© *DHAKA UNIVERSITY JOURNAL OF MANAGEMENT*
Volume 14, No. 1, December 2022
DOI: https://doi.org/10.57240/DUJM140103
Page No**:** 35-55, ISSN**:** 2221-2523

IR 4.0 in the Apparel Industry of Bangladesh: Prospects and Challenges

Sadia Sharmin[1]

Abstract: *Over the past decade, the world has been heading towards the fourth industrial revolution, with many countries adopting the latest innovations and technological upgrades, which essentially are meant to meet the growing demands of consumers in every sector of an economy. The research first reviewed the existing theories and concepts regarding IR4.0 and then utilized the "Industry 4.0 Readiness" model of Impulse Industry 4.0-Readiness of the Association of Germany's Engineering Industry (Verband Deutscher Maschinen- und Anlagenbau) as the guiding framework for devising an original, suitable, readiness model to evaluate 135 RMG factories (big, medium and small) in Bangladesh. A mixed methodology approach is followed in the research, implying the utilization of both quantitative and qualitative tools. This exploratory research focused on how companies make use of technological tools and methodologies and how they are prepared to adopt the massive changes, brought forward by IR 4.0. Based on this study's findings, apparel companies should focus more on using technologies such as AI, Sensors, ERP, SMV, GSD, Big Data, Cloud, M2M communication, etc. to boost Bangladesh's global competitiveness. In addition, respondents believed that digital transformation could create a smart factory to optimize the manufacturing system and it has a very substantial impact on industry 4.0. Furthermore, this exploratory study exposed that the apparel industries of Bangladesh are encountering major challenges in IR 4.0 strategy design and equipment organization to aid IR 4.0 demands.*

Keywords: *Apparel industry, Bangladesh, Fourth Industrial Revolution, IR 4.0 readiness, Impulse Industry 4.0-Readiness, Verband Deutscher Maschinen- und Anlagenbau (VDMA)*

Introduction

There are numerous facts and figures, and subsequent movements in the economy of Bangladesh which are inclined toward a massive potential for growth in technology-driven manufacturing and service sectors in this country in the coming future. To begin with, during the last decade, Bangladesh's economy has maintained more than 6 percent (on average) GDP growth rate. Among the fifteen areas recognized for determining national income, the endowment of the manufacturing sector is crucial to overall GDP growth and involves substantial usage of modern technologies. The readymade garments (RMG) (in this paper, readymade garments industry and apparel industry will be synonymous) sector in Bangladesh, a $38.52 billion industry (Export Promotion Bureau, July-May 2021-2022) and the largest export earner has initiated green manufacturing by establishing 135 eco-friendly green buildings (Dhaka Tribune, 2017), the highest in the world. Keeping up with the blistering technological changes, both the world's apparels and fashion are on the verge of a drastic evolution. Technological progress, coupled with innovations, is flooding the fashion landscapes, especially in manufacturing, electronic retailing,

[1] DBA Fellow, Department of Management and Joint Secretary to the Government of Bangladesh.

mass customization, and consumer expectations. Consequently, it has now become pertinent for the government to design evidence-informed policy instruments for the establishment of the green industry while keeping in line with the existing national laws, rules, and acts associated with the environment, water, electricity, energy, and international standards. Besides, businesses must purposefully pursue a set of changes, both from an organizational productivity standpoint as well as a technologically supportive one.

Recent evidence suggests that technology is pushing reality into the 4th industrial revolution for some countries. Experts argue that 4th industrial revolution will present opportunities to maximize wealth through an uninterrupted boost of inclusive GDP, and improve upon social development indicators like education, health, and environment. Sustaining output growth, achieving employment, and wages, technological upgradation and movement up the value chain, and the problems faced by developing country firms in implementing so are quite extensively known. These include particular problems of (1) funding the purchase of new (hence, riskier) technologies, (2) up-skilling workers and employees, and (3) obtaining land for horizontal expansion, especially in location clusters. Alongside these issues exist the notorious infrastructural constraints, utility supplies, and predictability of policies, and to tackle the overall problems related to technology upgradation, this second set of issues are prioritized while forming policy responses through good governance and by enhancing the practice of investment. International evidence, however, does not deem these initiatives to reap any benefit either in the short or medium term; rather, a thorough understanding of each problem, and a tailor-made solution/ policy from the government to tackle that particular problem is required to find a way forward.

It is about time to make an assertive move towards elevating our level of competitiveness and becoming compatible with industry 4.0 (or IR 4.0). For us, the big questions are: where are we standing (stages) in terms of the industrial revolution? Do we have the right kind of strategies and policies to build an enabling environment? Do we have the exact knowledge, skills, resources, and incentive to implement smart factories? Do we know the impacts of these changes on the economy in general and labour market in particular? Therefore, understanding the depth of the situation will require a careful consideration of the readiness of the RMG industry to embrace IR 4.0. The purpose of IR 4.0 is to convert industrial manufacturing through information and technology and by making the most out of the benefits of modern innovations. Therefore, an Industry 4.0 production system is both flexible and safe and enables industries to produce more customized products with high efficiency. Most developing nations, such as Bangladesh, Pakistan, India, Philippines, and Nigeria, depend on the manufacturing of products to be delivered to foreign countries/companies. Therefore, if these countries could add the administration of their manufacturing productions and chain productions, the present rate of unit output would be significantly increased compared to unit input, a key, consequent factor of Industry 4.0 to consider for these countries to move ahead.

1.2 The Rationale of the Study

The extensive grounds upon which this study is firmly built can be broadly classified into two folds: the impressive progress of Bangladesh as per the global development yardsticks and the

massive contribution of the apparel industry to that very progress. With the recent qualification of Bangladesh to graduate into a developing nation from LDC, and scheduled to be officially recognised in 2026, coupled with the government of Bangladesh's 2041 vision of becoming a full-fledged developed nation, the most natural response of academia is to assess the strengths and weaknesses of the country, and the overwhelming achievements of RMG industry make the apparel sector a focal point of development-oriented discourses. The apparel sector of Bangladesh is known as a trendsetter among industries and has 85% endowment to the total exports of the nation, its preparation for embracing IR 4.0, and the potential consequences of implementation will therefore determine whether the entire industrial sector can cope up and/or achieve the 4th industrial revolution in the long run or not. Hence, though IR 4.0 is seen as a natural transition towards further development of a country, the preparation that goes into implementing it and the spillover effects it could induce must be assessed in the most dominating industrial sector first, which is the apparel industry for Bangladesh.

1.3 Objectives

The following two specific objectives were conceived to examine the situation in adopting IR in the apparel industry of Bangladesh:

1. to explore the areas where the apparel industry needs to be prepared in adopting and implementing Industry 4.0.
2. to examine challenges and opportunities for the apparel industry in implementing Industry 4.0.

1.4 Research Questions:

The subsequent two questions that would be discussed in this article were investigated in the form of a questionnaire survey, FGD and case study analysis. The key questions are as follows:

1. what are the areas where the apparel industry in Bangladesh needs to prepare to adopt and implement IR.4.0?
2. what are the challenges and opportunities for the apparel industry in Bangladesh to implement Industry 4.0?

2. Literature Review

Though the fourth industrial revolution is still at a nascent stage in Bangladesh, it has been in practice in different parts of the globe for quite some time. Hence, a thorough review of the existing pieces of literature on IR 4.0, along with the limited ones available even with modest correlation with the apparel sector of Bangladesh, is imperative, and presented below, starting from the very roots of the revolution – its conceptual understanding.

The various definitions of the 4th industrial revolution suggest that this idea is still evolving, and yet to be refined further. For example, Sniderman et al in their Deloitte AG report define Industry 4.0 as smart and connected manufacturing (Sniderman et al, 2016). Similarly, Brettel et al (2014) state that "Industry 4.0 focuses on the establishment of intelligent products and

production processes"; the authors have further said that within the factory of the future, Cyber-Physical-Systems (or CPS) will allow an exchange of information between humans, machines and products alike, and since they can collect and process data, they can operate some chores independently while interacting with people through interfaces (Brettel et al, 2014). Along with such developments, many scholars, nations, and even industries have come up with a diverse range of synonyms to represent Industry 4.0. Some of those synonyms include Industrial Internet, Connected Enterprise, SMART Manufacturing, Smart Factory, Manufacturing 4.0, Internet of Everything, and Internet of Things for manufacturing.

The definition of Industry 4.0 was first announced in 2011 at the Hannover Messe trade fair by the German federal government. Germany Trade and Invest (GTAI) defines Industry 4.0 as a paradigm shift made possible by technological advances which constitute a reversal of conventional production process logic. Simply put, this means that industrial production machinery no longer simply 'processes' the product, but that the product communicates with the machinery to tell it exactly what to do (Sniderman, Mahto & Cotteleer, 2016).

A fundamental feature of Industry 4.0 is the concept of the 'factory of the future' (FoF), which is now known as the 'smart factory.' FoF was first coined in 1986 by Irwin Welber during his speech at the 1986-international conference on robot manipulators. According to him, FoF would tout urn to be an extensive intelligent machine. This would operate with a highly integrated, organised knowledge base. He had also pointed out the fact that both suppliers and customers would need to play crucial roles in the FoF ecosystem (Haddara & Elragala, 2015).

The Fraunhofer Institute examined the efficiency and expansion prospects of businesses utilizing Industry 4.0 technologies in 2013. Its primary effects come from five technological fields: embedded systems, smart factories, powerful networks, cloud computing, and IT (Information Technology) security (Bauer, W.; Schlund, S.; Marrenbach, D.; Ganschar, O. 2014).

According to Rüßmann et al. nine technologies are essential to the growth of companies/ organisations in the era of IR 4.0. These comprise both technical tools and procedures, for example, automated robots, simulation, horizontal and vertical system integration, industrial IoT, cyber security, cloud-based services, additive manufacturing (3D printing), augmented reality, and big data analysis (Rüßmann et al. 2015).

On the other hand, Hermann et Reckons IR 4.0 is as the true digitisation of industry, which encompasses innovative technological advancements and ideas regarding the organisation of the value chain. By monitoring physical processes through Cyber-Physical Systems (CPS), mapping the physical world in the virtual world, and decentralizing operational decision-making, Industry 4.0 builds a standardised design of a smart factory (Hermann et al.2016).

Industries are opting to escalate digitisation to meet the demands of consumers, which seem to be always changing. Heynitz, H.V. et al stated that manufacturing with digitalisation becoming increasingly popular and necessary, especially, may experience notable benefits, including significant depletions in inventory, logistics and material handling expenditures, shorter lead times, and fewer shortages during shipment (Heynitz, H.V. et al 2016).

Furthermore, Kolberg and Zühlke (Lean Automation enabled by Industry 4.0 Technologies, 2015) have identified Smart operator, Smart product, Smart machine and Smart planner as the four enablers of a Smart Factory. Since Industry 4.0 is still quite a new concept, in the present context virtually there are no scholarly publications with relevant to Industry 4.0 in Bangladesh. However, several publications and reports can be found regarding the applications of Industry 4.0 concepts in developed countries. A report by Deloitte has identified the advantages of Industry 4.0 offered to the Swiss manufacturing industry, which are applicable to any other country in the world including Bangladesh even though we are a developing country. This study also observes the performance of Swiss manufacturing companies, the benefits they have reaped and the problems that they incur with these digital metamorphoses to say, called the IR 4.0. Some of the suggested benefits comprised increasing competitive neutralising prospects and lowering risks, adjusting talent and IT resources, creating openings for specific business segments, and leveraging the push from exponential technologies (Deloitte, 2015).

Wang et argues that the realisation of Industry 4.0 necessitates (1) horizontal integration of the value chain, (2) a networked production system and vertical integration, and (3) end-to-end digitisation of engineering design throughout the value chain. According to them, these needs are assisted by emerging technologies, including IoT, wireless sensor networks, big data, cloud-based services, embedded systems, and mobile Internet (Wang et al. 2016).

Hermann, Pentek, and Otto analysed 50 studies and managed to recognise four fundamental tools required to adopt Industry 4.0 inside an organisation (Hermann, Pentek, and Otto, 2016). These include CPS, IoT, the Internet of Services, and the Smart Factory; all of them are though broad categories and do not pinpoint the technical tools required to implement them.

With all the aforementioned smart features, Industry 4.0 aims to solve "real-world" problems with mini assistance from humankind (Al-Mhiqani, et al., 2018). But to better understand the context of the Fourth Industrial Revolution, a few other definitions can be looked at: for instance, some experts call it an "integration of complex machinery and devices, with sensor and software, used to predict and control business results" (Haber, Juanes, Toro, & Beruvides, 2015), while others simply view it as "a smart manufacturing concept where machines and products interact with each other without human control" (Kang, et al., 2016). Some kinds of literature call it "the interaction of digital and physical processes in a cross geographical and organizational setting" (Adler, Schmitt, Wolter, &Kyas, 2015), while others phrase it as "a holistic system of people and machines for the flow of goods, services and data with a high degree of autonomy in decision making" (Hermann, Pentek, & Otto, 2016).

3. Methodology

3.1 Research Design

Choosing an appropriate method of research depends mostly on the type of research such as explanatory or action research (Chapman et. al, 2005). In this research, mixed method are being applied where qualitative and quantitative methods both are present. In the quantitative method, data is collected in numerical forms, in the qualitative method, data is collected in textual form.

The following formula was used for determining the sample size n:
n = N*X / (X + N – 1),
where,
X = Zα/22 *p*(1-p) / MOE2,
and Zα/2 is the critical value of the normal distribution at α/2 (e.g. for a confidence level of 95%, α is 0.05 and the critical value is 1.96), MOE is the margin of error, p is the sample proportion, and N is the population size (Cochran, 1963).

3.2 Sampling Design of Sampling

- Population size: This is the total number of distinct factories in Bangladesh. The sample size doesn't change much for populations larger than 100,000.
- *Sample proportion*: The sample proportion is the expected results to be. This can often be determined by using the results from a previous survey or running a small pilot study.
- *Sample size*: Using the formula given above putting MOE 5%, confidence level 95% and population size 4000 and sample proportion 90%, the sample size is 134.

Target Population

Using the formula given above putting MOE 5%, confidence level 95% and population size 4000 and sample proportion 90%, the sample size is 134. The sample proportion is taken from previous studies where it was found that data get saturated in the case of more than 120 Bangladesh apparel industry factories.

Calculation,
N = 4000, Zα/2 = 1.96, p = 0.9, MOE = 0.05

$$X = (1.96)^2 \times 0.9(1 - 0.9) \div (0.05)^2 \cong 138$$

$$Sample\ size, n = \frac{(4000 \times 138)}{(138 + 4000 - 1)} = 134$$

A total of 200 factories were reached randomly from the list through email using the sampling. Upon which 138 responses were received. However, during the data cleaning process, 3 responses could not be used for analysis due to a lack of adequate responses. In the end, the analysis was made using the responses from 135 factories.

Sampling Frame

A sampling frame is a list of all the items in the population. It's a complete list of everyone or everything that needs to study. In this case, the member list of BGMEA and BKMEA has been used as a sampling frame for the survey.

4 Results and Discussion

The study explores the areas where the apparel industries in Bangladesh need to prepare themselves to adopt and implement IR.4.0. Therefore, it discusses the challenges and prospects for embracing IR 4.0 in the apparel industry of Bangladesh. The present research examines 134 sampled apparel industries in Bangladesh regarding to inspect the areas where the apparel industries in Bangladesh need to prepare themselves to adopt and implement IR.4.0 and find out the challenges and opportunities of the apparel industries in Bangladesh in pursuit of IR 4.0

4.1 The areas where the apparel industry in Bangladesh needs to prepare itself to adopt and implement IR.4.0

According to the survey results, Production/Manufacturing, Marketing and IT are the main business segments within the company where there is very or great potential for industry 4.0. These segments are likely to be benefitted from the digital transformation to IR 4.0. On the contrary, the other areas like Sales, Services, Warehousing/logistics, and Procurement/purchasing have fewer possibilities of reaping the fruits of the revolution.

Table 1: Potential areas for industry 4.0

Areas	**Very or great potential**
Research and development	74.50%
Production/manufacturing	83.40%
Procurement/purchasing	79.10%
Warehousing/logistics	70.10%
Marketing	83.00%
Sales	57.10%
Services	60.20%
IT	**83.60%**

In table 1, 83.6% of responses have been recorded in the IT section suggesting section has a high potential where industry 4.0 can be implemented. The second and third highest are the production/manufacturing and marketing sections. The other segments such as procurement, logistics, marketing, and sales have lower potential segments regarding the implementation of industry 4.0.

Table 2: Transformations made in the recent past

Areas	**Moderate to strong transformation**
Research and development	60.70%
Production/manufacturing	74.80%
Procurement/purchasing	57.10%
Warehousing/logistics	41.50%
Marketing	54.30%
Sales	40.70%
Services	41.60%
IT	**59.20%**

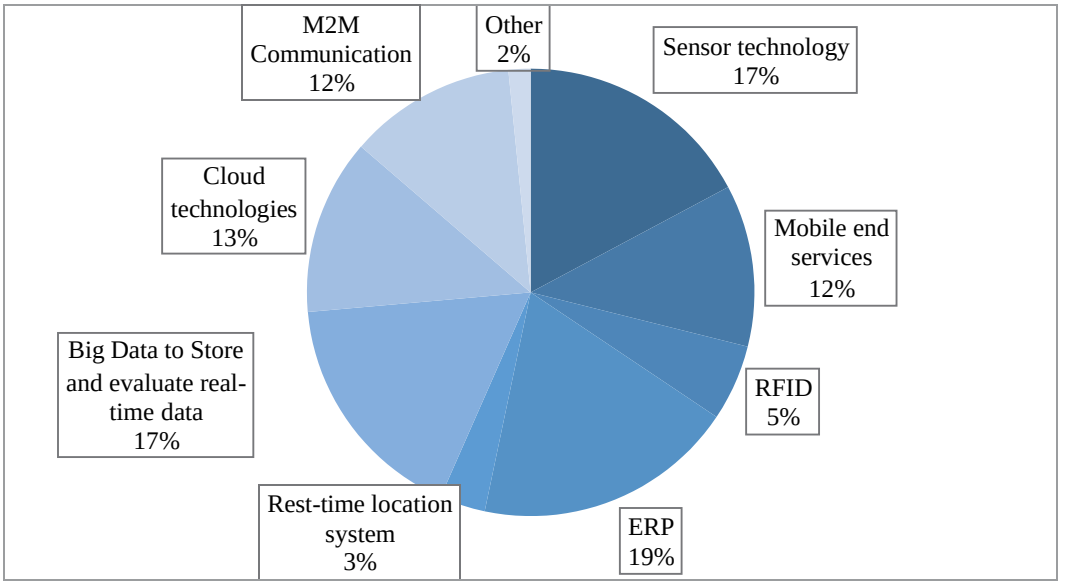
Based on the above table, research and development, production/manufacturing, and IT (60.7%, 74.8%, and 59.2% respectively) are indicating strong transformation to embrace the latest manufacturing technologies in their companies. However, the other segments such as warehousing/logistics, marketing, sales, and service have lower potential segments regarding the implementation of industry 4.0.

Table 3: Investment made in the last two years

Areas	**Made investment**
Research and development	96.20%
Production/manufacturing	96.40%
Procurement/purchasing	93.70%
Warehousing/logistics	93.80%
Marketing	56.30%
Sales	80.10%
Services	81.40%
IT	94.60%

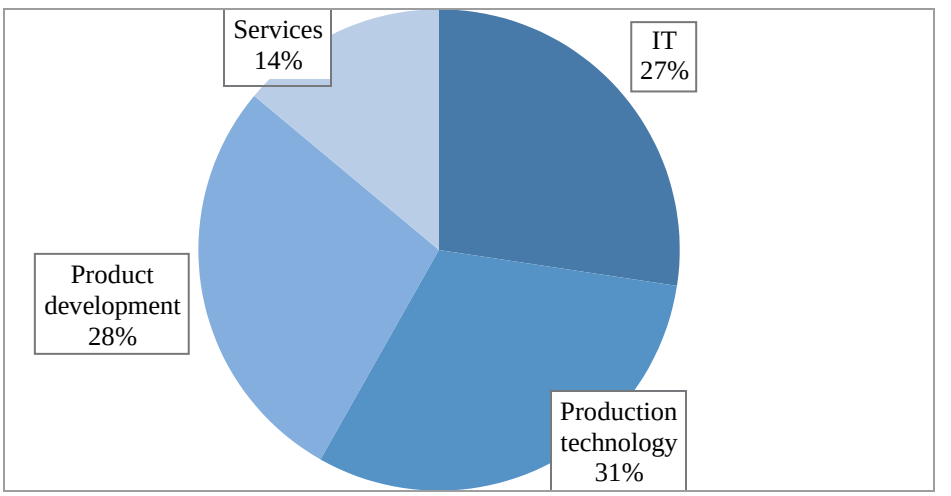
From the survey, it was found (table 3) that companies are investing mostly in IT, production/ manufacturing, research and development, procurement/purchasing, and warehousing/ logistics areas to digitise essential operational functions in the past two years. The other segments recently have lower level of investment for the execution of Industry 4.0.

Figure 1: Technologies require to enhance competitiveness



The above chart (figure 1) shows the technologies that companies need to enhance their business competitiveness. It has been observed that ERP (almost 19%), Big Data (17%), Cloud (13%), and M2M Communication (12%) have been mentioned as the most technologies essential for companies to enhance business.

Figure 2: Systematic technology and innovation management



The chart shows the areas where the responding companies consider having systematic technology and innovation management. The main areas for the implementation of Industry

4.0 are Production technology (31%), product development (28%), and IT (27%). While for Thailand-based companies the core areas are Production technology, IT, and product development (P. Koomsap et al, 2019).

4.2 The Challenges and Opportunities for the Apparel Industry in Bangladesh to Implement Industry 4.0

Industry 4.0 Challenges

Adapting industry 4.0 fully to the apparel industry of Bangladesh will have to face a few challenges and hurdles in the coming days. Several are necessary to create an enabling environment to be upgraded to industry 4.0. In this chapter, these challenges will be discussed in terms of enabling the environment for IR 4.0. This part will describe and explain the challenges of adapting IR 4.0 to the apparel industry of Bangladesh, which are derived from the FGD, case studies, and knowledge-sharing meetings conducted for this study. The challenges are mentioned below:

Initial investment cost:

Cyber-physical systems, robotics, virtual reality, 3D product design, wireless sensor networks, big data infrastructures, and their amalgamations are quite expensive, and to make matters worse, most apparel companies tend to be small-and-medium-sized enterprises, which are bound to find it challenging to afford such costs. Therefore, a thorough cost-benefit analysis of embracing IR 4.0 is duly required for the companies to smoothen their journey into the fourth industrial revolution, rather than impulsively rushing into the hype.

Privacy and security:

Many works of literature have shown apprehensions involving the privacy and security of digital data, and understandably so, hacking into information is not an uncommon phenomenon. The digital data of a smart factory is also subjected to confidentiality for the security of the factory itself and hence, rigorous protocols must be established in-between the communication among smart devices, among themselves, and humans, basically the entire virtual system involved, for the protection of information.

Technology Adaptation:

Most of the proposed innovations in the scope of IR 4.0 are generally new advances, meaning there is a severe scarcity of experienced workers who could operate these technologies. Therefore, public strategies ought to be created and upheld to build the amount of experienced labour. It is crucial to have a favourable/conducive environment for adapting to technological changes. By a favourable environment, it is meant the whole set of capabilities to roll out and maintain new technology. There is a set of factors that determine the ability to an adaptation to technology. These factors include infrastructure, technical knowledge, skilled manpower, innovation, internet penetration, cost of doing business, and many more.

Lack of a global standard:

As seen already, with multiple definitions, theories, and discourses associated with IR 4.0, it is easy to get bewildered for any apparel company that is interested in adopting the fourth industrial revolution. There is still an absence of a globally accepted/standardised Industry 4.0 maturity model, despite the introduction of the term a decade ago, and this gap needs to be filled to properly guide the aspiring firms and practitioners toward IR 4.0 (Gökalp, Şener, &Eren, 2017).

Social difficulties and Skilled Manpower:

Naturally, with the emergence of IR 4.0, companies will be inclined to recruit more high-skilled labour who could operate complex machines, with rapt attention and efficiency, and this poses a significant social problem – unemployment, especially in the low or semi-skilled workforce. The World Economic Forum predicted a loss of jobs for 5 million people in 15 developed countries by the year 2021 due to the introduction of Industry 4.0(World Economic Forum, 2016). Henceforth, a thorough guideline is essentially required to prepare the existing labour force for arising technologies (Gökalp, Şener, &Eren, 2017).

Because of the fourth industrial revolution, indeed, many conventional jobs will be rendered obsolete by new skills and forms of jobs, and companies' regular tasks are likely to be performed by machines rather than humans. However, the digital transformation in the apparel sector could boost Bangladesh's global competitiveness. Moreover, the transparency of the apparel companies can be readily enhanced when the factory has customer access to the integrated production processes and real-time report generation regarding the production system.

For any country, having skilled manpower is a blessing to adapt to any technological changes and maintain them. Unfortunately, we don't have plenty of skilled manpower to implement technological changes. Still, in 2018, we have to depend on foreign expertise to implement and maintain most of our development projects. Bangladesh has a huge population of approximately160 million, it lacks in having manpower with digital skills which is very important when talking about the capability of adapting to new technologies because new technologies usually require more digitally skilled manpower to produce goods and services using the most sophisticated production processes. The number of technical training institutions and the quality of technical training is not up to the mark, which needs to be addressed.

Technological progress, at any time frame, is bound to raise concerns regarding the future of human labour for their potential replacement by machines and robots; however, the major findings of this study reveal that IR 4.0 do not pose any threats to human labour, provided the workforce has been enabled to adapt to new advancements, and governments set up policies, and also follow them strictly, that protect the vulnerable labour population from any unprecedented and unwanted ramifications of technological progress. Routine jobs that require less communicative and cognitive skills, the likes of office work, or construction and manufacturing, are most subjected to automation. But occupations like instructing, nursing, and taking care of the elderly, where multiple tasks have to be performed and require adaptability, genuine inventiveness, and social

knowledge, are hard to be automated. Thus, it is safe to say that a new technological revolution is not likely to substitute all of the human work force with machines and robots (Evanthika, 2019).

Internet Penetration:

The Internet is like a one-stop solution for every problem. There is no area where the internet can't help. We are living in the era of the internet and information technology. The whole business model has changed and been changed by the online business model. The Internet has made business much easier and reached out to people living all over the world. Internet users ranking is a very good tool to evaluate the capability of adaptation to technological change.

Innovation Capability:

The more innovative a country is the more likely it is to adapt to new technology quickly and efficiently. The capacity to innovate leads the industry to a higher position with a higher return. Bangladesh has been lacking this capacity since the beginning. Then again, to be innovative people, need to be educated properly and need to have the right skill. Education is an essential indicator of having skilled and innovative manpower to cope with any kind of technological change. While assessing this indicator, quality is much more important than quantity. In our country, we have a literacy rate of 72.76, which does not provide the actual scenario. Though our universities are providing a good number of fresh graduates they lack innovative ideas and digital skills. We are producing Business graduates with BBA and MBA but they are not coming up with innovative ideas or starting a new business or developing new business models rather we are creating stereotypical employees who can only follow orders and that is something which is making the difference between us and other rapidly growing economies like India and Malaysia.

Policy Implementation:

To escalate the pace of industrialization in Bangladesh, its government proclaimed the 'National Industrial Policy-2016'. The major and fundamental objectives of the Industrial Policy (NIP) 2016 include sustainable and comprehensive industrial growth through making of dynamic employment to produce new entrepreneurs, mainstreaming women in the industrialization process, and international market linkage. However, policies like NIP-2016, export and import policies (2018-2021), and the five-year plan didn't lean light the challenges of the 4th industrial revolution and other issues. Though we have National Strategy for Artificial Intelligence of Bangladesh (2019) either we have to include IR 4.0 in our Industrial Policy, or we have to generate other strategies or policies which will uphold IR 4.0 as a whole.

4.3 Industry 4.0 Opportunities for Apparel Industry

New technology and inventions contribute to the betterment of industries and human lives during each industrial revolution. The fourth industrial revolution (4IR) is currently altering how people work and live. The 4IR is revolutionizing traditional operational procedures in the apparel sector with automation, artificial intelligence, 3D printing and knitting, robotics and intelligent manufacturing, augmented reality, and other technologies. Simultaneously, it is transforming the

sector by bringing new consumer trends. As the RMG sector becomes more competitive with the adoption of 4IR technology, Bangladesh must accept and utilize technical benefits to maintain a greater piece of the pie of global garment exports. The following prospects have been revealed during KII, FGDs, and Case studies.

High Productivity Worker

Until recently, global fashion garment procurement followed a cost-cutting paradigm. This is why ready-made clothing took off in Bangladesh: the country was able to supply adequate quality apparel at a low cost due to cheap labour. Every year, approximately 37 public and private institutions in Bangladesh graduate textile students, adding to the skilled workforce accessible labour that will lead to modern technology use in the apparel sector by the skilled graduates.

The transition from the Cost-Based Model to the Fast Fashion Model

As previously indicated, global garment sourcing has been following a cost-effective trend for some time. Changes in the fashion business have had an impact on the sourcing paradigm, which has converted into a trend known as 'fast fashion.' Fast fashion refers to affordable and trendy clothing that is manufactured and sold in record time. The concept of fast fashion is to develop, manufacture, and produce large quantities of apparel to replicate any existing trend and frequently update retail store shelves. The key causes for the emergence of fast fashion are lower garment production costs, streamlined operations, and increased consumer spending. So being cost-effective is no longer the only necessity. To remain competitive, faster production and shorter lead times are required. To keep up with the ever-changing market, the ready-made clothes business must embrace digitalization and automation. A photo-realistic virtual simulation of design concepts, for example, can replace the time-consuming design conceptualization, sample creation, and prototype process. The requirements of quick fashion can be satisfied by utilizing technology in automating various manufacturing procedures.

Transforming 'Fast Fashion' to 'Precise Fashion'

As previously stated, quick fashion has risen as a result of low-wage production. This fast-fashion paradigm is now turning into something dubbed 'correct fashion,' thanks to the overnight creation of ever-changing customer wants. Precise fashion refers to the concept of correctly matching the fashion industry's ever-changing trends. It entails paying attention to all of the subtleties of consumer wants and creating attire that perfectly suits the nuances and trends. For example, global sporting events such as the Olympics or big fashion events such as the Met Gala can influence accurate fashion. Undoubtedly, flexibility is essential to match precision, as the demand for garments may be affected by factors such as the outcome of a football game. Another effect of this trend is that the average production lead time has decreased from 120 to 90 days. This new precise fashion model has spawned at least four distinct trends: near-shoring, automated production, and computerized designs that replace manual labour, less time spent on shipping items, and a nuanced, precise supply of garments.

Inclusive Opportunities in Bangladesh's Context

While the risk of unemployment looms large over the apparel sector of Bangladesh in the face of the fourth industrial revolution, the opportunities that also come along with this transition are immensely lucrative, and in fact, are essential for the survival of the industry to a large extent, as also opined by the former president of the BGMEA, Rubana Huq: "It makes no sense for us to slow down and not automate" (Emont, 2018). The global apparel market, thanks to the practice of fast fashion, is heading towards IR 4.0 which puts tremendous pressure on the lead time of Bangladesh's apparel industry, which only comes second to China, as the world's leading garment exporter. Though cheap labour has kept the nation competitive for decades, without adopting innovations and technologies, that position could well be vulnerable (Fahim, Chyon, Suman, & Islam, 2020). However, by embracing IR 4.0, Bangladesh can turn things around by minimizing lead time, and increasing customer responsiveness, that too within budget – or to put it simply, become more internationally competitive, hold a strong foothold on the global market, by making optimum use of resources.

Moreover, Bangladesh must cash into the "China Plus" opportunity innovation. China's dominance over the global apparel market is overwhelming, but with increasing labour costs and other materials, Chinese manufacturers are now considering an investment in other countries such as Vietnam and Ethiopia, in an attempt to further their position in apparel sourcing and produce on a greater scale overseas. In addition, China is shifting focus to digitization and automation for their 'Made in China 2025' initiative. So, the biggest exporter of garments is not only creating spaces for other countries to pitch in, but also promoting technological advancement, and that must be noted by Bangladesh. An earlier report published by the World Bank in 2016 showed that a 1% rise in apparel price in China would lead to a 1.36% additional demand for Bangladeshi garments in the USA, and a 1% rise in expected wages in China would increase the odds of women entering the labour force by 30.6% in Bangladesh (The Financial Express, 2016). These figures clearly show that any changes put forth by China are bound to impact the apparel industry of Bangladesh, and they must accordingly. More importantly, for Bangladesh to enjoy more jobs and a rise in exports, there must be productivity improvements, which, as lauded by all experts, is the key outcome of adopting IR 4.0.

Speaking of productivity, experts have predicted that businesses will be able to ramp up their productivity by around 30% with the realisation of the fourth industrial revolution (Bari, Habib, & Akash, 2021). The various elements of IR 4.0, such as automation, simulation, big data analysis and internet of things, will make the manufacturing systems more flexible, thereby, allowing industries to meet individualized customer requirements or to inaugurate new products in a shorter time, without putting much strain on costs, since with automation comes greater control over the entire value chain of the production process (Bari, Habib, & Akash, 2021). For instance, by utilizing block chain technology, shipments of apparel can be recorded, tracked, and traced, that too without the help of a bookkeeper, which ensures rapid and anonymous transactions. This will, in turn, enable customers to be aware of the sourcing of products and the corresponding compliance with safety and human rights. At the same time, producers can earn more because,

with such transparency, consumers will be willing to spend more on the products (Shibli, 2022). Furthermore, history suggests that the fear of losing jobs due to automation is not justified. This is because between 1980 and 2017, China, Bangladesh, Pakistan, and Indonesia witnessed a prominent growth in textile and apparel industry employment, despite the upsurge of robotics and automation that took place during this timeline (Manchanda, Schlorke, & Schmitt, 2020). Therefore, be it for survival or for becoming a stronger candidate in the global apparel market, the opportunities that the new technologies and innovations of IR 4.0 offer, need to be meticulously observed by the policymakers, manufacturers, and other relevant stakeholders.

5. Major Findings from case studies and KIIs/knowledge sharing meeting

Case studies:

For the assessment of the readiness level of factories in terms of embracing IR 4.0, it was crucial to acquire insights from some of the long-running factories/industries of Bangladesh and understand what they think are the challenges, the benefits, and the potential pockets of implementing the much-coveted 4th industrial revolution. Four factories/industries were approached in this regard, and their useful understanding of IR 4.0 is presented below.

According to Beximco Textile & Apparel Division, the two obvious benefits of realizing the various tools of IR 4.0 are a rise in production capacity and a boost in productivity.

As a concern of Panam Group, Metro Knitting & Dyeing Mills Limited stated that various means of technology and innovation could be seen within the organization. For instance, as an attempt to be globally competitive in the era of fast fashion, thanks to the investment of Panam Group in Coast Digital's Fast React Plan solution, which is a production planning solution, the company has been able to foresee its plan 12 months ahead rather than 3 months (Knitting Industry, 2020). Besides, Metro utilizes software-based technology in cutting fabrics, which retains fabric, time, and money, and increases quality by confirming precision in measurements during the cutting. Besides benefitting production capacity and productivity, Metro reckons that the fourth industrial revolution will greatly improve data accuracy, which is crucial to the development of an industry.

As stated by Esquire Knit Composite Limited, a company that seems to be only growing over the years considering introducing auto spreaders and cutters as part of adopting IR 4.0. It also states the importance of providing automation to a skilled workforce to maximize the benefits of the fourth industrial revolution; moreover, it is mentioned that supply chain management is another aspect of the entire production that could be automated and made better.

Shanta Industries Limited recommends standardizing Standard Minute Value (SMV) for different products, for instance, using GSD (Generalise Sewing Data) software. Shanta Industries Limited also considers data accuracy to be a significant positive outcome of adopting IR 4.0, besides theincrement in production capacity and overall productivity.

KIIs/Knowledge Sharing Meeting

A total of 15 factory representatives at the management level were present at a knowledge-sharing meeting. The idea was to understand their perception of the adoption of industry 4.0 in their respective factories. During the discussion, a lion's share of recommendations were about different kinds of training, including lean six sigma, supply chain management, and logistics training, machine maintenance training, technician development training for automation, ergonomics-related training, adapting to changes over time training, and mid-level supervisor training – all of which are meant to equip the respective workforce with adequate IR 4.0 skills. However, everyone seems to unanimously believe that IR 4.0 will boost production capacity, efficiency, and data accuracy to a great extent, along with the provision for higher quality products, better planning, better information systems, and an overall improvement in accountability.

6. Conclusion

The fourth industrial revolution or Industry 4.0 or IR 4.0 is certainly here to stay. Though it is a fairly new movement, many nations have begun to adopt it. Bangladesh, too, is considering engaging in the revolution, and rightly so, I believe. The spotlight is on the apparel sector or the RMG industry, in the case of Bangladesh, because of its massive contribution to the economy, and the numerous prospects of IR 4.0 in the manufacturing industry. The thesis sheds comprehensive light on the various elements of the revolution and their impact on the global apparel market. It also breaks down the theories and concepts related to IR 4.0, and how they can be practiced or realised in the garments sector. However, the thesis stands out, I think, for being the very first evaluation of Bangladesh's RMG sector's level of readiness for adopting IR 4.0. This assessment is crucial because IR 4.0 is not simply a move towards more automation, but it comprises highly complex technologies and ideas, which cannot be effectively utilized without figuring out the question: "Are we ready for it?". Other nations followed a similar approach before embracing the revolution and taking leaves out of their books, and their readiness index, this thesis reveals the current standing of the RMG factories of Bangladesh, and that finding alone, is significant for policymakers, the industry itself, and academicians. Unfortunately, however, after a thorough assessment, the study finds the majority of the RMG factories at an intermediate level of readiness for IR 4.0. In each and every aspect of Industry 4.0, there still remains a lot to be done before our RMG industry can implement it, let alone enjoy the facilities. In that regard, the thesis provides recommendations, and more importantly, highlights both the strengths and weaknesses of our mighty apparel sector. For us to remain mighty, and in fact, thrive furthermore in the future internationally, it is quite evident that we have to eventually adopt IR 4.0; given that though, more such readiness assessment needs to be conducted so that our progress, be it gradual, heads in the right direction.

6.1 Recommendations

The implementation of 4IR requires considerable changes in knowledge skills, and attitudes (KSAs) in hiring, and training, both for employers and employees, and adopting new technologies into their industries. For successful adoption of IR 4.0 technology and implementation of it in the apparel industries the following measures can be recommended:

1. Developing New Leadership Capabilities for the 4IR:

We have to develop positive and modern thinking leadership capabilities of people in the apparel sector considering technology and innovation. The industries have to come out of the old-traditional manufacturing process. They should adopt the right technology and build new innovative people strategies for future work.

2. Skill Disruption:

The demand for skilful workers in IT technologies will rise for the extensive use of software, robotics, and data analytics. There is no room for the traditional workforce or low-skilled people. The risk of losing old-aged people's jobs will also increase. Hence, industry owners should create training facilities for their existing workforce within the IR4.0 technology adoption purview.

3. Managing the Integration of Technology in the Workplace:

The latest technology could alter job responsibilities between humans and robots and algorithms, which can have consequences of job displacement. Human resources may introduce concepts of re-skilling, redeployment, and job reinvention.

- Re-skilling: refers to the search for employees with "adjacent skills," It gives workers a lateral learning opportunity.
- Redeployment: This is when employees are re-positioned within the company to avoid redundancy.
- Reinvention: It is vital to remember that automation affects tasks rather than jobs. Therefore, it is necessary to rethink and restructure or redefine the job.

4. Enhancing the Employee Experience

The core of the employee experience is employee engagement. Without having the right set of skills and knowledge (KSAs), it is hard for employees to engage in work as they did before the fourth industrial revolution. As technology is altering how employees work in various ways, and as a result, it has an increasingly created positive or negative impact on employee experience. It has to ensure that all the employees are continuously engaged in work through technology.

5. Building an Agile and Personalized Learning Culture

The concept of agile learning is a method of training and development that emphasizes speed, collaboration, and flexibility in employee learning. By implementing an agile and personalized learning culture, organizations can ensure that employees have enough time and facilities for training as needed.

6. Reforming TVET (Technical and Vocational Education Training):

In the Technical and Vocational Education Training institutes of Bangladesh, the total courseware-Competency Standard (CS), Competency-based learning material (CBLM), and Assessment tool should be redesigned based on the concept of automation and new technology related to the fourth industrial revolution.

7. Funding for human resource development and new technology adoption:

To have a skilled workforce for accelerated growth in Bangladesh, the National Human Resource Development Fund (NHRDF) was established in 2018. It is time to activate NHRDF for helping the youth prepare themselves for market-responsive demand for work in the manufacturing sectors. At the same time, the government should give some financial support to the manufacturing industries, especially the apparel industries, to adopt new technology in supply chain management and logistics, machine maintenance, technician development for implementing automation, and industry four. More specifically, in the department of accounts and financing, store, cutting, sewing, finishing, designing, real-time data collection, research, and development financial support might be extended from the government side.

8. Financial Assistance for IR 4.0 technology adoption:

Implementing IR 4.0 in the apparel industry needs to embrace CPS, AI, M2M communication, autonomous robotics, additive manufacturing or 3D printing, big data, etc. which are expensive. By using these technologies, apparel industry associations, Government and International organisations can take initiatives to arrange funds related to IR 4.0 technology implementation in the RMG sector.

6.2 Limitations of the Study

The main limitation of the research was the lack of research or study conducted about the implementation of IR 4.0 in the apparel industries in Bangladesh. There are only a few write-ups related to IR 4.0, and the impact of IR 4.0 on cheap labor engagement in the Bangladeshi apparel industry, which made it difficult to review the literature. Therefore, literature of studies similar to our research conducted in other countries is mostly used in the literature review process. Besides, since IR.4.0 is a new concept for Bangladesh, many misconceptions are prevalent.

6.3 Scope for Further Research

There are plenty of areas where more research could be conducted in the future with regard to IR in the RMG sector of Bangladesh. A list of such areas of research is given below –

I. There is a need for productivity analysis of the RMG sector comparing the various levels such as beginner, intermediate and experienced levels of industry 4.0.
II. Factories will be required to improve the organisational strategy through research to accelerate their industry 4.0 goals.
III. It will be essential to identify the skill gaps of the future RMG workers regarding experiencing industry 4.0.
IV. A comprehensive exercise is required to indentify the needs and steps for creating enabling environment for industry 4.0.
V. Comparative studies are required to assess a country's status in view of the competitive countries such as Vietnam, Sri Lanka, Cambodia, the India, etc.
VI. There could be a well-developed comprehensive tool for the evaluating level of industry 4.0 for the factories. This will help the buyers to assess factories and their capacities.

6.4 Implications of the Study

Since the study explores the current capacity and future strategy of the apparel industry of Bangladesh in its quest of achieving the Industrial Revolution 4.0, its findings are likely to be significant for multiple stakeholders.

- *For policymakers*: They will be able to witness and understand the infirmities as well as the strengths of the apparel industry in instilling IR 4.0, thereby, giving them the scope of planning and acting accordingly in line with Bangladesh's vision 2041.
- *For investors:* to make the transition from mid-level factories to advanced ones with automation of 4th industrial revolution's stature, understandably, a lot of investment is needed, but most importantly, investment needs to be directed in the right areas, and in this regard, the findings of the study will be crucial to potential investors of the apparel sector.
- *For academicians*: quite limited literature exists at present in terms of readiness level for IR 4.0 in the context of Bangladesh, and even none, when it comes to narrowing it down to the focus on the country's largest export contributor, the apparel industry. Therefore, this study will act as the building block for academicians to develop further discourses, and, in turn, aid the decisions of policymakers.

Reference

Ahmad, S. *et al.* (2020) 'Towards sustainable textile and apparel industry: Exploring the role of business intelligence systems in the era of industry 4.0', *Sustainability*, 12(7), p. 2632.

Akdil, K. Y., Ustundag, A. and Cevikcan, E. (2018) 'Maturity and readiness model for industry 4.0 strategy', in *Industry 4.0: Managing the digital transformation*. Springer, pp. 61–94.

Alam, S. and Dhamija, P. (2022) 'Human resource development 4.0 (HRD 4.0) in the apparel industry of Bangladesh: a theoretical framework and future research directions', *International Journal of Manpower*.

Alayón, C., Säfsten, K. and Johansson, G. (2017) 'Conceptual sustainable production principles in practice: do they reflect what companies do?', *Journal of Cleaner Production*, 141, pp. 693–701.

Almandeel, S. *et al.* (2021) 'THE ROLE OF LEADERSHIP IN INDUSTRIAL REVOLUTION (IR 4.0) ACHIEVEMENT AND CREATIVE THINKING STRATEGIES'.

Anderl, R. (2015) 'Industrie 4.0–technological approaches, use cases, and implementation', *at-Automatisierungstechnik*, 63(10), pp. 753–765.

Bhuiyan, A. B. *et al.* (2020) 'Industry 4.0: challenges, opportunities, and strategic solutions for Bangladesh', *International Journal of Business and Management Future*, 4(2), pp. 41–56.

Bücker, I. *et al.* (2016) 'Towards a methodology for Industrie 4.0 transformation', in *International Conference on Business Information Systems*. Springer, pp. 209–221.

Canetta, L., Barni, A. and Montini, E. (2018) 'Development of a digitalization maturity model for the manufacturing sector', in *2018 ieee international conference on engineering, technology and innovation (ICE/ITMC)*. IEEE, pp. 1–7.

Farhana, K. *et al.* (2022) 'Business Trend Analysis of RMG Industry in Context of Bangladesh-A Case Study', *International Journal of Industrial Management*, 14(1), pp. 515–528.

Ghoreishi, M., Happonen, A. and Pynnönen, M. (2020) 'Exploring industry 4.0 technologies to enhance circularity in textile industry: role of internet of things', in *Twenty-first International Working Seminar on Production Economics*, p. 16.

Gokalp, M. O. *et al.* (2016) 'Big data for industry 4.0: A conceptual framework', in *2016 International Conference on Computational Science and Computational Intelligence (CSCI)*. IEEE, pp. 431–434.

Götz, M. *et al.* (2020) 'Effects of Industry 4.0 on FDI in the Visegrád countries', *Final report. Vistula University, Supported by the International Visegrad Fund*.

Hizam-Hanafiah, M., Soomro, M. A. and Abdullah, N. L. (2020) 'Industry 4.0 readiness models: a systematic literature review of model dimensions', *Information*, 11(7), p. 364.

Hofmann, E. and Rüsch, M. (2017) 'Industry 4.0 and the current status as well as future prospects on logistics', *Computers in industry*, 89, pp. 23–34.

Jiang, Z. *et al.* (2022) 'The evolution of production scheduling from Industry 3.0 through Industry 4.0', *International Journal of Production Research*, 60(11), pp. 3534–3554.

Nick, G. and Pongrácz, F. (2016) 'How to measure industry 4.0 readiness of cities', *Industry 4.0*, 1(2), pp. 136–140.

Nilsson, M. *et al.* (2018) 'Mapping interactions between the sustainable development goals: lessons learned and ways forward', *Sustainability science*, 13(6), pp. 1489–1503.

Rahman, Z. U. and Maniam, V. A. (2022) 'The Relationship between Drivers of Business Ethics and Business Sustainability Mediated by Business Ethics Practices among the Ready-Made Garments Companies in Bangladesh.', *International Journal of Early Childhood*, 14(03), p. 2022.

Schwab, K. and Davis, N. (2018) *Shaping the future of the fourth industrial revolution: A guide to building a better world*. Currency.

Şener, U., Gökalp, E. and Eren, P. E. (2018) 'Towards a maturity model for industry 4.0: A systematic literature review and a model proposal', *Industry*, 4, pp. 291–303.

Shabur, A., Hridoy, M. W. and Rahman, K. A. (2021) 'The investigation of challenges of implementing Industry 4.0 in Bangladesh', *Academia Letters*, 2.

So, J. C. (1987) 'Some empirical evidence on the outliers and the non-normal distribution of financial ratios'.

Sommer, L. (2015) 'Industrial revolution-industry 4.0: Are German manufacturing SMEs the first victims of this revolution?', *Journal of Industrial Engineering and Management*, 8(5), pp. 1512–1532.

Souza, R., Ferenhof, H. and Forcellini, F. (2022) 'Industry 4.0 and Industry 5.0 from the Lean perspective', *International Journal of Management, Knowledge and Learning*, 11.

Wijewardhana, G. E. H. *et al.* (2020) 'New product development process in apparel industry using Industry 4.0 technologies', *International Journal of Productivity and Performance Management*.