mistakes.	LGED, Roads and Highways and construction firms can benefit from such solution.
3	Rigitech	Switzerland	It's offering improved logistics through cargo drone delivery. The drones can carry up to 3kg, which it says represents more than 80% of parcels shipped today, with a 80km flight range on one battery.	Target applications include e-commerce, healthcare, humanitarian efforts and more.
4	LuxAI	Luxemburg	QTrobot is a proactive social robot designed to assist autism professionals in helping children with autism spectrum disorder to learn new social, emotional and communicational skills.	A growing number of autism children in Bangladesh can benefit from such innovation
5	Farm Robotics	Spain	Robot that balances animal welfare with farm productivity by monitoring chickens using sensors and AI	Agriculture, poultry and livestock

In Bangladesh, robot making activities are primarily for the purpose of participating in competition, including robot Olympiad. Building business out of robotics could be promoted to university students. Necessary supports could be provided in building laboratories and proving financing and mentoring to turn some bright ideas into startups. Robotics startup in Bangladesh are yet to spread wing.

5. Bangladesh's Readiness: Strengths and Weaknesses

5.1 User Firm and Industry Level

All major consulted sectors are under tremendous pressure to deal with cost, quality, lead time, consistency, and productivity issues. In both domestic and export markets, they are being increasingly pressed for offering higher quality at decreasing price. On the other hand, they need to pay increasing amount for key inputs like labor and energy. Although Robotics is being pursued to address such conflicting issues, but there appears to be lack of awareness at the management level about what is the unfolding scope to benefit from Robotics to address these pressing issues. Target firms in different sectors seems not to have adequate cost benefit analysis capability, particularly due to the lack of data of usages of robots in comparable situations. As a result, they cannot often assess likely implication of adoption of Robotics in certain tasks. Due to lack of clarity of robotics technology potential in terms of technological feasibility, and economic viability, often management is failing to take appropriate decisions. The scarcity of competent human resource is also limiting their ability to undertake pilot projects. Moreover, they cannot reach out local professional firms in offering such feasibility analysis service. Despite such limitation, stakeholder consultation reveals that there is a strong interest among stakeholders to leverage Robotics possibility for addressing their pressing competitiveness. Even industry associations, and related line ministries do not have adequate intelligence to guide firms to figure out how leverage robots, as opposed to being scared off.

5.2 Skilled Manpower for Using Robotics Solution

This is a concern among the statehooders. They expressed serious dissatisfaction about the limited availability of skilled people and service delivery capacity for diagnosing faults of PLC based automation systems. Often, they need for days or weeks for the foreign technicians to show up diagnose faults and make plan the plants up and running again. As Robotics are sophisticated, and run by software, lack of skilled human resource for operating and repairing Robots. Lack of availability of skilled human resource will seriously influence the cost and benefits of Robotics. It has also been learned that FDIs in certain industries also look for available human resources having the capability of working with Robots, and also configuring as well as repairing them.

5.3 Skilled Manpower for Process Redesign and Robot Programming

There appears to be extreme scarcity of professionals available for programming industrial robots in Bangladesh. Although University of Dhaka has an undergraduate degree program in Robotics, but like many other academic programs, this program has also very limited exposure to Robots being used in Industry. The Robotics laboratory setup at BUET should be linked with industrial applications. Moreover, there is a need of linking industrial and production engineering programs with Robotics for developing necessary skilled professionals for reengineering work processes to accommodate Robots. Polytechnique institutions have also an important role to play in this regard.

5.4 Education, Training and R&D Capacity

Robotic R&D capacity is extremely inadequate in the country (Rokonuzzman, M. and Moyeen, M. , 2019). In one hand, there is no collaborative R&D programs for pursuing the opportunities in Robotics. On the other hand, there appears to be very limited academic capacity in the country to pursue graduate programs in Robotics. IT education being delivered at Secondary and Higher Secondary level do not have adequate coverage on Robotics. At the university level, some elective courses are being offered. Moreover, these courses mostly cover theoretical lessons. Only couple of universities have laboratory in Robotics. Training capacity for developing skilled human resource to work in collaboration with Robots, supervising them, and repairing them is highly inadequate. Poly-technique institutions should be empowered to develop necessary training programs in collaboration with the industry.

5.5 Innovation Capacity of IT Firms and Start-ups

Although, Bangladesh's start-up scene is highly active, there are hardly start-ups in the area of Robotics. But there has been encouraging initiatives among students to make robots, and participate in Robotics competition. Inspiration of youths' robot making should be linked with potential opportunities in the industry, and R&D capacity to foster Robotics start-ups. Success of robotic startups mostly rely on patentable ideas, and linkage with the industry. In addition to seed fund, they need patents to fuel their robotic startup mission. In the global scale, Bangladesh position to innovate is in weak position, as shown in Table. 5. Bangladesh needs to make significant progress, particularly in R&D and collaboration, for leveraging start-ups possibilities in Robotics.

Table 5: Bangladesh's Position in Key Indicators of Global Competitiveness Index

sl	Relevant indicators used by Global Competitiveness Index 4.0 2018	Bangladesh's position among 140 countries
1	Intellectual Property Protection	119
2	Internet users as percent of population	122
3	Skillsets of graduates	121
4	Digital skills among population	120
5	Critical thinking in teaching	104
6	Venture capital availability	98
7	Growth of Innovative companies	97
8	R&D expenditure as % of GDP	72
9	Patent applications per million population	106
10	Companies embracing disruptive ideas	108

5.6 Degree of Relevance of Robotics in Different Sectors of Bangladesh

Table 6: Mapping of Degree of Relevance of Robotics to Different Sectors

sl	Sectors	Degree of Relevance to Robotics			Observations
		Low	Medium	High	
1	Ready Made Garments		x		Sewbot will take 5 to 10 years to mature Use of robotics for finishing like fading is expanding
2	Textile		x		Robotics in handing chemicals and fabric inspection. Technology complexity is high
3	High-tech Manufacturing			x	Precision manufacturing and consistency could not be handled with labor. Commercial solutions are available
4	Leather, leather products, and footwear			x	Increasing demand for precision and consistent operation. Robots can reduce wastage and improve quality. Competitors are already taking the advantage
5	Agriculture			x	Farming robots and UAVs are getting increasingly popular in the world
6	Constructions		x		Further technology development needed for having economically attractive opportunities
7	Plastic Products		x		In a few selective operations could be used.
8	Furniture			x	For high precision operation, robotics operations are highly relevant
9	Teleportation, RPA, & IIoT for BPO			x	IIoT is an expanding area, and RPA is gaining maturity
10	Transportation		x		Mobility for delivery is gaining traction
11	Elderly Care and Service Robots		x		Bangladesh has enough labor force to look after elderly people. But it offers opportunity for service export through teleoperation
12	Search & Rescue	x			High technology development barrier, and limited commercial demand
13	Blue Economy (Ocean & Marine)		x		High level investment is needed to explore blue economy with robotics
14	Food Processing			x	Food safety is a growing issue, and commercial robots could be adapted
15	Manufacturing, SMEs			x	Low cost co-bots could be adapted for improving quality and reducing cost of SMEs.
16	e-Commerce (warehouse, logistics)			x	Robotics for warehouse is gaining traction for effective and efficient order filling.
17	Waste segregation and recycling	x			R&D barrier is high for developing robotics solution. Moreover, Bangladesh recycling yet to attain sophistication to benefit from robotics
18	Light Engineering			x	Light engineering sector would be suppler of parts for Robots
19	Pharmaceuticals			x	For bio-safety reasons, robotics is gaining popularity
20	Healthcare service delivery			x	For healthcare service delivery by maintaining bio-safety, robotics could be useful options.

6. Bangladesh's Response to Cope up and Leverage Robotics

6.1 Strategy

Our strategy development focuses on creating the market and ecosystem capacity for creating suitable capacity for (i) Leveraging Competitiveness, (ii) Coping up with job loss and creating jobs so that net effect on jobs is positive, (iii) Developing skilled workforce for using Robots, (iv) Developing manpower for process redesign and robot programming, (vi) Developing capacity for repair, production of spare parts, and manufacturing robots, (vii) Conducting R&D, pursuing innovation, empowering Youths, and creating start-up success stories.

Strategy shaping forces: There are a few basic forces shaping the strategy: (i) Robotics is continuously changing competitiveness, (ii) Robotics has a natural tendency of killing jobs, but the net effect on jobs should be positive, (iii) Competitiveness of firms as well as industries should keep improving , (iv) Local value addition capacity should be increased for maximizing benefit, (v) Sustainable market and system capacity should be developed, and (vi) Changes should be predictable and manageable so that pain from transformation is minimized.

Strategy: The basic strategy has been to (i) monitoring and predicting unfolding robotics scenario, and (ii) figuring out target areas to benefit from and (iii) developing local market and system capacity for adopting, adapting, customizing, advancing, fusing and innovating in (iv) collaboration with complementary partners so that (v) local value addition and intelligent usages of robotics keep progressing.

Acquiring High-end productive knowledge out of Robotics strategy: With a position of 103 among 128 countries in the Economic Complexity Index, coping up with 4IR would be a daunting challenge for Bangladesh. Since the first industrial revolution, the gap of accumulating productive knowledge among countries has been increasing dramatically. The differential of holding this vital capability is largely attributed to the growing variations of complexities of products being produced and traded by different countries. It also often depends on the overseas engagement of the workforces, who return to their homelands with the experience of construction and development of complex products. The level of complexity of products being produced and profitably traded in the international market is also a measure of local value addition and per capita income contribution from industrial activities. In building higher-level productive knowledge to succeed in producing increasingly more complex products, Bangladesh needs to acquire complex productive knowledge while pursuing productive activities that will ensure profitable returns.

The crucial challenge is to find the opportunities to harness the possibilities in the age of 4IR. This Robotics strategy focuses on this vital issue. Acquiring a productive knowledge base in the 4IR technology stack has been a major challenge for Bangladesh. Unfortunately, the academic institutions and the classroom processes imparting knowledge and skills are extremely inadequate compared to the alternative means of acquiring those through experience and real-world applied R&D centric project-based learning. It appears that collaborative R&D based strategy of leveraging Robotics hold potentials to exploit diverse possibilities. Such practicality opens the opportunity of engaging researchers, faculty members, students and also an industry to explore relevant technologies, assess capabilities, and improve them further so that they can succeed in Robotics-based service innovations. As a result, among the participants, this mission will lead to productive knowledge development

around these technologies. The availability of such competencies will empower existing firms as well as start-ups to recombine those bits and pieces of productive knowledge to create a larger variety of smarter and better products for leveraging the AI-driven fourth industrial revolution.

6.2 Strategic Dimensions: *10 pronged*

1. **Keep Monitoring and Predicting:** With respect to each target sector, keep monitoring global, regional and national unfolding robotic scenario, including technology offerings, adoption patterns, techno-economic feasibility, and state of readiness.

2. **Assess Feasibility of Benefit from Robotics:** Perform sector specific value chain analysis, detect target links, and perform detailed technological and economic feasibility analysis for the adoption of robotics for addressing quality, cost, consistency, and lead time issues. Such analysis should also consider local value addition scope in candidate robotic solutions.

3. **Detect Entry Points and Expansion Route for Stepwise Progression:** Detect suitable entry points in each sector, and figure out likely expansion route along with roadmap of progression in a stepwise fashion—both for usages of robotics and value addition in adopting robotics.

4. **Design Demonstration Projects:** Perform commonality and variation analysis for each the sector specific entry points, and based on such analysis design demonstration projects. Such demonstration project design must take into consideration of detecting the scope of adding value through programming, software development, maintenance, and innovation.

5. **Undertake Collaborative Demonstration Projects:** Undertake demonstration projects in partnership with key stakeholders like target user firms, industry associations, education and training institutions, IT and other technology providing firms, and line ministries.

6. **Strengthen the System Capacity:** From the experience of demonstration, figure out the role of different actors; upon doing so strengthen each actor and facilitate engagement among them forming a system capacity.

7. **Support R&D and Promote Startups:** Figure our research and innovation need, sponsor collaborative R&D, and promote startups to take emerging ideas to market and develop firms around them.

8**. Policy and Regulation for Creating the Market of Local Value Addition:** Transform necessary policies and regulations for urgency and also interest for intelligent leveraging of Robotics for having net positive effect on jobs, growth of firms, and straitening of national competitiveness.

9. **Strengthen Training, Education and R&D Capacity:** Assess the need of user firm level awareness as well as technology and innovation management capacity, training requirement for skilled manpower for using forthcoming sector specific robotic solutions, and education and R&D capacity for producing human resources for robot programing, software development and innovation, and accordingly address them. Particularly, focus should be given on developing center of excellence capacity in associations, training, education and R&D, and technology & service provider levels.

10. **Promote Robotics based STEM education:** Use of robotics toys in STEM education serves two major purposes. On the one hand, it will develop hands on experience among next generation workforce to demonstrate concepts and experiment with STEM concepts in real life. On the other hand, it will seed the capability of engaging in Robotics innovation, and being friendly with robots in workspace.

6.3 Action Items, Responsibilities, and Implementation Time Line

The implementation details spelling out actions and responsibilities are shown in Table 7.

Table 7: Mapping of Action for Implementing this strategy

Strategic Dimensions	Action Items	Time Line			Responsibilities
		2020-2022	2023-2025	2026-2030	
1. Keep Monitoring and Predicting Unfolding Scenario	Monitor commercial offerings	x	x	x	ICT Division
	Adoption pattern in Bangladesh, Regional countries, China and advanced countries				
	Monitor Robotic Startups, and Venture capital				
	Monitor major R&D programs of different countries, and patents				
	Keep reviewing unfolding Robotic strategies and Policies of different countries, and their implications on competitiveness				
	Keep creating awareness among stakeholders				
2. Assess Feasibility of Benefits from Robotics	Perform value chain analysis of target sectors	x			ICT Division Industry Associations Concerned Line Ministries
	Detect candidate links where robotics could be leveraged				
	Perform economic and technology feasibilities in target links				
	Figure out the likely effect on competitiveness indicators like cost, quality, and lead time				
	Assess local value addition scope in supplying robotic solution in candidate links				
	Keep creating awareness among stakeholders				
3. Detect Entry Points and Expansion Route	Detect the suitable entry point in each segment for adopting robotic solution	x			ICT Division Industry Associations Concerned Line Ministries
	Figure out expansion route for robotic usages				
	Detect entry point and value addition pathway for adapting, customizing, retrofitting, and innovating robotic solution				

	Assess analysis on jobs for making sure that the net effect on jobs is positive.				
4. Design Demonstration Projects	Upon performing commonality and variation analysis, design demonstration projects	x	x		ICT Division Industry Associations Concerned Line Ministries
	Detect local value addition scope thorough robot programming, software development, and innovation				
	Detect the need for technology absorption, and advancement capacity need				
	Detect the scope of adding value through local production				
5. Undertake Collaborative Demonstration projects	Detect complementary partners and induct them for undertaking demonstration projects		x	x	ICT Division Industry Associations Concerned Line Ministries UGC Board of Technical Education
	Analyze demonstrated data to assess technological and economic feasibility				
	Define operation, maintenance, work process reengineering, innovation, software development, HW development and manufacturing, and R&D need for adopting demonstrated potential				
	Promote demonstrated potential for creating awareness and mobilizing partnerships as well as investment				
6. Assess the Gap and Strengthen the System Capacity	Figure out the roles to be played by each actor for increasing the local value addition in adaptation, customization, manufacturing, software development, operation, and maintenance			x	ICT Division Industry Associations Concerned Line Ministries UGC Board of Technical Education
	Strengthen the capacity of each of the actors to play due role				
	Adapt policies and regulation for ensuring optimal engagement of each of the actors, consequentially developing the system capacity				
	Use incentives and also regulation for creating both the supply and demand of demonstrated robotics solutions				
7. Support R&D, Empower Collaboration, and Promote Startups	Define R&D issues for leveraging the scope of innovation			x	ICT Division Concerned Line Ministries UGC
	Develop R&D capacity of target actors like Universities and support collaborative R&D projects.				
	Promote technology transfer, and foster start-ups for taking innovations to market				

	Support patenting of ideas so that local successes can penetrate in the global market				
	Promote startups through collaborative R&D, concept demonstration, patent filling, shared innovation & incubation space, and seed funding.				
8. Policy and Regulation for Creating the Market of Local Value Addition	Figure out market and system weaknesses which could be addressed through policy and regulatory changes			x	ICT Division Concerned Line Ministries
	Reform needed policies and regulation, including offering incentives for improving the quality, reducing the cost, and creating jobs out of robotics possibilities				
9. Strengthen Training, Education and R&D Capacity	Determine skill development need for robot usages, robot programing, software development, component manufacturing, and maintaining robots			x	ICT Division, Industry Associations, Line Ministries, UGC, Board of Technical Education
	Open diploma programs for developing human resource for robot programming, configuration, trouble shooting and maintenance				
	Develop training facilities in partnership with industry associations for the purpose of adoption, customization, and maintaining robotics solutions				
	Develop education capacities in Engineering Universities and training capacities in Poly-technique institutions				
	Develop R&D capacities, including setting up R&D Labs, offering research grants, offering tax incentives to collaborative firms, and supporting M.Sc and PhD programs.				
10. Promote Robotics based STEM education	Introduce basics of robotics in ICT education at the School and College level			x	ICT Division, Ministry of Education
	Develop laboratory manuals for performing STEM related experiments with Robotics toys as part of ICT curricula				
	Setup laboratories in schools and colleges based on Robotics toys and train teachers accordingly				
	Offering lesson on robotics-based transformation of the economy and society as a whole				

7. Overall Observations and Recommendations

This strategy development exercise was very engaging one. Stakeholder consultation through a series of focused group discussions opened the communication link and provided important ground level data. Background literature review played an important role in the process. On the one hand, literature review helped to shape up our thinking to figure out issues to be looked upon. Knowledge gathered through literature review played pivotal role in shaping the scope and triggering stakeholder consultation. At the end, inputs from stakeholders were processed within the evolving global technology and industry insights to draw lessons and design strategy for Bangladesh. Here are some major observations and recommendations.

1. **Megatrend:** Robotics has been evolving, and expanding the penetration beyond conventional areas like Automobile and Electronics. Robots are getting smarter and increasingly more flexible as well as adaptable. In addition to labor saving, Robotics is also offering higher precision and lower wastage in productive activities. As a result, Robots are getting vital tool for offering higher quality at decreasing cost.

2. **Poses threat and opportunities:** Robots are posing both threat and opportunities to Bangladesh. One the one hand, competitors are taking advantage of Robots for addressing their high labor cost issue. On the other hand, use of Robots is leading to higher quality and reduced wastage. Such reality is continuously eroding Bangladesh's competitiveness in both domestic and export market.

3. **Focus on Robotics a strategic tool:** Bangladesh should not be just afraid of Robots as it kills jobs. Yes, Robotics has natural tendency of reducing labor requirement. But it performs tasks with higher level precision, leading to improved quality and reduced wastage. Bangladesh should look into Robotics as a strategic tool to improve competitiveness issue—higher quality at lower cost.

4. **Add value to Robots:** Robots are not like off the shelf products like cars. They should be adapted, and customized to get the most value. Moreover, workplaces should be redesigned and products to be produced by Robots should also be redesigned to make them robot friendly. Such reality demands significant local capacity for benefiting from Robots. Focus should be on both usages and adding value to Robots.

5. **Focus on Competitiveness:** Instead of encouraging adoption of Robots, the focus should be on improving competitiveness by leveraging robotics. The journey should progress in a stepwise fashion with clear focus on economic benefits maximization. Moreover, Robotics should be harnessed for expanding the industrial foot print of Bangladesh, which labor-based strategy cannot attain.

6. **Collaborative Approach:** Robotics is an evolving technology. Development in other areas like sensors, connectivity and algorithms are contributing to the capability growth of Robots. Therefore, focus should be on developing competence on a set of technologies. More importantly, although technology integration makes news worthy demonstrations, but they fail to create appeal in the industry. In collaboration with industry, the focus should on addressing competitiveness issues with Robotics.

7. **R&D, Innovation and Startups:** As Robotics is showing sign of megatrend, there will be apple scope of innovation. Moreover, our youths are showing interest to Robotics to play with their creativity. This opportunity should be harnessed to create high playing jobs in Robotics. But it requires R&D for advancing component technologies and fusing them to innovate solutions. For this reason, there should emphasis on collaborative R&D and developing system capacity to harness the create urge of the youths.

8. **Centre of Excellence for Robotics:** Develop a center of excelling for leveraging robotics. It will demonstrate a model of collaborative value addition centric approach for leveraging frontier technologies. The center will also predict unfolding scenario, and offer advisory as well as policy inputs. This center of excellence may grow as national institute for Automation, Robotics, and Smart Manufacturing. However, the focus should be on integrating multiple stakeholders, as opposed to being an isolated public office.

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Appendix A

Stakeholders Inputs: Gathered through Focused Group Discussions

A.1 Teleportation, Robot Process Automation (RPA) & Industrial Internet of Things (IIoT) for Business Process Outsourcing (BPO)

Platform: Zoom

Participants:

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Summary of inputs provided by the participants is shown in the following table. Table A.1

Table A.1: Inputs provided by participated stakeholders of the BPO industry

Teleportation, RPA & IIoT for BPO	**Number of firms**			**Revenue in $millions**			**Growth trend and prospect**		**Employment**		
	Local	JV	FDI	Domestic	Export	Total	Last 3 years	Next 5 years	Total	Male	Female
Unfolding Robotic Scenario, having relevance to Bangladesh's Interest	Technology prospects and global offerings	Adoption in Bangladesh		Adoption in regional countries		Adoption in China		Adoption in advanced countries			
	Some RPA tools are available internationally and are being applied into the medical sector.	Some company in Bangladesh are working on Chatbot implementation, Speech recognition, and Voice recognition though it's in preliminary stage but it is improving		India, Philippines, and Thailand are far ahead in RPA. As a result, they have already taken over Bangladesh's wage differential.		The adoption of teleportation, RPA & Industrial IoT is far advanced in China.		Emotional Intelligence and Voice Analysis are far advanced. There is seamless transfer of roles from machine to human in service delivery.			
Unfolding threat and opportunities (gathered from stakeholders)	Competitiveness (Cost, Quality, Productivity)	Jobs: Loss and Creation		Education, Skill, R&D and Innovation		Opportunities for IT industry		Youth empowerment and start-ups			
	Using RPA tools, efficiency increased by 45%. The cost will reduce by 50% and improve quality and productivity.	RPA will cause job loss but at the same time, in a competitive market, there will be a high chance to upskill/re-skill the existing resources and explore new era. In that case, RPA will help to create new job as well.		Data layering knowledge and AI coding skills need to learn at the university level. Sufficient training is required for Data analytics. Huge Investment is needed for research and development		Considering the data layering service, and IoT, there is a huge opportunity to scale up the operation and to create a new industry.		Considering IoT, new start-ups will be taken place. And we need to analyze, how we can use the IoT application and engage the young generation for research and development			
Bangladesh's readiness, strength and weakness (gathered stakeholders)	User Firm and Industry level	Skilled manpower for using Robotics solution		Skilled manpower for process redesign and robot programming		Education, training and R&D capacity		Innovation capacity of IT firms and start-ups			

	We are in a very preliminary stage on scratching the surface and exploring the RPA	Skill development, upskilling, and re-skilling is required in an integrated manner.	Need to create integrated research education and innovation center	Require centrally coordinated research and development center to get the maximum benefit of the return on investment	There is an innovation scope of Bangla voice recognition, analysis, voice to text, call quality, automated robotic call for IT firms and start-ups
Bangladesh Strategy (suggested by stakeholders)	Leveraging competitiveness (Cost, and Quality, Productivity)	Coping up with job loss and creating jobs	Developing manpower for using robots	Developing manpower for process redesign and robot programming	Conducting R&D, pursuing innovation, empowering youths, promoting start-ups
	We need to have an integrated strategy of human resource development, R&D, and innovations to leverage RPA to address the quality, cost, and productivity.	Need to leverage an integrated approach where job loss and job creation will be adjusted	Holographic training needs to be introduced to reorganize the process and reengineering the automation	A demand analysis tool needs to be introduced for a particular process. Introduce an Integration approach from Idea formation to the demonstration and to innovation to the deployment	Potential use cases of BPO through Teleoperation, RPA & IoT in partnership with BPO firm and University Scope of human resource development Opportunity for R&D, innovations and new start-up

A.2: Inputs provided by participated stakeholders of the Construction industry

Platform: Zoom

Participants:

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Table A.2: Inputs provided by participated stakeholders of the Construction Industry

Constructions	Number of firms			Revenue in $millions			Growth trend and prospect		Employment		
	Local	JV	FDI	Domestic	Export	Total	Last 3 years	Next 5 years	Total	Male	Female

Unfolding Robotic Scenario, having relevance to Bangladesh's Interest	Technology prospects and global offerings	Adoption in Bangladesh	Adoption in regional countries	Adoption in China	Adoption in advanced countries
	Off-site prefabrication systems, On-site automated and robotic systems, brick laying machines, Drones and remotely operated vehicles, and Excavators are being used for construction to help get the work done and to review worksite and surrounding before and after the construction Robots could be used in laying tiles and plastering	The construction industry in Bangladesh is adopting Electromechanical, and utilization of sensor Automation in reinforcement fabrication is being used on a smaller scale Heavy steel companies are using the robotic type solution for cutting and welding of the steel	Regional countries are increasing robotic solution for lifting, shifting and robotics excavation in construction automation	China is producing construction robotic solution largely and using on-site automated and robotic systems and drones for construction	Advanced countries are using the robotic solution like Off-site prefabrication systems, On-site automated and robotic systems, Drones and autonomous vehicles, brick laying machines and Excavators for construction. Automation is being used in installing railway tracks, and also prefabricated slabs of long bridges.
Unfolding threat and opportunities (gathered from stakeholders)	Competitiveness (Cost, Quality, Productivity)	Jobs: Loss and Creation	Education, Skill, R&D and Innovation	Opportunities for IT industry	Youth empowerment and start-ups

	Using robots in the construction site is safer for repetitive works, it's would be cost-effective once it increases the quality and productivity.	There is little job loss threat but at the same time, more jobs will be created through proper skill development, planning, and execution	Constructions materials skills are highly required There is a huge scope of innovation and R&D for customized robotic solution for construction Investment is needed for research and development and Innovation	Huge opportunities for the IT industry to providing a customized software solution to run construction work through the robotic solution We need to focus on the operation and maintenance of the robots a well.	New start-ups will take place to create a robotic solution and we need to engage the young generation for research and development, innovation to create customized robotic solutions.
Bangladesh's readiness, strength and weakness (gathered stakeholders)	User Firm and Industry level	Skilled manpower for using Robotics solution	Skilled manpower for process redesign and robot programming	Education, training and R&D capacity	Innovation capacity of IT firms and start-ups
	Heavy steel companies are using the robotic solution for cutting and welding of the steel	A certain level of skills is required to control, service, and maintenance of the robotic solution	Need to have integrated learning through the collaboration of industry and academia for process redesign and robot programming	Need to have integrated learning through the collaboration of industry and academia through collaborative development projects for technology assessment, adaption, and also advancement. On the job training is required to learn customized robotic solution for a specific task	Collaboration with IT firms to provide need basis solution. There is a scope of innovation, service, and maintenance of the robotic solution for IT firms and start-ups. Particularly, IT firms should grow as broad technology firms for supporting innovation and usages of technologies for the construction industry in the age of the forth industrial revolution.

Bangladesh Strategy (suggested by stakeholders)	Leveraging competitiveness (Cost, and Quality, Productivity)	Coping up with job loss and creating jobs	Developing manpower for using robots	Developing manpower for process redesign and robot programming	Conducting R&D, pursuing innovation, empowering youths, promoting start-ups
	We need to have an integrated strategy to leverage robotic solutions to address quality, cost, and productivity. Collaboration with construction firms is required to provide a customized solution A model pilot project should be undertaken and feasibility should be evaluated within the local context. Initiatives can be undertaken with railway track linking, slipper placing in an existing project through a bilateral discussion	There is a chance of job loss for repetitive works, at the same time new jobs will be created through proper upskilling and re-skilling human resources for service, maintenance and operation of the robotic solution	Training on robotic solution needs to be introduced to reorganize the process and reengineering the automation. Moreover, collaborative pilot projects to adapt robotic solutions and to demonstrate the applications on the ground will produce initial skill base for operating as well as adapting robotics in construction.	A demand analysis tool needs to be introduced for a particular process. Through industry-academia, and govt collaboration, need to develop manpower for process redesign and robot programming. As robotic solutions are early stage of growth, collaborative R&D for adaptation and innovation will lead to the development of needed human resources.	Induct industry-oriented skills training programs to support and growth of the industry. Conduct R&D and support start-ups to grow and empowering youth through proper mentoring and skill development

Action items for implementing strategy (by stakeholders)	Take a pilot project in partnership with concerned public agencies like Railway, Roads and Highways, and LGED, IT industry, Universities, Polytechnique institutions, and construction industry for the purpose of technology assessment and demonstration within local context, adaptation capability development, and undertaking R&D for innovation and startups.				
Responsibilities for Implementation (by stakeholders)	ICT division should take the lead to mobilize supports from concerned agencies like Railway, Roads and Highways	Ministry of labor and employment	Polytechnique and vocational institutions	UGC	ICT Division, IT industry, Construction industry, and UGC

A.3: Inputs provided by participated stakeholders of the Light Engineering Industry

Platform: Zoom

Participants:

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Table A.3: Inputs provided by participated stakeholders of the Light Engineering industry

Light Engineering	Number of firms			Revenue in $millions			Growth trend and prospect		Employment		
	Local	JV	FDI	Domestic	Export	Total	Last 3 years	Next 5 years	Total	Male	Female
	50000			6850	319.74	7169.74	Approx.30%	Approx.30%	1 Million	0.98 M	o.o2 M
Unfolding Robotic Scenario, having relevance to Bangladesh's Interest	Technology prospects and global offerings	Adoption in Bangladesh	Adoption in regional countries	Adoption in China	Adoption in advanced countries						
	In the light engineering sector, 97% of enterprises represent SME. Only a few enterprises are big and they use robots in conducting their precision jobs. But these SMEs could contribute at each point of the value chain of the robot industry in terms of the manufacturing of parts and repair & maintenance services.	Only a few large engineering enterprises could use robots in conducting their precision jobs.	In South Asia, Indian engineering firms use robots. At the same time, engineering SMEs work with robot companies as vendors.	China is using heavily robot at their enterprises as labour cost is going up so fast. Engineering SMEs of China also work with robot companies as vendors.	Advanced countries use robot at their each and every function due to acute shortage of labour. They collect necessary spare parts from Asian countries.						
Unfolding threat and opportunities (gathered from stakeholders)	Competitiveness (Cost, Quality, Productivity)	Jobs: Loss and Creation	Education, Skill, R&D and Innovation	Opportunities for IT industry	Youth empowerment and start-ups						
	Not threat, rather more business opportunities in terms of supplying spare parts and	No job loss, many categories of jobs will be created.	Around 50000 light engineering workshops produce high-tech, medium-tech, and low-tech import-substitute and exportable	IT industries will supply software to future robot company.	Country's youth can establish many startups to provide spare parts and repair & maintenance						

	repair & maintenance services.		engineering goods every year. Over time, they built a certain level of expertise and technical know-how in undertaking R&D, reverse engineering, and production of engineering goods on a commercial basis. They are using digital cutting & finishing technology (CAD & CAM) and conventional technologies.		services to robot industries.
Bangladesh's readiness, strength and weakness (gathered stakeholders)	User Firm and Industry level	Skilled manpower for using Robotics solution	Skilled manpower for process redesign and robot programming	Education, training and R&D capacity	Innovation capacity of IT firms and start-ups
	In the light engineering sector, 97% of enterprises represent SME. These SMEs do not have sufficient scales of production to use robots. Only a few large engineering enterprises could use robots in conducting their precision jobs.	In the light engineering sector, a certain level of skills to produce spare parts of the robot. As well as necessary mold & die, plastic injection molding machine for plastic parts and rubber injection molding machine for rubber parts for robot industry and die casting machine for metal parts could be manufactured by light engineering workshops.	Some techno-entrepreneurs of this industry will prepare the design of robots through mechanical drafting with compute aided drawing (CAD).	Over the last 50 years, light engineering workshops are producing various types of machinery, spare parts, and offering repair & maintenance services and thereby they built a certain level of skills, expertise, and technical know-how in undertaking R&D and reverse engineering.	There is a scope for IT firms to provide software to robot companies and new start-ups for innovation, service and maintenance of the robotics solution
Bangladesh Strategy (suggested by stakeholders)	Leveraging competitiveness (Cost, and Quality, Productivity)	Coping up with job loss and creating jobs	Developing manpower for using robots	Developing manpower for process redesign and robot programming	Conducting R&D, pursuing innovation, empowering youths, promoting start-ups

	Reduce cost of capital and import duty of basic metals should be reduced.	No job loss threat. Job nature will be changed.	Light engineering firms need skilled manpower for Mechanical drafting through CAD, 3D Scanner/Printer, 3D Printer, CNC Lathe and Milling, CNC Laser Cutter, Die Casting, Manufacturing of Mold & Die, Extruder machine, CMM (Coordinate Measuring Machine), Heat Treatment	A demand analysis tool needs to be introduced for a particular process. Introduce an Integration approach from Idea formation to the demonstration and to innovation to the deployment	Induct skilled training programs at engineering universities and polytechnic institutes. Encouraging B2B start-ups i.e. small business initiatives to provide design, various metal components, and repair services to the robot industry. Establishment of a dedicated tech park in collaboration with any internationally reputed robot manufacturer. Supports start-ups through mentoring, networking, marketing, funding, and incubation.
Action items for implementing strategy (by stakeholders)	Develop a right long-term robot industry development strategy on the basis of inputs from light engineering industries.	Establish a robot industry industrial park or cluster.	Reduce import duty of basic metals.	Ensuring long term industrial credits at a minimum rate of interest.	Induct right skill-occupations at engineering universities and polytechnic institutes.
Responsibilities for Implementation (by stakeholders)	Ministry of ICT	Bangladesh Hi-tech Park Authority	National Board of Revenue	Ministry of Finance and Bangladesh Bank	National Skills Development Authority (NSDA)

A.4 Inputs provided by participated stakeholders of the Waste Segregation and Recycling Industry

Platform: Zoom

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Table A.4: Inputs provided by participated stakeholders of the Waste Segregation and Recycling industry

Waste Segregation and Recycling	Number of firms			Revenue in $millions			Growth trend and prospect		Employment		
	Local	JV	FDI	Domestic	Export	Total	Last 3 years	Next 5 years	Total	Male	Female
Unfolding Robotic Scenario, having relevance to Bangladesh's Interest	Technology prospects and global offerings	Adoption in Bangladesh	Adoption in regional countries	Adoption in China	Adoption in advanced countries
	Waste sorting by a robotic arm, Waste collecting and disposal system, Waste collection from the water body, Road sweeping and washing system, and Road vacuum cleaner	Waste collecting and disposal system, Waste collection from the water body, Effluent Treatment Plants (ETP) implementation, Street sweeping robot, and Street cleaning and vacuum	Waste collection from the water body, Street sweeping robot, and Street cleaning and vacuum	Waste sorting by the arm, Waste collecting and disposal, and street sweeping robot	Waste sorting robot, Artificial Intelligence (AI) for garbage sorting, and Street sweeping robot
Unfolding threat and opportunities (gathered from stakeholders)	Competitiveness (Cost, Quality, Productivity)	Jobs: Loss and Creation	Education, Skill, R&D and Innovation	Opportunities for IT industry	Youth empowerment and start-ups
	The cost will be increased but a massive improvement will be achieved on quality and productivity	Street sweeping and cleaning robots will cause job loss for sweepers. It will create an opportunity to come out from boring and tiresome job to a driver/robot operator.	Create an opportunity for robot operation training, research and development, and innovation	Will create a new market for the IT industry and scope to boost Artificial Intelligence (AI) implementation	Start-up scope will be enhanced and youth engagement will be increased
Bangladesh's readiness, strength and weakness (gathered stakeholders)	User Firm and Industry level	Skilled manpower for using Robotics solution	Skilled manpower for process redesign and robot programming	Education, training and R&D capacity	Innovation capacity of IT firms and start-ups
			Need adequate training on robot technology to	Need to be addressed in academic and R&D	Innovative product design and implementation need

	local government, City corporation, municipality	Will not be so difficult if we have proper planning on skill development	process redesign and robot programming	environment to create an ecosystem	to be improved especially on the mechanical side thus will create an opportunity for IT firms and start-ups
Bangladesh Strategy (suggested by stakeholders)	Leveraging competitiveness (Cost, and Quality, Productivity)	Coping up with job loss and creating jobs	Developing manpower for using robots	Developing manpower for process redesign and robot programming	Conducting R&D, pursuing innovation, empowering youths, promoting start-ups
	The cost will be competitive but if we consider quality and productiveness, it will be worthy	Coping up with job loss will not be much challenging and work nature will be changed where skilled manpower will be required	Operator manpower development should be relatively easy as they just need to learn to use the robots as any other appliance.	Huge funding will be needed as the opportunity cost for manpower developing (R&D) since this is mostly a new sector.	Need to be addressed in academic and R&D environment thus will lead to empowering youths and promoting start-ups
Action items for implementing strategy (by stakeholders)	Since this stakeholder of this type of product is local Government, they should be integrated with developing system	For driving such equipment's short-term training should be provided by manufacturer or supplier	Short term training should be enough to cop up the new technology	Support and cooperation from the Government is mandatory	Local Government can allocate R&D funding for University and start-ups
Responsibilities for Implementation (by stakeholders)	The mindset needs to be changed Training, servicing warranty should be included with the product	Counselling to the user Allocating people who lost jobs to other sectors or train them to cop up with new devices.	Training and educating budget need to be allocated for it	Assign proper manpower who is interested in this field rather than those who just work.	Youths need to be encouraged to address this social service by the allocation of R&D opportunity.

A.5 Inputs provided by participated stakeholders of the Plastic Goods Industry

Platform: Zoom

Participants:

Mr. Md Jashim Uddin		BPGMEA	President
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Mr. Quazi Anwarul Haque		BPGMEA	Director

Table A.5: Inputs provided by participated stakeholders of the Plastic Industry

Plastic Products	Number of firms			Revenue in $millions			Growth trend and prospect		Employment		
	Local	JV	FDI	Domestic	Export	Total	Last 3 years	Next 5 years	Total	Male	Female
Unfolding Robotic Scenario, having relevance to Bangladesh's Interest	Technology prospects and global offerings	Adoption in Bangladesh	Adoption in regional countries	Adoption in China	Adoption in advanced countries
	The robotic solution is offering unloading injection-molding machines, trimming parts, assembling components, sorting and inspection tasks	The plastic industry in Bangladesh is adopting Programmable logical control, autoloader machine, and injection molding. For some specific products, the robot is being used	Regional countries are increasing robotic solution for their plastic industry	China is using robotic solutions largely in the plastic industry to raw plastic and rubber materials as well as finished products	Advanced countries are using robotic solution largely for unloading injection-molding machines, trimming parts, sorting, as well as finished products
Unfolding threat and opportunities (gathered from stakeholders)	Competitiveness (Cost, Quality, Productivity)	Jobs: Loss and Creation	Education, Skill, R&D and Innovation	Opportunities for IT industry	Youth empowerment and start-ups
	Using robots for unloading plastic injection molding machine and rubber injection molding machine is the most common and most cost-effective that increase quality and productivity.	There is little job loss threat but at the same time, more jobs will be created through proper planning and execution	We need to have skilled resources for the PLC ladder logic program, and process integration test. Need to create separate education institutions for the plastic industry to produce technical human resources, upskilling midlevel managers, and engineers.	Need to focus on the creation of the robotic solution locally thus will create the opportunity for the IT industry or new industry We need to focus on the operation and maintenance of the robots a well.	New start-ups will be taken place to create a robotic solution and we need to engage the young generation for research and development, innovation to create the robotic solutions.

			Investment is needed for research and development, and R&D		
Bangladesh's readiness, strength and weakness (gathered stakeholders)	User Firm and Industry level	Skilled manpower for using Robotics solution	Skilled manpower for process redesign and robot programming	Education, training and R&D capacity	Innovation capacity of IT firms and start-ups
	Some big companies are using the robotic solution on a smaller scale	A certain level of skills is required to produce spare parts of the robot. Like plastic injection molding machine for plastic parts and rubber injection molding machine for rubber parts for the robot industry could be manufactured	Need to have integrated learning through the collaboration of industry and academia for process redesign and robot programming	Need to have integrated learning through the collaboration of industry and academia	There is a scope of innovation, service, and maintenance of the robotic solution for IT firms and start-ups
Bangladesh Strategy (suggested by stakeholders)	Leveraging competitiveness (Cost, and Quality, Productivity)	Coping up with job loss and creating jobs	Developing manpower for using robots	Developing manpower for process redesign and robot programming	Conducting R&D, pursuing innovation, empowering youths, promoting start-ups
	We need to have an integrated strategy to leverage robotic solutions to address quality, cost, and productivity.	There is little job loss threat but at the same time, scope for more job creation through upskilling and re-skilling human resources	Training on robotic solution needs to be introduced to reorganize the process and reengineering the automation	A demand analysis tool needs to be introduced for a particular process. Through industry-academia, and govt collaboration, need to develop manpower for process redesign and robot programming	Induct industry-oriented skills training programs to support and growth of the industry. Support start-ups to grow and empowering youth through proper mentoring and skill development

A.6: Inputs provided by participated stakeholders of the e-Commerce Industry

Platform: Zoom

Participants:

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Table A.6: Inputs provided by participated stakeholders of the e-Commerce (warehouse & logistics) industry

e-Commerce (warehouse, logistics)	Number of firms			Revenue in $millions			Growth trend and prospect		Employment		
	Local	JV	FDI	Domestic	Export	Total	Last 3 years	Next 5 years	Total	Male	Female
	1200					**1,000**			**125000**	**92500**	**32500**

Unfolding Robotic Scenario, having relevance to Bangladesh's Interest	Technology prospects and global offerings	Adoption in Bangladesh	Adoption in regional countries	Adoption in China	Adoption in advanced countries
	Robotic solutions like Drone, Pressure Plant robots can be good technology prospects to improve warehouse management and delivery system.	Inventory management software is not introduced properly. Need to look into it before going to robotic solution Due to geographical and infrastructure issues, a robotic solution is in a very preliminary stage to think about warehouse management robot and drone system for delivery Customization of a robotic solution is very important considering the local demand For the delivery purposes, we are using the post offices for manual delivery where developed countries are using the Gas stations for charging and maintenance of the robotic solution like Drone. Delivery with the robotic solution, we can run a test	The robotic solution is not that much adopted in regional countries	China is using robotic solutions largely in logistics to support e-Commerce, automated warehouse.	Advanced countries are offering a complete solution from order picking process to warehouse management and delivery system through the robotic solution

		model considering smart city where applicable Some companies have started experimenting with it.			
Unfolding threat and opportunities (gathered from stakeholders)	Competitiveness (Cost, Quality, Productivity)	Jobs: Loss and Creation	Education, Skill, R&D and Innovation	Opportunities for IT industry	Youth empowerment and start-ups
	The cost will reduce. Quality and productivity will increase through robotic solution but we need to customize/redesign the solution locally instead of importing solution	No job loss will cause due to robotic solutions rather work nature will be changed.	We need to have skilled resources for customization of a robotic solution locally Huge Investment is needed for research and development	Considering the local condition, infrastructure, and customization of robotic solutions, there is an opportunity to scale up the cooperation and to create a new industry.	New start-ups will be taken place to create a localized robotic solution and we need to engage the young generation for research and development to create a unique solution.
Bangladesh's readiness, strength and weakness (gathered stakeholders)	User Firm and Industry level	Skilled manpower for using Robotics solution	Skilled manpower for process redesign and robot programming	Education, training and R&D capacity	Innovation capacity of IT firms and start-ups
	We are in a very preliminary stage of scratching and exploring the robotic solution to fit in our own context.	Skill development, upskilling, and re-skilling is required in an integrated manner and local context.	Need to create integrated research education and innovation center for process redesign and robot programming	Require centrally coordinated research and development center to get the maximum benefit of the return on investment	There is an innovation scope of local robotic solution for IT firms and start-ups
Bangladesh Strategy	Leveraging competitiveness (Cost, and Quality, Productivity)	Coping up with job loss and creating jobs	Developing manpower for using robots	Developing manpower for process redesign and robot programming	Conducting R&D, pursuing innovation, empowering youths, promoting start-ups

(suggested by stakeholders)	We need to have an integrated strategy to leverage localized robotic solutions to address quality, cost, and productivity. A pilot project should be undertaken and feasibility should be evaluated within the local context.	Need to leverage an integrated approach where job loss and job creation will be adjusted	Training on localized robotic solution needs to be introduced to reorganize the process and reengineering the automation	A demand analysis tool needs to be introduced for a particular process. Introduce an Integration approach from Idea formation to the demonstration and to innovation to the deployment	Potential use cases of warehouse and logistics management and delivery system in partnership with e-Commerce firm, University, and Govt. organization Opportunity for a new start-up

A.7 Inputs provided by participated stakeholders of the Search and Rescue Industry

Platform: Zoom

Participants:

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Table A.7: Inputs provided by participated stakeholders of the Search and Rescue industry

Search & Rescue	Number of firms			Revenue in $millions			Growth trend and prospect		Employment		
	Local	JV	FDI	Domestic	Export	Total	Last 3 years	Next 5 years	Total	Male	Female

Unfolding Robotic Scenario, having relevance to Bangladesh's Interest	Technology prospects and global offerings	Adoption in Bangladesh	Adoption in regional countries	Adoption in China	Adoption in advanced countries
	Swarm robotics, Semi-Automated Control System, ML & CV Implementation, Role-Based Hierarchy, Drone Delivery System, Firefighting Smart Trucks, Rescue Drone Navigation & Crowd Control, Disaster Recovery Center, Using augmented reality for search and rescue mission	Regulation, Policy, and Licensing of SAR Products Creating Awareness of SAR Applications, SAR Product Manufacturing, and Certifications SAR for Defense/Law Enforcement Sector	Snake Robots for disaster site data collection	Miniature robots for water delivery in a firefighting situation Providing necessary item i.e food, medicines to trapped people using remote-controlled robots	BiPED for earthquake site rescue, SAR Robots for Water Rescue or Lifeguard, Autonomous rescue vessels, UAV for SAR missions
Unfolding threat and opportunities (gathered from stakeholders)	Competitiveness (Cost, Quality, Productivity)	Jobs: Loss and Creation	Education, Skill, R&D and Innovation	Opportunities for IT industry	Youth empowerment and start-ups
	Higher Cost for local manufacturing	The job will be created in the manufacturing	New SAR Training Institution	IT firms can develop applications for SAR	

	Strict QA policy for products Productivity increases upon successful implementation	industries, component sourcing, Service and maintenance Jobs involving human life risk can be replaced by SAR robots	Universities can be encouraged to conduct research on SAR applications funded by grants.	products in collaboration with proper authorities	Opportunity for new start-ups to work in the field of SAR Robotics.
Bangladesh's readiness, strength and weakness (gathered stakeholders)	User Firm and Industry level	Skilled manpower for using Robotics solution	Skilled manpower for process redesign and robot programming	Education, training and R&D capacity	Innovation capacity of IT firms and start-ups
	Firefighting, Defense, other Gov Agencies can utilize SAR technology Industries can help manufacture SAR Robots	Digital Firefighting training platform SAR Robotic experts can help and build train skilled workforce	Technicians can be trained to operate/program SAR Robots Vocational Training can be conducted for specialized SAR workers	Proper curriculum and guideline are required for mass education/training Funding is required for proper R&D	The startup can collaborate with R&D labs IT firms can produce tools for the advancement of R&D and innovation
Bangladesh Strategy	Leveraging competitiveness (Cost, and Quality, Productivity)	Coping up with job loss and creating jobs	Developing manpower for using robots	Developing manpower for process redesign and robot programming	Conducting R&D, pursuing innovation, empowering youths, promoting start-ups

(suggested by stakeholders)	Available workforce QA standard implementation	Helping workers who lost jobs to gain new skills for SAR robotics adoption Industries can help bring new jobs to manufacture SAR products	New training institution to develop technical operators/workforce for SAR products	Specialized training for Engineers to implement SAR Robotic solutions	R&D Facility to build a hub for innovators and robotics experts for creating SAR products

A.8 Inputs provided by participated stakeholders of the Elderly Care Industry

Platform: Zoom

Participants:

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Table A.8: Inputs provided by participated stakeholders of the Elderly Care and Service industry

Elderly Care and Service Robot	Number of firms			Revenue in $millions			Growth trend and prospect		Employment		
	Local	JV	FDI	Domestic	Export	Total	Last 3 years	Next 5 years	Total	Male	Female
Unfolding Robotic Scenario, having relevance to Bangladesh's Interest	Technology prospects and global offerings	Adoption in Bangladesh	Adoption in regional countries	Adoption in China	Adoption in advanced countries
	Assistive robots for the elderly such as rehabilitation robots, assistive social robots.	Not that much but Bangladesh has a history of the rapid adoption of technology	Japan already adopted elderly care & service robots in many fields	China is a leading example of adopting robotics in the service sectors.	Japan already adopted elderly care & service robots in many fields as well as North America, and Europe region are also advanced for service robots
Unfolding threat and opportunities (gathered from stakeholders)	Competitiveness (Cost, Quality, Productivity)	Jobs: Loss and Creation	Education, Skill, R&D and Innovation	Opportunities for IT industry	Youth empowerment and start-ups
	Bangladesh can produce these goods at a cheaper rate than importing the ready product	There is a scope of job loss for using service robots in Industry/manufacturing sector but at the same time new skillset will create more opportunity	Some universities are offering academic courses on robotics Many universities have a robotics club Funding is required for R&D and Innovation	There is a huge opportunity for the IT industry to create new products and maintenance of service robots and software integration.	Channeling students produced from the relevant field Different competitions resulted in a boom of startups
Bangladesh's readiness, strength and weakness (gathered stakeholders)	User Firm and Industry level	Skilled manpower for using Robotics solution	Skilled manpower for process redesign and robot programming	Education, training and R&D capacity	Innovation capacity of IT firms and start-ups
	Industrial robots are used in various industries such as automotive, electrical	Available manpower's emerged from different	Manpower having the proper programming knowledge & capable of	Industry-Academia collaboration is highly required	People with experience in this field can initiate the firms and can train the

	& electronics, chemical, rubber & plastics, machinery, metals, food & beverages, precision & optics & others. The automotive industry is the largest end-user of industrial robots.	competitions and science fairs.	handling the automation process.	Modification of the curriculum, training program	interested ones and thus innovation come into place
Bangladesh Strategy (suggested by stakeholders)	Leveraging competitiveness (Cost, and Quality, Productivity)	Coping up with job loss and creating jobs	Developing manpower for using robots	Developing manpower for process redesign and robot programming	Conducting R&D, pursuing innovation, empowering youths, promoting start-ups
	Very few in the industry are interested in importing from outside because they may be concerned about quality.	Coping up with job loss will not be much challenging and work nature will be changed where skilled manpower will be required	This is practical in regional countries because they understand how much it is needed in their lives Considering the pandemic situation and improvement of the service, we need to develop manpower through proper training	The practical experience is more important rather than education in the robotics sector in general	R&D Facility to build a hub for innovators and robotics experts for creating service products Create an opportunity to promote innovations and start-ups
Action items for implementing strategy (by stakeholders)	Give a secure supply of key ingredients to continue working on the respective field	Provide logistics support related to market entry legal procedures.	Provide interest free financial support for any short-term crisis of contributing parties.	Give special marketing opportunities through government TV channels at a reduced costs.	Provide opportunities for the implementation of an idea by deploying the pilot phase.

A.9 Inputs provided by participated stakeholders of the Ready-Made Garments and Textile Industry

Platform: Over the mobile phone

Participants:

Professor Dr. Muhammad Abdul Moyeen		Pride Group	Chairman

Table A.9: Inputs provided by participated stakeholders of the RMG and Textile industry

Robotics and automation has been expanding in the textile and RMG sector for reducing the variability caused by the human touch. As a result, compliance is increasing, quality is improving, and wastage is reducing. With the introduction of advanced automation based machinery, often skill requirements at the operation level decreases. But higher-level skill is needed to look after the maintenance of those machines. Moreover, higher-level analytical tasks are sometimes created with the introduction of advanced technologies. As a result, job polarization effect causing the hollowing out the middle is created.

In situations where experimentation is needed to fine-tune operation, like in dying, automation appears to be not much of help, due to rigidity. Such automation should be made flexible by the addition of higher-level AI to offer adaptive solutions. There appears to be an emerging scope with AI innovation in such areas. This offers R&D and innovation scope to local academic institutions, IT industry, and Start-ups.

The introduction of advanced machinery requires reengineering of the production process, and the adaptation of the workforce. It appears that there is a local competence to offer this service.

A.10: Inputs provided by participated stakeholders of the Agriculture & Food Processing Industry

Platform: Zoom

Participants:

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Mr. Md.Mizanur Rahman	export@prangroup.com	PRAN Group	Chief of Export

Table A.10: Agriculture & Food Processing

Agriculture & Food Processing	Number of firms			Revenue in $millions			Growth trend and prospect		Employment		
	Local	JV	FDI	Domestic	Export	Total	Last 3 years	Next 5 years	Total	Male	Female

Unfolding Robotic Scenario, having relevance to Bangladesh's Interest	Technology prospects and global offerings	Adoption in Bangladesh	Adoption in regional countries	Adoption in China	Adoption in advanced countries
	The agricultural robot can be used for specific agricultural purposes like harvesting, monitoring the environment, soil analysis and to increase crop yields Robots can be seamlessly integrated for lean manufacturing within the food industry The robot can able to make high precision movements within the workplace, with the regulated safety measured in place – mitigating workplace accident levels as much as possible.	Some companies have fully automated mechanical systems from production to packaging. The robot can help there to load and unload products in different kind of machines.	The robotic solution is not that much adopted in regional countries for agriculture and food processing. But they are increasing the usages of the robots in agriculture and food processing sector	China is moving ahead with a huge robot farming mostly unmanned tractors, pesticide applicators, and rice transplanters.	Advanced countries are going for a massive deployment for harvesting, soil analysis, pesticide applicators and to increase crop yields
Unfolding threat and opportunities (gathered from stakeholders)	Competitiveness (Cost, Quality, Productivity)	Jobs: Loss and Creation	Education, Skill, R&D and Innovation	Opportunities for IT industry	Youth empowerment and start-ups

	Need to check commercially feasible to introduce robot automation to reduce cost and increase quality and productivity but we need to customize/redesign the solution locally instead of importing solution	Robot automation will cause job loss but as we have low-cost labor, we need to check whether it is commercially feasible to go for automation.	We need to have skilled resources for customization of a robotic solution locally Huge Investment is needed for research and development & innovation for a local context	There will be a huge scope of robot maintenance and operation. Considering the local condition, customization of robotic solutions, there is an opportunity to scale up the cooperation and to create a new industry.	New start-ups will be taken place to create a localized robotic solution and we need to engage the young generation for research and development to create a unique solution.
Bangladesh's readiness, strength and weakness (gathered stakeholders)	User Firm and Industry level	Skilled manpower for using Robotics solution	Skilled manpower for process redesign and robot programming	Education, training and R&D capacity	Innovation capacity of IT firms and start-ups
	We are in a very preliminary stage of scratching and exploring the robotic solution to fit in our own context.	A certain level of skills is required for the maintenance and operation of the robotic solution.	Need to have integrated learning through the collaboration of industry and academia for process redesign and robot programming. Particularly capacity should be developed for troubleshooting by accessing machines digitally.	Need to have integrated learning through the collaboration of industry and academia	There is a scope of innovation, service, and maintenance of the robotic solution for IT firms and start-ups
Bangladesh Strategy (suggested by stakeholders)	Leveraging competitiveness (Cost, and Quality, Productivity)	Coping up with job loss and creating jobs	Developing manpower for using robots	Developing manpower for process redesign and robot programming	Conducting R&D, pursuing innovation, empowering youths, promoting start-ups

	Considering the hygiene issue, productivity and to grab the global market, we need to go for robot automation To increase export demand, we need to focus on robot automation for meat and fish processing A pilot project should be undertaken based on meat, fish, and food processing and feasibility should be evaluated within the local context. Collaboration between govt and financial sector to provide less interest loan to grow SME's	There is a chance of job loss but we need to leverage an integrated approach where job loss and job creation will be adjusted	Training on localized robotic solution needs to be introduced to reorganize the process and reengineering the automation	A demand analysis tool needs to be introduced for a particular process. Through industry-academia, and govt collaboration, need to develop manpower for process redesign and robot programming	Need R&D first based on a project like meat, fish and vegetable processing to check the feasibility Support start-ups to grow and empowering youth through proper mentoring and skill development

Table A.11: Inputs provided by participated stakeholders of the High-tech industry

High Tech Manufacturing	Number of firms			Revenue in $millions			Growth trend and prospect		Employment		
	Local	JV	FDI	Domestic	Export	Total	Last 3 years	Next 5 years	Total	Male	Female

Unfolding Robotic Scenario, having relevance to Bangladesh's Interest	Technology prospects and global offerings	Adoption in Bangladesh	Adoption in regional countries	Adoption in China	Adoption in advanced countries
	Robotics is increasingly used to improve enterprise, industrial, and military automation. In addition, robots are finding their way into more consumer use cases as the general public's concerns fade and acceptance grows in terms of benefits versus risks	Though a few large engineering enterprises use the robotic solutions in conducting their precision jobs however the adoptability in Bangladesh is beyond any question. Over the period, technology is being smoothly adopted by the Bangladeshi people	In regional countries, the adoption of robotic solution and manufacturing of the robotic solution is not that much adopted but they are increasing robotic process automation significantly	China is using robotic solution largely at their enterprises mostly and they are also producing the robotic solution for process automation	Advanced countries are far advanced in using robotic solutions in every expects.
Unfolding threat and opportunities (gathered from stakeholders)	Competitiveness (Cost, Quality, Productivity)	Jobs: Loss and Creation	Education, Skill, R&D and Innovation	Opportunities for IT industry	Youth empowerment and start-ups
	Robot automation is largely cost-effective for repetitive work that increase quality and productivity.	There will be some job loss but new jobs will be created through service, maintenance, operation, and innovation of the robotic solution and at the same time, need to focus on the proportion of the job loss and job creation for more sustainability	We need to have sufficient facility for research and development and innovation. Need to implement advance technology courses in University and create scope for R&D and Innovation	Opportunities are unlimited and Bangladesh has to grab this opportunity. There is a scope for IT industries to work on robot process automation, robot programming	The country's youth has the courage to establish a new business in this era. Need start-ups fund to help young to contribute and grow significantly.

			Industrial training should be included at the university level		
Bangladesh's readiness, strength and weakness (gathered stakeholders)	User Firm and Industry level	Skilled manpower for using Robotics solution	Skilled manpower for process redesign and robot programming	Education, training and R&D capacity	Innovation capacity of IT firms and start-ups
	Some companies have started on a smaller scale	Some universities have started implementing updated course curriculum in order to create the right skilled manpower but the number is very insignificant	Training programs on an algorithm to use sensors, IoT, Big data, analytics, machine learning is highly required which are the basic needs of robot process automation	Universities, polytechnic institutes, and IT firms should have training facilities and R&D capacity to create skilled manpower for robotics. They also should start providing industry-specific training.	There is a huge scope for IT firms to provide software to robot companies and new start-ups for innovation, service, and maintenance of the robotics solution
Bangladesh Strategy (suggested by stakeholders)	Leveraging competitiveness (Cost, and Quality, Productivity)	Coping up with job loss and creating jobs	Developing manpower for using robots	Developing manpower for process redesign and robot programming	Conducting R&D, pursuing innovation, empowering youths, promoting start-ups
	To leverage competitiveness, we have to give importance to increasing skilled manpower. To do that we have to start industrial training at the education institutes. There should be a mutual understanding between education institutes and ICT firms. Many IT firms are not interested to	Using robots will create unemployment for some type of laborer and also create employment opportunities for skilled educated manpower, who can contribute to design robots, develop programs for robots, contribute to innovation, contribute to R&D, provide innovative ideas, help to implement those ideas, etc.	We have to develop manpower to create robots to modify/ update their programs and input data as per requirement.	A demand analysis tool needs to be introduced for a particular process. Introduce an Integration approach from Idea formation to the demonstration and to innovation to the deployment	Induct skilled training programs at engineering universities and polytechnic institutes. Supports start-ups through mentoring, networking, marketing, funding, and incubation.

	provide industrial training to fresh graduates. The government can take initiatives and provide incentives to convince IT firms in this regard.				

Table A.12: Furniture Sector

Furniture	Number of firms			Revenue in $millions			Growth trend and prospect		Employment		
	Local	JV	FDI	Domestic	Export	Total	Last 3 years	Next 5 years	Total	Male	Female

Unfolding Robotic Scenario, having relevance to Bangladesh's Interest	Technology prospects and global offerings	Adoption in Bangladesh	Adoption in regional countries	Adoption in China	Adoption in advanced countries
	Robotic automation solutions for the wood industries contribute significantly to increasing productivity and the availability of products. The industry is particularly benefiting from the use of fully automated production lines, which brings unmatched precision and a rapid return on investment. The ability to take over jobs in dusty, hot, or hazardous environments means robots can also take charge of unpleasant, arduous of health-threatening tasks, which help improve workplace health and safety. The robotic solution can also offer materials handling, machine tending and assembly, picking, packing and palletizing, painting and coating, sanding, polishing and finishing.	Some companies are using robotic solutions on a smaller scale for precision and to reduce cost, wastage, and material consumption.	The regional countries are increasing robotic solution for high precision and to increase productivity	The adoption in China is very high. They are using robots for materials handling, machine tending and assembly, picking, packing and palletizing, painting and coating, sanding, polishing, and finishing.	Advanced countries are using the robotic solution for automated production lines, to increase productivity, to get high precision, and to meet the human resource crisis.

Unfolding threat and opportunities (gathered from stakeholders)	Competitiveness (Cost, Quality, Productivity)	Jobs: Loss and Creation	Education, Skill, R&D and Innovation	Opportunities for IT industry	Youth empowerment and start-ups
	To get high precision and to reduce cost, the robotic solution would a better option to meet the demand of the global market. We need to customize/redesign the solution locally instead of importing solution	The robot will not only cause job loss, but it will also create jobs on a larger scale considering service, maintenance of the robotic solution	University courses need to be updated based on market demand. To get the maximum benefit from robots, we need to operate it effectively, and to do that, re-engineering is required. For customization and re-engineering of the robotic solution, we need to focus on R&D and innovation.	There will be a huge opportunity for the IT industry for local support for software, to create customized solutions and robot programming. The opportunity for robot customization, re-engineering, innovation, service, maintenance, operation thus will lead to a new industry	New start-ups will be taken place to create a localized robotic solution and we need to engage the young generation for research and development and re-engineering the robotic solution to meet the local demand.
Bangladesh's readiness, strength and weakness (gathered stakeholders)	User Firm and Industry level	Skilled manpower for using Robotics solution	Skilled manpower for process redesign and robot programming	Education, training and R&D capacity	Innovation capacity of IT firms and start-ups
	We are in a preliminary stage using the robotic solutions to get high precision and to reduce the cost of production. To reach the global market, high precision is required and for high precision and consistency of the production, the robotic solution is a must.	A certain level of skills is required for the service, maintenance, and operation of the robotic solution.	We need to focus on re-engineering the product and process in order to get the maximum advantage of the robot and automation. We need to have integrated learning through the collaboration of industry and academia for process redesign and	PLC based professional courses could be introduced. The robot is also required to create spare parts of the robot where R&D capacity should be increased.	There is a scope of innovation, service, and maintenance of the robotic solution for IT firms and start-ups

			robot programming. Particularly capacity should be developed for troubleshooting by accessing machines digitally.		
Bangladesh Strategy (suggested by stakeholders)	Leveraging competitiveness (Cost, and Quality, Productivity)	Coping up with job loss and creating jobs	Developing manpower for using robots	Developing manpower for process redesign and robot programming	Conducting R&D, pursuing innovation, empowering youths, promoting start-ups
	We need to explore the opportunity to reach the global market. To reduce wastage and to have green technology and sustainable production, we need to use the robotic solution Considering the high precision, productivity, cost of material and to grab the global market, we need to go for robotics solution	There is a chance of job loss but we need to leverage an integrated approach where job loss and job creation will be adjusted We need to concentrate on a cost-benefit analysis that would help the decision-making process	Training on customized robotic solution needs to be introduced to reorganize the process and reengineering the solution	Build local capacity to redesign the product to get the maximum benefit of robotic automation Through industry-academia, and govt collaboration, need to develop manpower for process redesign and robot programming	Induct industry-oriented skills professional training programs to support and growth of the industry. Conduct R&D and support start-ups to grow Need to engage youths for innovation, robot programming, research, and development.

Table A.13: Leather, Leather Products, and Footwear

Leather, Leather Products, and Footwear	Number of firms			Revenue in $millions			Growth trend and prospect		Employment		
	Local	JV	FDI	Domestic	Export	Total	Last 3 years	Next 5 years	Total	Male	Female

Unfolding Robotic Scenario, having relevance to Bangladesh's Interest	Technology prospects and global offerings	Adoption in Bangladesh	Adoption in regional countries	Adoption in China	Adoption in advanced countries
	The robotic solution is offering like a lasting line with conveyor, lasting line "module type", automatic upper steaming, automatic shoe ironing and stabilization, automatic dying and reactivation, automatic vulcanization, automatic cold pounding, automatic buffing, automatic shoe primer and cement application, and automatic sole primer and cement application.	The adoption of robotics and automation technology is a very big challenge. Some companies are having semi-automation in footwear and leather goods. Center of Excellence (CoE) of Industry skill council (ISC) is helping the industry to cope up with the technology being introduced, CoE is developing manpower through the required skill to support industry demand.	Rapid technological advancement in the leather footwear sector in regional countries.	China is adopting the fourth industrial revolution in all aspects despite having a demographic dividend. China is using robotic solutions largely in the leather and footwear industry	Advanced countries are using robotic solutions largely in the leather and footwear industry. Automatic upper streaming, automatic dying, reactivation, vulcanization, cold pounding, and buffing machine.

Unfolding threat and opportunities (gathered from stakeholders)	Competitiveness (Cost, Quality, Productivity)	Jobs: Loss and Creation	Education, Skill, R&D and Innovation	Opportunities for IT industry	Youth empowerment and start-ups
	We need to use the robotic solution in production for our efficiency, productivity, and quality	In the leather industry, mostly unskilled and semi-skilled people work so there is a job loss threat for robot	We need to cope up with technological advancement and training infrastructure in the leather industry	Need to focus on the creation of the robotic solution locally thus will create the opportunity	New start-ups will be taken place to create customized robotic solutions and we need to engage the young

		automation but at the same time, more jobs will be created through proper planning and execution where blending is very important.	We should give emphasis on ToT for the trainer to upgrade their skill level as new technology is coming up always. Scope for innovation and R&D	for the IT industry or new industry We need to focus on the operation and maintenance of the robots as well.	generation for research and development, innovation to create the robotic solutions.
Bangladesh's readiness, strength and weakness (gathered stakeholders)	User Firm and Industry level	Skilled manpower for using Robotics solution	Skilled manpower for process redesign and robot programming	Education, training and R&D capacity	Innovation capacity of IT firms and start-ups
	We are in a very preliminary stage of exploring robotic solution in the footwear industry No consultation farm is being introduced yet to guide the assessment of the improvement in terms of quality, cost, and productivity	A certain level of skills is required to operate robotic automation and to get the maximum benefit out of it.	Need to have integrated learning through the collaboration of industry and academia for process redesign and robot programming. Particularly capacity should be developed for troubleshooting by accessing machines digitally.	Need to have integrated learning through the collaboration of industry and academia where R&D capacity will be enhanced.	There is a scope of innovation, service, and maintenance of the robotic solution for IT firms and start-ups
Bangladesh Strategy (suggested by stakeholders)	Leveraging competitiveness (Cost, and Quality, Productivity)	Coping up with job loss and creating jobs	Developing manpower for using robots	Developing manpower for process redesign and robot programming	Conducting R&D, pursuing innovation, empowering youths, promoting start-ups
	We want to be a part of the fourth industrial revolution and robotic automation, and for that, we need to have an expert	There is a job loss threat but at the same time, due to the change of demand and new requirements, new	We need to focus on human resource development for that reason a	We need to create a customized solution with robotic automation to create the value of this sector and for that, we	Induct industry-oriented skills training programs to support and growth of the industry.

	intervention to find out the scope and implication of robotic automation We need to look into technology feasibility, economic feasibility, and return on investment but we should embrace technological advancement otherwise we will be left behind of it. Our overhead wages cost is less but at the same time, productivity is less too. The average overhead cost of a finished product must have to be brought down below $.75 cent by introducing robots in the footwear industry against the present $1.5 dollar to compete in the international market. Once we have good quality products, the new order will come up that will increase the opportunity of new employment as well. Now, our export market is $1 billion USD in the leather and footwear industry and our target is $5 billion USD but the	employment opportunities will come up. For that reason, we need to focus on re-skilling and upskilling to cope up with the new requirements	needs assessment is highly required. Require technical know-how to operate the robot and robotic solution and we need expert as well For the service and maintenance of the robotic solution, professional training and investment are required for this sector. Training on robotic solution needs to be introduced to reorganize the process and reengineering the automation	need expert opinion and field visits regularly. Through industry-academia, and govt collaboration, need to develop manpower for process redesign and robot programming	Support start-ups to grow and empowering youth through proper mentoring and skill development

	global market is $230 billion USD. Only robotic technology can help us to reach our target. Shoe lust forma is required to have automation for high precision. The robot can help but proper automation with the integration of software applications is highly required to get the desired outcome.				

Table A.14: Manufacturing and SME's

Manufacturing and SME's	Number of firms			Revenue in $millions			Growth trend and prospect		Employment		
	Local	JV	FDI	Domestic	Export	Total	Last 3 years	Next 5 years	Total	Male	Female

Unfolding Robotic Scenario, having relevance to Bangladesh's Interest	Technology prospects and global offerings	Adoption in Bangladesh	Adoption in regional countries	Adoption in China	Adoption in advanced countries
	Universal Robots' UR3, UR5, and UR10 bring all necessary qualities to make automation for companies of all sizes and industries successful. For manufacturing companies, collaborative lightweight robots are an economic alternative to expensive. They make automation affordable for small and medium-sized enterprises.	Very few SME's are using the robotic applications on a smaller scale.	The small and medium scale enterprises sector in India is witnessing a steadily increasing penetration of robotics.	Adoption in China is very high. They are taking steps to implement and improve automation especially in an area such as manufacturing, SME's	Advanced countries are using the robotic solution in their SME's to increase productivity, reduce cost, and meet the human resource crisis.
Unfolding threat and opportunities (gathered from stakeholders)	Competitiveness (Cost, Quality, Productivity)	Jobs: Loss and Creation	Education, Skill, R&D and Innovation	Opportunities for IT industry	Youth empowerment and start-ups
	Need to check commercially feasible to introduce robot	Robotic automation will cause job loss but at the same new	Awareness building development program is highly required to	There will be a huge opportunity for the IT industry to create	New start-ups will be taken place to create a localized robotic solution

	automation to reduce cost, increase quality and productivity. We need to customize/redesign the solution locally instead of importing solution	job opportunity will be created Need to focus on feasibility whether it is commercially viable as we have low-cost labor	understand the advantages of using the robot and RPA We need to have skilled resources for customization of a robotic solution locally Huge Investment is needed for research and development & innovation for a local context	customized solutions and robot programming. Opportunity for robot customization, innovation, service, maintenance, operation thus will lead to a new industry	and we need to engage the young generation for research and development to create a unique solution.
Bangladesh's readiness, strength and weakness (gathered stakeholders)	User Firm and Industry level	Skilled manpower for using Robotics solution	Skilled manpower for process redesign and robot programming	Education, training and R&D capacity	Innovation capacity of IT firms and start-ups
	We are in a very preliminary stage of scratching and exploring the robotic solution to fit in our own context.	A certain level of skills is required for the service, maintenance, and operation of the robotic solution.	We need to focus on redesigning the product and process in order to get the maximum advantage of the robot and automation. Need to have integrated learning through the collaboration of industry and academia for process redesign and robot programming. Particularly capacity should be developed for troubleshooting by accessing machines digitally.	Need to have integrated learning through the collaboration of industry and academia	There is a scope of innovation, service, and maintenance of the robotic solution for IT firms and start-ups

Bangladesh Strategy (suggested by stakeholders)	Leveraging competitiveness (Cost, and Quality, Productivity)	Coping up with job loss and creating jobs	Developing manpower for using robots	Developing manpower for process redesign and robot programming	Conducting R&D, pursuing innovation, empowering youths, promoting start-ups
	To achieve a middle-income country by 2021, and a developed country by 2041, technology up-gradation, robotics automation is necessarily addressing the fourth industrial revolution The selection of trade is very important, decide initially which sector would get more preference to go for robot automation. eg: Light engineering, automobile, pharmaceutical, or foundry. Explore the opportunity to reach the global market. Considering the hygiene issue, productivity and to	There is a chance of job loss but we need to leverage an integrated approach where job loss and job creation will be adjusted Using Robots and robotic solutions are costly for SMEs. We need to focus on how it can be adopted. We need to concentrate on a cost-benefit analysis that would help the decision-making process	Training on localized robotic solution needs to be introduced to reorganize the process and reengineering the automation We need to focus on the skill gap issue and create a baseline survey.	Build local capacity to redesign the product to get the maximum benefit of robotic automation Through industry-academia, and govt collaboration, need to develop manpower for process redesign and robot programming	We need to define a penetration strategy through pursuing innovation and empowering youths to find a suitable entry to get into and to create a good example Conduct R&D and support start-ups to grow

	grab the global market, we need to go for robot automation				

A.15 Participants list of FGD's on National Robotics Strategy of Bangladesh

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