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INDUSTRY 4.0: AN EMPIRICAL ANALYSIS OF SUSTAINABLE BUSINESS PERFORMANCE MODEL OF BANGLADESHI ELECTRONIC ORGANISATIONS

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A R T I C L E I N F O.

Keywords:
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Abstract

Industry 4.0 is a German initiative aimed at creating a smart factory that integrates emerging and future technologies such as big data analysis, industrial IoT, additive manufacturing, virtual reality, cloud technology, and industrial robotics to create a cyber physical system (CPS) that interfaces with human equipment arrangements to produce smart manufacturing systems that are cost-effective and environmentally friendly (Alani & Alloghani, 2019). Industry 4.0 was resulted from an initiative by the German government towards an advanced technology strategy for 2020.

Background of the Study

Industry 4.0 is a German initiative aimed at creating a smart factory that integrates emerging and future technologies such as big data analysis, industrial IoT, additive manufacturing, virtual reality, cloud technology, and industrial robotics to create a cyber physical system (CPS) that interfaces with human equipment arrangements to produce smart manufacturing systems that are cost-effective and environmentally friendly (Alani & Alloghani, 2019). Industry 4.0 was resulted from an initiative by the German government towards an advanced technology strategy for 2020.

Changing market conditions and increasing competition drive companies to increase their collaboration along the supply chain(Manufacturing, 2020). Technological innovations enable businesses to increase their integration tremendously. The fourth industrial revolution (Industry 4.0) enables the integration of information technology with industrial technology (Alkhater et al., 2015). The adoption of Sustainable Industry 4.0 includes many complex technologies that come with challenges for many organizations. Previous research suggests that conventional manufacturing might have to be adjusted to Industry 4.0(Hamzeh et al., 2018).

Companies that do not embrace new developing technology risk being surpassed by more successful rivals. Tornatzky & Fleischer (1990) discovered that more than only technology influences technological adoption and that an organization should consider other factors (Winberg & Ahrén, 2018). Tornatzky and Fleischer (1990) developed the Technology-Organisation-Environmental Framework to describe technological adoption in organizations. This framework recognizes that technology adoption must consider the technical context and the organisational and environmental contexts (Winberg & Ahrén, 2018). When a new technology is meant to be utilized by actors inside an organization, the organization's adoption of the technology is insufficient. According to Lanzolla & Suarez (2012), organisations must also ensure that the target users approve the technologies deployed. Otherwise, businesses risk wasting time and money developing technology that may someday be seen as obsolete by their target audiences (Lanzolla & Suarez, 2012). The Technology Adoption Model (TAM model) may describe how people accept technologies to allow technology acceptance. It claims that acceptability is determined by perceived utility and perceived ease of use (Davis, 1989).

The manufacturing sector has seen several technological advancements throughout history, the most significant of which are classified as the four industrial revolutions. Many nations have benefited from technical breakthroughs and industrialization due to these revolutions, which have contributed to today's production systems (Liao, et al., 2017). With the advent of machinery and mechanical manufacturing in the late 18th century, the first industrial revolution began. The second industrial revolution started in the early twentieth century, introducing the assembly line and electrically driven mass manufacturing. The third industrial revolution, which is still going on, began in the 1970s and involves integrating information technology and electronics into manufacturing systems to boost production automation. The internet, digitization, and technology drive the next industrial revolution, Industry 4.0, which will usher in a vastly more intelligent and connected industrial future (Kagermann, et al., 2013). Even though the fourth industrial revolution has not yet been completely implemented, it is predicted to impact current businesses and organisations substantially. Many nations have created strategic projects and committed billions of dollars to help with digitalization and the transition to Sustainable Industry 4.0. This includes countries such as Germany, Japan, the United States, the United Kingdom, Singapore, Sweden, and the European Union (Swedish Government Office, 2017).

Through growing digitization and a better representation of the physical world in the digital systems employed in production, the impending industrial revolution, Sustainable Industry 4.0, may provide an even more sophisticated manufacturing industry. Machines and processes in the value chain may communicate and act autonomously and make optimal and proactive choices, which are some of the features of Industry 4.0. (Kagermann, et al., 2013). Industry 4.0 offers significant cost-cutting and efficiency-improving possibilities for many manufacturing enterprises. According to a poll of 235 European firms, 36% predict Industry 4.0 will enhance efficiency by 11-20% in the next five years, while 37% expect it will improve by more than 20%. According to the same poll, 35 percent of manufacturing organizations anticipate Industry 4.0 to lower costs by 11-20%, with 21% expecting cost reductions of more than 20%. Better management and planning of production processes, enhanced quality, and enhanced flexibility are some of the most promising aspects of Industry 4.0, which enable data analysis, information interchange, and the use of real-time data (Geissbauer, et al., 2014). Industry 4.0 can provide significant benefits in terms of quality, cost savings, flexibility, and product customization (Baheti & Gill, 2011; MacDougall, 2014).

Several factors will influence the success of new technology adoption procedures. Sustainable Industry 4.0 adoption in manufacturing organizations may be thought of as a collection of technologies and ideas rather than a single technology. Furthermore, despite the enormous potential of Industry 4.0, many organizations are not ready to deploy it and are having difficulty determining how Industry 4.0 may add value to their manufacturing processes. As a result, further research is needed to determine which variables production businesses should examine to embrace Industry 4.0 better and how production processes might be enhanced, especially by using Industry 4.0 principles. Furthermore, identifying current production processes may advise on what ideas will be most suited to implement in the existing methods, reducing investment costs and maximizing the use of present production facilities (Winberg & Ahrén, 2018).

Industry 4.0 and Bangladesh

The stream of globalization is urging Bangladesh to adopt the technologies of Industrial 4.0. This study examined the opportunities and problems created by the adoption of FIR in Bangladesh. A recent study found that automation would substitute 800 million unskilled workers worldwide by 2030 (World Economic Forum, 2020). To cope with the technologies of industry 4.0, both developed and developing countries face serious challenges. The developed nations perhaps face less risk than developing nations because of their advanced technologies and skilled human resources.

However, due to a lack of skilled human resources, large-scale investment, modern infrastructure, unstable political culture, and ineffective public policy, developing countries are lagging in the global market. South Asian developing countries such as India, Pakistan, Nepal, and Sri Lanka are also moving towards FIR. They are trying to adopt Industry 4.0 to upgrade their local industries (Adhikari, 2020; Rashid, 2020). Gradually Bangladesh is emerging as one of the fastest-growing economic power in South Asia, with notable progress in many fields.

If Bangladesh can sustain this development rate, it is expected that Bangladesh will leave the Least Developed Country (LDC) category by 2024 (Kim, 2018). Innovations of FIR can be a vital force that can help Bangladesh to achieve its goal. But the journey towards institutionalization of FIR is a humongous task for the government. The government needs to take appropriate policies to cope with the technological advancement of the FIR. Otherwise, the FIR will be a curse instead of a blessing for us.

Therefore, this study identifies and analyzes the factors of Sustainable Industry 4.0 adoption for electronics manufacturers and examines how processes in manufacturing need to be adjusted to implement Industry 4.0 in Bangladesh successfully. This thesis aims to contribute to successful Sustainable Industry 4.0 adoption in the manufacturing process and, therefore, contribute to developing effective technological advancement in Bangladeshi electronic companies.

Problem Statement

The key explanations for the flaws in the industry 4.0 implementation regions are the high capital investment levels and the unknown economic rewards. Further, there is a lack of acceptable knowledge and skills in the employees required to cope with emerging technologies and automation. Here is an absence of clarity in the guidelines for implementing industry 4.0, which has made ambiguity in many organizations (Rawat & Purohit, 2020).Wu, et al. (2016) suggest further research to focus on the challenges that prevent competent supply chain partners from collaborating. The study refers to Fitzgerald (2013, cited in Wu, et al., 2016, p. 411) who stated that industrial internet in its current state is rather an intranet where data is not shared among supply chain partners. As mentioned by Bagchi and Sk joett-Larsen (2003), information integration allows management to examine the organization's operation in totality, enabling the individual members of the chain to act more like a single entity. Zhou, Liu, and Zhou (2015) defined Industry 4.0 as integrating information and communications technologies with industrial technology. Therefore, it can be stated that it is crucial for new manufacturing companies to successfully implement the concept of Industry 4.0 to maintain their competitive advantage. Studies have pointed out the challenges of implementing Industry 4.0. Lee, Zhang and Ng (2017) stated three main challenges of Smart Factory adoption. Firstly, high quantities and types of IoT devices. Secondly, the large extent of data exchange and thirdly, establishment and maintenance of reliable cloud platforms. There seems to be a broad consensus that security and privacy issues are a significant challenge for IoT adoption (Bi, Xu and Wang, 2014; Agrawal and Lal Das, 2011, cited in Ben-Daya, Hassini and Bahrain, 2017, p. 9; Haddud, et al., 2017; Lee and Lee, 2015). Another issue pointed out is the lack of compatibility between different IoT systems, which can weaken their use for decision-making (Bowman et al., 2009, cited in Ben-Daya, Hassini and Bahroun, 2017, p. 11). Another study stated that high adoption costs could be seen as the main internal challenge, while lack of skilled workers was seen as the primary external challenge to the adoption of Industry 4.0 (Tortorella and Fettermann, 2017).Previous studies have pointed out challenges to the adaption from technological,organizational, resource, and financial perspectives, mainly on a conceptual level. However, previous studies have not investigated challenges to Sustainable Industry 4.0 adoption in the manufacturing process, as has been pointed out earlier. The problem is accordingly that it remains unclear how fundamental processes need to be adjusted. Consequently, organizations are not prepared to implement the concept of Industry 4.0 due to the lack of research in that field. It is, therefore, necessary to research how manufacturing processes need to be adjusted to adopt Industry 4.0. Pereira and Romero (2017) stated it is important for companies to be aware of the main implications of Sustainable Industry 4.0 adoption. Furthermore, the authors have pointed out that the fourth industrial revolution is being predicted in contrast to previous industrial revolutions. It allows companies to take actions to be prepared for this transformation. This research aims to investigate the relationships between industry 4.0 adoption factors and Sustainable Business Performance of Bangladeshi electronic companies.

To date, some papers have been published, above all in management literature, studying the main changes in business management models and firms' main components. The academic discussion on Industry 4.0, the analysis of its content and its detailed description, and the explanation of its possible future developments deserve more attention. Therefore, the topic of Industry 4.0 is still under-studied, although research in this domain has rapidly developed, above all in the last three years. This research will add significant knowledge for the industry and the academic people. One of the paramount significances of this study is its implication to the manufacturing industry in Bangladesh.

Literature Review

The concept of Industrial 4.0

The concept of Industry 4.0 emerged in Germany in 2011, to refer to a government economic policy based on high-tech strategies (Burmeister, Luettgens, and Piller,2015); characterized by automation, digitization of processes, and the use of electronic and information technologies in manufacturing (Lee, Bagheri & Kao, 2015). Likewise, for the personalization of production, the provision of services and the creation of value-added businesses. And, due to the interaction and information exchange capacities between humans and machines (Lee, Bagheri & Kao, 2015). Throughout history, technological development has had a major impact on manufacturing systems, first with the steam engine and the mechanization of processes, then with mass production, automation, and robotics; and more recently, with what has been called "industry 4.0" and is already considered the "Fourth Industrial Revolution," due to its potential and benefits related to integration, innovation, and process autonomy.

Industry 4.0 and smart manufacturing concepts are relatively new and contemplate the introduction of digital technologies in the manufacturing industry. That is, the incorporation into the manufacturing environment of technologies such as the Internet of Things, mobile computing, the cloud, big data, wireless sensor networks, embedded systems and mobile devices, among others (Kolberg & Zühlke, 2015; Lasi, Fettke, Kemper, Feld and Hoffmann, 2014). Some of these technologies have already been used for years, but in isolation; however, its integration a possible capabilities is what the empowers to transform the manufacturing industry, with fully integrated, automated and optimized production processes; and with significant results in improving operational efficiency and organizational performance (Lee, Bagheri & Kao, 2015). The impact of this technological transformation is that it affects all aspects of the organization, from production and organization to research and development, inventory control, management, and customer support, etc. (Fettke, Kemper, Feld and Feld, and Hoffmann, 2014). Likewise, the business vision and performance is changing. Its impact has been such that industry 4.0 is already considered as a systemic innovation process that redefines business models and provides a fully integrated global perspective of the environment and organization (Lasi, Fettke, Kemper, Feld and Hoffmann, 2014).

Industry 4.0 Adoption in Bangladesh

Bangladesh, a country of the Asia-Pacific region, is one of the fastest-growing economies, and its GDP is hovering around 6% to 8% during the last two decades. Bangladesh's export earnings are growing at a substantial rate, around 10% percent, with some fluctuations which are projected to be the twenty-eighth biggest economy in the world by 2030 (Bhattacharya et al., 2002; Griffin & Robinson, 2016; Humphrey, 2019).

The concept of Industry 4.0 has gained enormous popularity and importance since the Bangladeshi government first introduced it at the Dhaka International Fair in November 2011. During the last few decades of the 20thcentury, Industry 3.0 was a massive leap forwardthe advent of computer systems and automation ruled the industrial scene. However, in Bangladesh, the opportunities are not entirely grabbed by the industries because of amply available labor and access to limited software (Sarkar, 2020). Many Bangladeshi organizers were still stuck in industry 2.5, with their paper-based processes and heavy human dependency. Bangladesh is now all geared up to hurl directly into the next revolution i.e. industry 4.0, where machines will be equipped with the ability to communicate (Islam et al, 2019).

In recent decades using the core technology in a narrow range of the industry 4.0, digital pieces of machinery, big data, IoT Devices i.e.(Soil Moisture, Solar Irradiation, Air temperature & moisture, Leaf Wetness), Data Model i.e. Irrigation data model, Crop Management and Soil properties), AI in farm machinery, seeding the soil, farm management, production forecasting, data, and Software module such as Mobile App and irrigation are created a new era of prospect for food security of 170 millions of people in Bangladesh (Rezvi, 2018; Salim & Rahman, 2018). For Readymade Garments (RMG) and Textile, Furniture, Agro-processing, Leather and Footwear, Tourism and Hospitality sectors of Bangladesh, the Fourth Industrial Revolution is graceful to release extensive industrial automation and to disrupt nearly every industry i.e., Readymade Garments (RMG) and Textile industries contribute significantly in GDP by 14.07%, in export income by about 82% and employ 4 million workforces. To cope with the productivity, growth, and competition, the manufacturing sector in Bangladesh is adapting automation technologies gradually despite having huge threats of losing low wages, jobs, and workers.

Furthermore, about 90 percent of total industrial units comprise SMEs that are still lagging in the adoption of revolutionary technology and mostly using first, second, and third industrial revolution technologies. Despite having a considerable prospect of adoption of industry 4.0 in Bangladesh, it has many challenges, i.e. lack of awareness, labor skills, factory infrastructure, lack of enough investment, technology applications in production, etc. (Jabbour et al., 2017; Sarkar et al., 2017). As a developing nation, the country has been criticized for its lack of production, labor skills, factory infrastructure, technology applications, and low-level adjustments based on industry development and availability (Jabbour et al., 2017; Sarkar et al., 2017). Lack of awareness and knowledge of Industry 4.0, poor infrastructure, a lack of government support, the availability of cheap labor and human dependency in manufacturing, expensive technological installations, as well as health and safety issues, are all significant barriers for many countries (Ahmad, 1990; Humphrey, 2019; Jabbour et al., 2017; Moktadir et al., 2018; Sarkar et al., 2017).

However, to accelerate economic development and reap the full benefits of Industry 4.0, public and private organisations are taking immediate policy and investment support, infrastructural support, education and training, and upgrading and upskilling measures, among other things, to ensure that Industry 4.0 can be adopted and implemented in the manufacturing and service industries (M. A. Islam et al., 2018). Industry 4.0 mechanisms provide huge prospects for industrial units with significant investments to not only speed up production but also stimulate economic development (Moktadir et al., 2018; Siddik et al., 2017).

As the fourth Industrial Revolution's disruptive technologies continue changing every sphere of our life, i.e. production, economy, business, governments and countries, society and cultural interactions in the world around us, so new challenges arise. As an emerging developing nation, Bangladesh is adopting revolutionary technologies gradually in every sector for socioeconomic development despite having lots of challenges such as lack of awareness, insufficient funding, and availability of cheaper labor, lack of digital infrastructure, skill laggings, and socioeconomic challenges. But in recent years, public and private authorities taking endeavors in the development of infrastructure and human, technical, and financial capacity to upgrade the education and training systems to reap the benefits from 4IR. Thus, the study reviews the practical results of identifying the challenges and opportunities and prescribed strategic solutions presented by the Industry 4.0 revolution, especially in Bangladesh.

Technological Factors

The fourth industrial revolution is marked by the convergence of digitalization and automation, which allows machines to become more intelligent, interactive, and user-friendly. These new technologies will have a significant influence on how people work. New sorts of robots will be able to interact with people. When paired with other coming technologies, this technology will create wholly new computer models that will complement human activities, particularly cognition. As a result, the following issues must be addressed in order to bridge the gap between engineering and computer science: privacy concerns, surveillance, and distrust, general reluctance to change among stakeholders, the threat of redundancy, and the loss of many jobs to automated and it-controlled processes, and so on. There are also issues with a lack of regulation, standards, and forms of certification, legal issues, and data security, as well as the need to address all relevant changes, innovations, transformations, and new dimensions, and the necessary rules and acts will be produced to ensure that the fourth industrial revolution is implemented effectively in Bangladesh.

In the core of the Industry 4.0 concept, Smart Manufacturing technologies work as the central pillar of the internal operations activities (Ahuett-Garza and Kurfess, 2018), while Smart Product consider the external value-added of the products, when customer information and data are integrated with the production system (Dalenogare et al., 2018). These two dimensions consider technologies that have direct impact on manufactured products. Smart Manufacturing considers technologies for the product processing (production system), while Smart Products considers technologies related to the product offering. Therefore, it is assumed that Smart Manufacturing is the beginning and first purpose of Industry 4.0, while Smart Product is its extension. This vision follows the chronological recent evolution of the Industry 4.0 concept, which has its roots in the advanced manufacturing systems and its connections with other company processes (Yin et al., 2018; Dalenogare et al., 2018). Therefore, advanced manufacturing is expected to be able to give organizations a better competitive advantage. So, based on this literature review, the following hypothesis has been formulated:

Hypothesis H1: Technological factors have a significant and positive relationship with Sustainable Business Performance

Organizational Factors

To achieve Industry 4.0 alignment, companies must manage various internal and external aspects to increase company value and establish a long-term competitive advantage (Nagy et al., 2018). Horizontal, vertical, and digital integration and areas of standardisation that allow organisations to readily link with one another are all important elements (Gutierrez et al., 2015). Organizations will have to manage multiple complexities, including complex systems, as new models and methods must be developed and applied (Balasingham, 2016) ; comprehensive infrastructure, including a high-quality information network and internet connectivity; security and privacy, enforcing data protection (Rao et al., 2020) ; work organisation and design, as employee roles change (Yu & Schweisfurth, 2020); and new and relevant lean methodologies. Managing teams of highly specialised technical specialists and personnel educated to work in the new technology revolution, with unique profiles that are now nonexistent, is required for organisational success in this new period(Chien-Min & Peter, 1984; Yu & Schweisfurth, 2020; Zeb-Obipi et al., 2019). The factors that affect the performance of the Industry 4.0 can be divided into two categories: organisational and human factors, which are discussed in this section. The organisational factors refer to what the organisation must do to properly control the managerial variables that affect Industry 4.0 adoption (Shayan, Pyung Kim, & Tam, 2019). To ensure Sustainable Industry 4.0 Adoption, the human factors also include those that the manager and his team should effectively monitor. Among the above-mentioned organisational factors are Top Management support, Organisational Structure, Organisational Culture, and Strategy. So, it can be hypothesised that:

Hypothesis H2: Organizational factors have a significant and positive relationship with Sustainable Business Performance

Environmental Factors

The sustainability of Industry 4.0 is an important topic and has been largely addressed in the previous literature. Although the previous literature represents different views on this relationship, there is no clear consensus that Industry 4.0 has a long-term impact on environmental sustainability (Pretorius, 2014). Therefore, this paper focuses on environmental sustainability, and we will address studies that focus on dimensions that are particularly related to this. Other studies argue that start-ups and new companies included their strategies and vision on integrating Industry 4.0 and production with environmental sustainability. Studies by Ford and Despeisse(2018) and Jelonek and Urbaniec (2016) showed the benefits of adopting technology in manufacturing (such as 3D printing) for environmental sustainability but also revealed the presence of several challenges because the technology is still at an immature stage.

On the other hand, Stock and Seliger (2018) have argued that industrial value should be sustainability-oriented and Industry 4.0 provides tremendous opportunities to achieve this sustainability. In another study, the authors surveyed some German and Chinese companies to study the expected impacts of Industry 4.0 on environmental sustainability, with the environmental dimension linked through several factors: energy eciency and resources. According to Burritt and Christ (2016), environmental sustainability is positively impacted by Industry 4.0 through comprehensive digitization that provides more accurate, high-quality management and real-time event management for the external environment. In another study by Müller and Hopf (2017), the authors propose a model based on the triple bottom line (TBL), which is a model that includes the challenges and opportunities associated with the application of Industry 4.0; the authors conclude that there is a significant and positive relationship between the application of Industry 4.0 and its environmental benefits so that companies tend to adopt this technology more given its benefits and regardless of the company size and industry sector. In other studies, Tim et al. (2017) and Müller and Hopf (2015) have proposed a roadmap aimed to promote the optimal and sustainable use of natural resources by promoting circular economy principles in organizations in an Industry 4.0 approach to the recycling of waste, which is positive for the environment..Therefore, it can be hypothesized that

Hypothesis H3: Environmental factors have a significant and positive relationship with Sustainable Business Performance

Market Transparency

Market transparency refers to the availability of information and solutions to implement the technologies. It is reflected in governmental efforts to promote knowledge, establish public partnerships, and establish measures to compare technologies solutions of different provides. With various isolated solution providers, a highly fragmented market, with everyone having its standard, implies an immature industry. Thus, market transparency is a proxy for technological maturity. Manufacturing companies are more likely to adopt mature Industry 4.0 technologies than immature ones. The study by Wischmann et al. (2019) also highlights that a lack of user transparency, technological standards, and availability of solutions are severe obstacles for small and medium-sized enterprises. Based on this argument, the following indicators are proposed: a Information about products and services on self-adaptive technologies and digitalized processes are widely available; b. The market for self-adaptive technologies and digitalized processes is transparent concerning product and service features; c. The market for self-adaptive technologies and digitalized processes is transparent concerning product and service costs.Therefore, it can be hypothesized that:

Hypothesis H4: Specific Technological Factors have a significant and positive relationship with Sustainable Business Performance

Management Efficiency as Mediator

Previous research has shown that management efficiency can indeed affect industry 4.0 adoption (Sukarno & Syaichu, 2006; Alexiou & Sofoklis, 2009; Dietrich & Wanzenried, 2009; Sufian & Habibullah, 2009; Sudiyatno & Suroso, 2010; Purwoko & Sudiyatno; 2013; Prasanjaya & Ramantha, 2013; Margaretha & Zai, 2013; Dewi et al., 2016), but this is different from the findings of Widati, (2012); Sabir et al., (2013); Tan, (2013); Fajar et al., (2013) that management efficiency does not affect Sustainable Industry 4.0 Adoption. Differences in empirical research results on the effect of efficiency on industry 4.0 can be perceived as the difference due to the diversity of indicators in the measurement, the object under study, and the basic theory used. The inconsistencies of previous research findings provide an opportunity to re-examine the relationship between management efficiency and factors of industry 4.0 adotion. Based on research objectives and study on the conceptual framework of research, hence formulated hypothesis as follows:

Hypothesis H5: Management Efficiency significantly mediates the relationship between Industry 4.0 Adoption Factors and Sustainable Business Performance

Theory of Diffusion of Innovations

Rogers (2003) introduced the model of diffusion of innovations in 1962 that has been expanded and modified somewhat over the past four decades due to further research and theoretical development. The framework was developed out of several studies in this area. Rogers (2003) defines diffusion as follows: “Diffusion is the process in which an innovation is communicated through certain channels over time among the members of a social system”. Based upon this definition, Rogers (2003) defined four elements of the diffusion process: innovation, communication channels, time and a social system.

Innovation refers to an idea or practice that is perceived as new by the adoption unit. The perceived newness of the innovation by the individual is central, since it determines the individual's reaction to it. Rogers (2003) explains the different rates of innovation adoption by perceived attributes of innovations: “Relative advantage is the degree to which an innovation is perceived as better than the idea it supersedes”; “Compatibility is the degree to which an innovation is perceived as being consistent with the existing values, past experiences, and needs of potential adopters”; “Complexity is the degree to which an innovation is perceived as difficult to understand and use”; “Trialability is the degree to which an innovation may be experimented with on a limited basis”, and “Observability is the degree to which the results of an innovation are visible to others”. From the above literature review, the following conceptual framework has been developed”

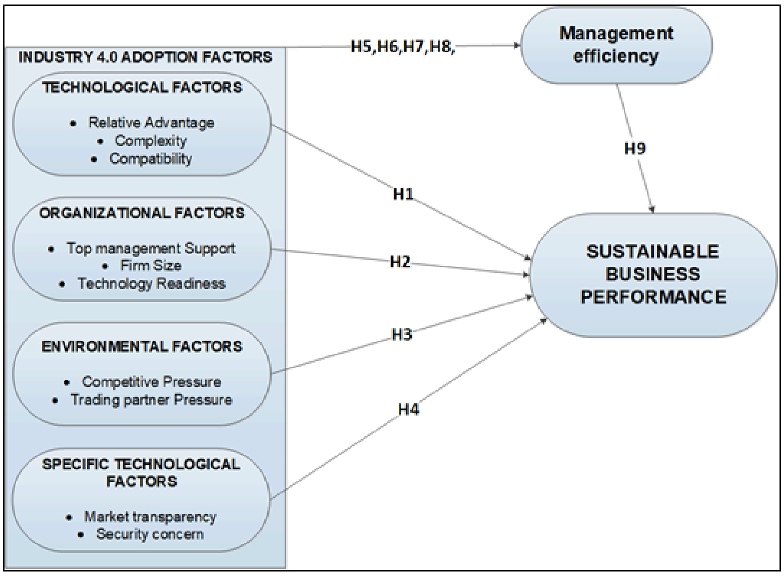

Figure 1: Research Model

Research Method

Since this study is to determine the influence of independent variables on dependent variable with mediating effect presence. Quantitative approach is best to be adopted. In fact, selecting quantitative research as research design will pave the way towards accomplishing research objectives. This is because quantitative approach is the most suitable method to test this empirical hypothesis and to generalize for a population. For this study, employees of three major electronic companies are selected as a population those who are the executive and employee in these companies.It is the most suitable design to meet all research objectives especially when the study wants to determine the degree of meaningful work as mediator. All the items are adopted from Masubelele (2019), Collins, A., & Baccarini, D. (2004) and Lo, A. Y., Xu, B., Chan, F., & Su, R. (2016). adapted According to the Bangladeshi manufacturing industry settings, the items are adapted from the main sources. The version of the survey will prepare in both English and Bangla language.

Table 1: Reliability of the Items

Factors and Descriptions	Cronbach's Alpha (Pilot Study)	Survey Items
Factor 1: Technological Factors	**.905**	**13 Items**
Relative Advantage	0.871	RA01-05
Complexity	0.917	COM01-04
Compatibility	0.927	CP01-04
Factor 2: Organisational Factors	**.891**	**11 Items**
Top Management Support	0.911	TMS01-04
Organisational Structure	0.906	OS01-03
Technological Improvement	0.857	TI01-04
Factor 3: Environmental Factors	**.900**	**14 Items**
Competitive Pressure	0.918	CP01-05
Trading Partner Pressure	0.925	TPP01-05
Industry Clusters	0.892	IC01-04
Factor 4: Specific Technological factor	**.935**	**13 Items**
Market Transparency	0.925	MT01-04
Security Concerns	0.945	SC01-04
Factor 5: Management Efficiency	**.925**	**05 Items**

		ME01-05
Factor 6: Economic Resilience	**.959**	**05 Items ER01- ER05**
Factor 7: Sustainable Business Performance	**.954**	**3 Items SBP01-03**
Overall	**.950**	**63 items**

Table 2: Formative Measurement Model Assessment

Formative Constructs	Item	Beta	SD	T value	P value
Environmental Factor	IC	0.890	0.019	47.279	0.000
	TPP	0.949	0.017	56.915	0.000
	CMP	0.644	0.047	13.742	0.000
Technological Factors	COM	0.884	0.022	40.411	0.000
	CP	0.844	0.030	27.761	0.000
	RA	0.758	0.043	17.687	0.000
Specific Technological Factor	MT	0.692	0.037	18.604	0.000
	TI	0.799	0.032	25.172	0.000
	SC	0.967	0.013	74.323	0.000
Organisational Factors	TMS	0.889	0.024	36.967	0.000
	TI	0.833	0.035	24.049	0.000
	OS	0.935	0.019	49.061	0.000

Table 1 and Table 2 shows the indicator loadings, composite reliability (CR) and Average Variance Extracted (AVE), Cronbach's Alpha of the reflective construct in this study. Hair et al, (2016) suggested loading values that equal to or greater than 0.708 will be retained. It indicated a latent variable was able to explain at least 50% of the indicator's variance. All items for Compensation, Recruitment, Training, Employee Participation, Performance Appraisal, Job Security, Information Technology Capability, and Organizational Performance were retained as all the loadings are greater than 0.708. The CR was above the minimum threshold of 0.7 and the AVE was greater than 0.50. Thus, the constructs met the reliability and convergent validity requirement.

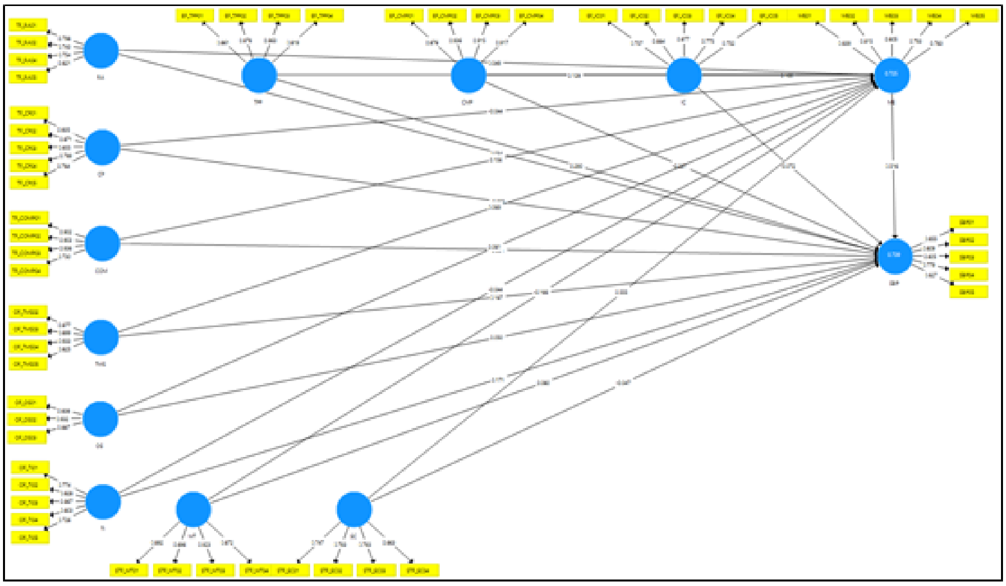

Figure 1: Measurement Model (two steps approach)

Table 3: Fornell-Larcker criterion

	CMP	COM	CP	IC	ME	MT	OS	RA	SBP	SC	TI	TMS	TPP
CMP	**0.911**												
COM	0.355	**0.871**											
CP	0.474	0.552	**0.824**										
IC	0.496	0.518	0.587	**0.811**									
ME	0.555	0.604	0.586	0.696	**0.807**								
MT	0.482	0.432	0.364	0.517	0.519	**0.896**							
OS	0.612	0.618	0.657	0.656	0.647	0.475	**0.887**						
RA	0.319	0.461	0.681	0.494	0.508	0.325	0.518	**0.780**					
SBP	0.410	0.585	0.548	0.638	0.780	0.497	0.664	0.509	**0.816**				
SC	0.527	0.520	0.571	0.692	0.775	0.723	0.551	0.481	0.636	**0.800**			
TI	0.711	0.407	0.620	0.613	0.595	0.521	0.672	0.486	0.580	0.631	**0.801**		
TMS	0.565	0.554	0.648	0.565	0.591	0.415	0.748	0.473	0.657	0.495	0.655	**0.884**	
TPP	0.462	0.581	0.565	0.766	0.683	0.493	0.728	0.530	0.740	0.610	0.543	0.653	**0.856**

Note: Complexity=CMP; COM=Compatibility; CP=Competitive Pressure; IC=Industry Clusters;ME= Management Efficiency; MT= Market Transparency; OS=Organisational Structure; RA= Relative Advantage; SBP=Sustainable Business Performance; SC= Security Concerns; TI=Technological Improvement; TMS= Top Management Support; TPP=Trading Partner Pressure;

Table 3 shows the results of discriminant validity by Fornell-Larcker criterion, the bolded values represent the square root of the AVEs on the diagonals which were higher than the correlations between constructs (corresponding row and column values). This shows that compared to other constructs of the model, the constructs are strongly related to their respective indicators (Fornell & Larcker, 1981; Chin, 1998), therefore suggesting a good discriminant validity (Hair, et al., 2017). Furthermore, the correlation between exogenous constructs is less than 0.85 (Awang, 2014). All AVEs have met all the conditions mentioned above.

The Fornell-Larcker criterion has been criticized recently, Henseler, Ringle, & Sarstedt, (2015) mentioned that it does not reveal the lack of discriminant validity in common research situations correctly. An alternative method has been proposed which is Heterotrait-Monotrait Ratio (HTMT) of correlations based on the Multitrait-Multimethod Matrix. Through HTMT, this study evaluates discriminant validity. When the HTMT value is greater than HTMT0.90 value of 0.90, the discriminant validity has a problem (Ho, 2006), or HTMT0.85 value of 0.85 (Kline, 2011).

Table 4: HTMT

	CMP	**COM**	**CP**	**IC**	**ME**	**MT**	**OS**	**RA**	**SBP**	**SC**	**TI**	**TMS**	**TPP**
CMP													
COM	0.390												
CP	0.526	0.618											
IC	0.546	0.584	0.665										
ME	0.613	0.687	0.657	0.801									
MT	0.524	0.481	0.399	0.584	0.579								
OS	0.687	0.702	0.748	0.756	0.743	0.533							
RA	0.369	0.534	0.776	0.589	0.599	0.374	0.612						
SBP	0.443	0.656	0.608	0.726	0.826	0.546	0.750	0.604					
SC	0.611	0.609	0.650	0.828	0.814	0.812	0.651	0.569	0.734				
TI	0.811	0.461	0.707	0.697	0.672	0.581	0.780	0.568	0.649	0.738			
TMS	0.616	0.616	0.719	0.628	0.657	0.450	0.845	0.548	0.723	0.565	0.741		
TPP	0.510	0.651	0.638	0.877	0.777	0.547	0.833	0.637	0.835	0.722	0.617	0.723	

Note: Complexity=CMP; COM=Compatibility; CP=Competitive Pressure; IC=Industry Clusters;ME= Management Efficiency; MT= Market Transparency; OS=Organisational Structure; RA= Relative Advantage; SBP=Sustainable Business Performance; SC= Security Concerns; TI=Technological Improvement; TMS= Top Management Support; TPP=Trading Partner Pressure;

In addition, Table 4clearly showed that the problem of discriminant validity between reflective constructs according to the ratios of HTMT does not exist. As can be seen, the highest inter construct ratio of HTMT is 0.414 (between the construct of EMP and COM). This ratio is lower than the cutoff 0.85, showing the discriminant validity for reflective constructs. In summary, the results of measurement model evaluation have shown that the model has attained the proposed satisfactory levels of constructs reliability and validity, which authorizes the researcher to move to the next stage and assess the structural model.

Direct Hypotheses Testing

Path coefficient was assessed to evaluate the significance of hypothesis tested between the constructs. Based on the model, there were 6 direct relationship results. T-statistic for all paths was generated using SmartPLS bootstrapping in order to test the level of significance. Running t-statistic on sample size 384 respondents and the direct hypotheses should have brought a result of >1.645, and indicated significant value at 0.05 level. From the Table 4.20 the assessment of the path coefficient, 09 relationships were found to have t-value > 1.645, thus at significant value of 0.05 level. Six hypothesis has been accepted, H1; H8; H9 are not supported (See Table 5)

Table 5: Structural Path Analysis Results

Hypo	Relation	Std. Beta	Std. Error	t-value	p values	Decision
H1	TF -> SBP	0.072	0.050	1.430	0.153	Not Supported
H2	OF -> SBP	0.211	0.062	3.386	0.001	**Supported*** **
H3	EF -> SBP	0.203	0.078	2.587	0.010	**Supported*** **
H4	STF -> SBP	-0.067	0.058	1.163	0.245	Not Supported
H5	ME -> SBP	0.486	0.087	5.614	0.000	**Supported*** **

Note: *Significance level = <0.05***;*

Mediation Assessment

Mediation significance test is conducted by bootstrapping approach because bootstrapping can be applied to small sample with confidence. Moreover, it has no sample and variable shape distribution assumption and test significance with confidence interval. This approach thus, is suited perfectly for PLS-SEM and in addition, it generates higher statistical power than Sobel test (Hair et al., 2017). Out of four mediationg relationships, Hypotheis 6 is not supported.

Table 6: Mediation Analysis Result

Hypo	Relationship	Beta	STDEV	T value	P Values	Decision
H5	TF -> ME-> SBP	0.094	0.032	2.997	0.003	**Supported**
H6	OF -> ME -> SBP	-0.022	0.028	0.928	0.354	Not Supported
H7	EF -> ME-> SBP	0.152	0.041	3.716	0.000	**Supported**
H8	STF->ME -> SBP	0.224	0.054	4.176	0.000	**Supported**

*Note: Significance level = <0.05***;*

Hypo	Direct Relationships	Decision
H1	Technological factors have a significant and positive relationship with Sustainable Business Performance.	Not Accepted
H2	Organizational factors have a significant and positive relationship with Sustainable Business Performance.	**Accepted**
H3	Environmental factors have a significant and positive relationship with Sustainable Business Performance.	**Accepted**
H4	Specific Technological Factors have a significant and positive relationship with Sustainable Business Performance.	Not Accepted

H5	Management Efficiency significantly influences Sustainable Business Performance.	**Accepted**
	Mediating Relationships	
H6	Management Efficiency significantly mediates the relationship between Technological Factors and Sustainable Business Performance.	**Accepted**
H7	Management Efficiency significantly mediates the relationship between Organizational factors and Sustainable Business Performance.	Not Accepted
H8	Management Efficiency significantly mediates the relationship between Environmental factors and Sustainable Business Performance.	**Accepted**
H9	Management Efficiency significantly mediates the relationship between Specific Technological Factors and Sustainable Business Performance.	**Accepted**

Discussion

The first and second objectives of this study are to identify and determine Factors influencing Sustainable Business Performance of Bangladeshi electronic companies in Bangladesh. To address these objectives, descriptive analysis and factor analysis were employed. In addition, a systematic literature review suggested that among several factors, Technological, Organizational, Environmental and Specific Technological were the most significant variables for Sustainable Business Performance. Analyzing the representative sample of Piedmont's local manufacturing units reveals a causal relationship between their openness to Industry 4.0 and performance. Further, the descriptive analysis' results make it possible to verify how Industry 4.0 is an emerging phenomenon in Bangladesh.

Extant literature in new technology adoption has shown that many manufacturing firms consider adopting new manufacturing technologies because of their benefits and opportunities (e.g. Kharuddin et al., 2015). Benefits of implementing I4.0, such as productivity and efficiency, are the important driving factors to implement I4.0 (Horvath and Szavo, 2019). Besides operational benefits, market and business opportunities are also regarded as why manufacturing firms consider adopting I4.0 (e.g. M€uller et al., 2018). Although promising advantages compel the firms to adopt I4.0, many firms face challenges in embracing Industry 4.0 (Rajput and Singh, 2019). Stentoft et al. (2021) found that Industry 4.0 is a nascent research area where extant academic literature lacks adequate drivers and barriers for I4.0. Several studies have shown that possible challenges and barriers could hamper firms' interest to initiate the digital transformation (e.g. Moktadir et al., 2018; Masood and Sonntag, 2020). Likewise, Stentoft et al. (2021) demonstrated that perceived barriers could directly lead to decisions not to invest in the new technologies.

Moreover, Of all the local manufacturing units surveyed, 15% have pursued adoption, measured in terms of the application of at least one pillar of 4.0-enabling technologies. The Bangladeshi local manufacturing units' adoption of Industry 4.0 still highlights a significant gap with Germany's national average, or a 25% adoption rate (BCG, 2018). This gap could be partially attributed to a delay in the nations' implementation of an Industry 4.0 national plan, compared to 2016 in Germany (Kagermann et al., 2019). Nevertheless, Piedmont is an important case study because the Italian region is ranked first in adopting Industry 4.0 as well as in its long tradition in the manufacturing sector. The data on the degree of openness to Industry 4.0 also confirms what was highlighted in a 'conceptual study (Sauter et al., 2016): a strong differentiation depending on the individual economic sector and the size of the manufacturing company. Moreover, local units in high-tech sectors – such as the chemical, petroleum, and plastic materials; metals; electronics; mechanical; and transportation industries – exhibited a higher degree of openness in terms of both breadth and depth. The confirmatory analysis, conducted through different regression models, verifies a positive relationship between the openness to enabling Industry 4.0 technologies and performance. This empirically confirms what was stated in Vogel-Heuser and Hess' (2016) work.

The third objective of this study to investigate the relationships between Industry 4.0 Adoption Factors and Sustainable Business Performance of Bangladeshi electronic companies. To address this objective, four hypotheses have been formulated. Hypothesis H1: Technological factors have a significant and positive relationship with Sustainable Business Performance; Hypothesis H2: Organizational factors have a significant and positive relationship with Sustainable Business Performance; Hypothesis H3: Environmental factors have a significant and positive relationship with Sustainable Business Performance; Hypothesis H4: Specific Technological Factors have a significant and positive relationship with Sustainable Business Performance.

The fourth objective of this study is to examine the mediating role of Management Efficiency in the relationship of Industry 4.0 Adoption Factors and Sustainable Business Performance of Bangladeshi electronic companies. The finding suggested that Management Efficiency significantly mediates the relationship between Technological Factors, Environmental factors Specific Technological Factors and Sustainable Business Performance. This study's findings are consistent with some of the findings described in the literature (Aldosari et al., 2021, Edwards et al., 2015). These findings fall well within popular change and organizational transition concepts and models such as “Bridge’s model of transition” (Bridges, 2003). Such models can explain the process organizations, as well as individuals, go through when transitioning into something new and unfamiliar. What they have in common is the description of transition being a multiphase process that will potentially experience a decrease in performance and well-being.

Tortorella et al. (2020) identified that emerging technologies lead to an improvement in the quality of the products and customer service level satisfaction, thereby increasing the overall efficiency of the organization. However, to achieve these benefits, organizations are required to create an environment of learning and knowledge sharing. The present study statistically validated ten performance dimensions. These measures can be used by the practitioners to evaluate their organization and build a performance-oriented manufacturing system.

Implications and Recommendations

The main objective of the present research work is to investigate the recent scientific literature and represents only a first step towards framing the new role of the smart operator. The main results showed that new technologies have an impact and involve numerous corporate stakeholders, both at a strategic, managerial, and operational level bringing numerous advantages and benefits while still presenting some limits and challenges to overcome. In addition, the textile and RMG industries of Bangladesh could occupy this huge market with Industry 4.0 and its advantages. Industry 4.0 could increase Bangladesh’s competitiveness with digitization and globalization. The technology can give the buyer a transparent view about the quality of the product. Furthermore, Industry 4.0 can reduce costs by eliminating hidden costs, waste and damage. The complexity of the industry 4.0 can create indexing technologies with cyber physical systems and sub-nanotechnology. Industry 4.0 has emerged with technology (augmented reality, cyber, loT, Big Data Analytics, etc.). Supporting a new revolution will require a multi-disciplinary role and responsibility. The manufacturing sector is more vulnerable to attacks with interconnection through cyber-physical systems. More white hackers are needed to develop a full-proof security system as attackers continue to search for loopholes. Combining old and new systems, techniques, equipment, protocols with complex protocols will be complicated. The integration of traditional IT infrastructure with the new IoT system integration requires extensive restructuring and retraining of the workforce. Digitization of manufacturing technology will require new incentives. Manufacturers need government policy support on loans and taxation.

This study offers a broader perspective of important factors influencing the decision-making for Industry 4.0 adoption. The first implication of our findings on driving factors is that firms need to be aware and convinced of various benefits and opportunities associated with Industry 4.0 and possible expectations of customers and competitors’ threats as these could drive them toward Industry 4.0

adoption. Therefore, authorities should organize more awareness programs discussing the benefits and opportunities of Industry 4.0 including improvement in the product image and higher technology standards, in parallel with increased funding opportunities. The firms will be more compelled to adopt Industry 4.0 if they are convinced by the advantages of Industry 4.0 and realize the importance of meeting customers need for digitally produced products. Moreover, the new finding of meeting customer requirements and improving quality image by upgrading their technologies sheds light on the importance of paying attention to changing needs of customers and improving the company image by adopting Industry 4.0 as some customers are more impressed by the image of a company that operates using Industry 4.0 technologies.

REFERENCES

1. Abatecola, G., Mandarelli, G., & Poggesi, S. (2013). The personality factor: How top management teams make decisions. A literature review. *Journal of Management and Governance*, *17*(4), 1073–1100. https://doi.org/10.1007/s10997-011-9189-y
2. Abdulrahman, H. (2019). *Industry 4.0 implementation strategy for Small Medium Enterprises Industry 4.0*. 1–85. https://scholar.uwindsor.ca/etd/8155
3. Accorsi, R., Bortolini, M., Baruffaldi, G., Pilati, F., & Ferrari, E. (2017). Internet-of-things Paradigm in Food Supply Chains Control and Management. *Procedia Manufacturing*, *11*(June), 889–895. https://doi.org/10.1016/j.promfg.2017.07.192
4. Adcroft, A., & Mason, R. B. (2007). The external environment's effect on management and strategy: A complexity theory approach. *Management Decision*, *45*(1), 10–28. https://doi.org/10.1108/00251740710718935
5. Agarwal, H., & Agarwal, R. (2017). First Industrial Revolution and Second Industrial Revolution: Technological Differences and the Differences in Banking and Financing of the Firms. *Saudi Journal of Humanities and Social Sciences*, *2*(11), 1062–1066. https://doi.org/10.21276/sjhss.2017.2.11.7
6. Alani, M. M., & Alloghani, M. (2019). Industry 4.0 and Engineering for a Sustainable Future. *Industry 4.0 and Engineering for a Sustainable Future*, 117–136. https://doi.org/10.1007/978-3-030-12953-8
7. Bag, S., Gupta, S., & Kumar, S. (2021). Industry 4.0 adoption and 10R advance manufacturing capabilities for sustainable development. *International Journal of Production Economics*, *231*(June 2020), 107844. https://doi.org/10.1016/j.ijpe.2020.107844
8. Bag, S., Yadav, G., Dhamija, P., & Kataria, K. K. (2021). Key resources for industry 4.0 adoption and its effect on sustainable production and circular economy: An empirical study. *Journal of Cleaner Production*, *281*(xxxx), 125233. https://doi.org/10.1016/j.jclepro.2020.125233
9. Balasingham, K. (2016). Industry 4.0: Securing the Future for German Manufacturing Companies. *School of Management and Governance Business Administration*, *11*(2), 15. http://essay.utwente.nl/70665/1/Balasingham_BA_MA.pdf
10. Baldassarre, F., Ricciardi, F., & Campo, R. (2016). The Advent of Industry 4 . 0 in Manufacturing Industry : Literature Review and Growth. *Microeconomics*, 632–643.
11. Barata, J., & da Cunha, P. R. (2021). Augmented product information: crafting physical-digital transparency strategies in the materials supply chain. *International Journal of Advanced Manufacturing Technology*, *112*(7–8), 2109–2121. https://doi.org/10.1007/s00170-020-06446-9
12. Bhuiyan, A. B., Ali, M. J., Zulkifli, N., & Kumarasamy, M. M. (2020). Industry 4.0: Challenges, Opportunities, and Strategic Solutions for Bangladesh. *International Journal of Business and*

Management Future, *4*(2), 41–56. https://doi.org/10.46281/ijbmf.v4i2.832

13. Candemir, M., Özcan, M., Güneş, M., & Deliktaş, E. (2011). Technical efficiency and total factor productivity growth in the Hazelnut Agricultural Sales Cooperatives Unions in Turkey. *Mathematical and Computational Applications*, *16*(1), 66–76. https://doi.org/10.3390/mca16010066
14. Chauhan, C., Singh, A., & Luthra, S. (2021). Barriers to industry 4.0 adoption and its performance implications: An empirical investigation of emerging economy. *Journal of Cleaner Production*, *285*, 124809. https://doi.org/10.1016/j.jclepro.2020.124809
15. Cheng, F. T., Tieng, H., Yang, H. C., Hung, M. H., Lin, Y. C., Wei, C. F., & Shieh, Z. Y. (2016). Industry 4.1 for Wheel Machining Automation. *IEEE Robotics and Automation Letters*, *1*(1), 332–339. https://doi.org/10.1109/LRA.2016.2517208
16. Cheng, G. J., Liu, L. T., Qiang, X. J., & Liu, Y. (2017). Industry 4.0 development and application of intelligent manufacturing. *Proceedings - 2016 International Conference on Information System and Artificial Intelligence, ISAI 2016*, 407–410. https://doi.org/10.1109/ISAI.2016.0092
17. Davis, D., Morris, M., & Allen, J. (1991). Perceived Environmental Turbulence and Its Effect on Selected Entrepreneurship, Marketing, and Organizational Characteristics in Industrial Firms. *Journal of the Academy of Marketing Science*, *19*(1), 43–51. https://doi.org/10.1177/009207039101900106
18. Deloitte Global Business Coalition For Education. (2018). *Preparing tomorrow's workforce for the Fourth Industrial Revolution | Deloitte | About*. 1–58. www.deloitte.com/about%0Awww.deloitte.com/about%0Ahttps://www2.deloitte.com/global/en/pages/about-deloitte/articles/gx-preparing-tomorrow-workforce-for-the-fourth-industrial-revolution.html?id=gx:2sm:3tw:4GBCed2018::6abt:20180919220600:SocialImpact-Report
19. Demartini, M., & Tonelli, F. (2018). Quality management in the industry 4.0 era. *Proceedings of the Summer School Francesco Turco*, *2018-Septe*, 8–14.
20. Erol, S., Jäger, A., Hold, P., Ott, K., & Sihn, W. (2016). Tangible Industry 4.0: A Scenario-Based Approach to Learning for the Future of Production. *Procedia CIRP*, *54*, 13–18. https://doi.org/10.1016/j.procir.2016.03.162
21. F. Hair Jr, J., Sarstedt, M., Hopkins, L., & G. Kuppelwieser, V. (2014). Partial least squares structural equation modeling (PLS-SEM). In *European Business Review* (Vol. 26, Issue 2). https://doi.org/10.1108/EBR-10-2013-0128
22. Ferreira, F., Faria, J., Azevedo, A., & Marques, A. L. (2016). Product lifecycle management enabled by industry 4.0 technology. *Advances in Transdisciplinary Engineering*, *3*, 349–354. https://doi.org/10.3233/978-1-61499-668-2-349
23. Fettermann, D. C., Cavalcante, C. G. S., Almeida, T. D. de, & Tortorella, G. L. (2018). How does Industry 4.0 contribute to operations management? *Journal of Industrial and Production Engineering*, *35*(4), 255–268. https://doi.org/10.1080/21681015.2018.1462863
24. Fettig, K., Gacic, T., Koskal, A., Kuhn, A., & Stuber, F. (2018). Impact of Industry 4.0 on Organizational Structures. *2018 IEEE International Conference on Engineering, Technology and Innovation, ICE/ITMC 2018 - Proceedings*. https://doi.org/10.1109/ICE.2018.8436284
25. Finch, S., & Gordon, I. (2013). *Probability and statistics: Random sampling*. 6, 10, 12.
26. Gaskin, J., & Lyytinen, K. (2010). Psychological ownership and the individual appropriation of technology. In *Proceedings of the Annual Hawaii International Conference on System Sciences*. https://doi.org/10.1109/HICSS.2010.472

27. Geissbauer, R., Schrauf, S., Koch, V., & Kuge, S. (2014). Industry 4.0 - Opportunities and challenges of the industrial internet. *Strategy& Formerly Booz & Company, PwC*, *13*, 1–51.
28. Genc, K. Y. (2014). Environmental Factors Affecting Human Resources Management Activities of Turkish Large Firms. *International Journal of Business and Management*, *9*(11), 102–122. https://doi.org/10.5539/ijbm.v9n11p102
29. Gentner, S. (2016). Industry 4.0: Reality, future or just science fiction? How to convince today's management to invest in tomorrow's future! successful strategies for industry 4.0 and manufacturing IT. *Chimia*, *70*(9), 628–633. https://doi.org/10.2533/chimia.2016.628
30. Giannetti, C. (2017). A framework for improving process robustness with quantification of uncertainties in Industry 4.0. *Proceedings - 2017 IEEE International Conference on INnovations in Intelligent SysTems and Applications, INISTA 2017*, *January*, 189–194. https://doi.org/10.1109/INISTA.2017.8001155
31. Hair, J. F. (2014). *3. Hair Book 2014 (PLS)*. https://doi.org/10.1108/EBR-10-2013-0128
32. Hallstedt, S. I., Bertoni, M., & Isaksson, O. (2015). Assessing sustainability and value of manufacturing processes: A case in the aerospace industry. *Journal of Cleaner Production*, *108*, 169–182. https://doi.org/10.1016/j.jclepro.2015.06.017
33. Hermann, M., Pentek, T., & Otto, B. (2015). Design Principles for Industrie 4.0 Scenarios: A Literature Review. *Technische Universitat Dortmund*, *1*(1), 4–16. https://doi.org/10.13140/RG.2.2.29269.22248
34. Hofmann, E., & Rüsch, M. (2017). Industry 4.0 and the current status as well as future prospects on logistics. *Computers in Industry*, *89*, 23–34. https://doi.org/10.1016/j.compind.2017.04.002
35. Hogg, A., Baldock, T., & Pritchard, D. (2011). Strathprints Institutional Repository. *Journal of Fluid Mechanics*, *666*, 521.
36. Islam, M. A., Jantan, A. H., Hashim, H. B., Chong, C. W., Abdullah, M. M., Rahman, M. A., & Abdul Hamid, A. B. (2018). Fourth industrial revolution in developing countries: A case on Bangladesh. *Journal of Management Information and Decision Sciences*, *21*(1), 1–9.
37. Iyer, A. (2018). Moving from Industry 2.0 to Industry 4.0: A case study from India on leapfrogging in smart manufacturing. *Procedia Manufacturing*, *21*, 663–670. https://doi.org/10.1016/j.promfg.2018.02.169
38. Jaghbeer, Y., Hallstedt, S. I., Larsson, T., & Wall, J. (2017). Exploration of Simulation-Driven Support Tools for Sustainable Product Development. *Procedia CIRP*, *64*(June), 271–276. https://doi.org/10.1016/j.procir.2017.03.069
39. Jajri, I., & Ismail, R. (2006). Technical efficiency, technological change and total factor productivity growth in Malaysian manufacturing sector. *Munich Personal RePEc Archive*, *2*(1966), 2–19.
40. Jamwal, A., Agrawal, R., Sharma, M., Kumar, V., & Kumar, S. (2021). Developing A sustainability framework for Industry 4.0. *Procedia CIRP*, *98*, 430–435. https://doi.org/10.1016/j.procir.2021.01.129
41. Jayashree, S., Reza, M. N. H., Malarvizhi, C. A. N., Gunasekaran, A., & Rauf, M. A. (2022). Testing an adoption model for Industry 4.0 and sustainability: A Malaysian scenario. *Sustainable Production and Consumption*, *31*, 313-330.
42. John W. cresswell. (2014). *Research Design by John w creswell*.
43. Kamble, S. S., Gunasekaran, A., & Sharma, R. (2018). Analysis of the driving and dependence

power of barriers to adopt industry 4.0 in Indian manufacturing industry. *Computers in Industry*, *101*(March), 107–119. https://doi.org/10.1016/j.compind.2018.06.004

44. Karimulla, U. (2020). *An Assessment on the Adoption of Industry 4 . 0 Technologies in South African Fabrication Industry*. University of Johannesburg.
45. Khan, M. (2008). *Technological Upgrading in Bangladeshi Manufacturing: Governance Constraints and Policy Responses in the Ready-made Garments Industry*. 1–51. http://eprints.soas.ac.uk/9961/
46. Khanzode, A. G., Sarma, P. R. S., Mangla, S. K., & Yuan, H. (2021). Modeling the Industry 4.0 adoption for sustainable production in Micro, Small & Medium Enterprises. *Journal of Cleaner Production*, *279*, 123489. https://doi.org/10.1016/j.jclepro.2020.123489
47. Kiraz, A., Canpolat, O., Özkurt, C., & Taşkın, H. (2020). Analysis of the factors affecting the Industry 4.0 tendency with the structural equation model and an application. *Computers and Industrial Engineering*, *150*, 106911. https://doi.org/10.1016/j.cie.2020.106911
48. Kohnová, L. (2018). Overcoming Industry 4 . 0 Challenges Through Open Innovation: Literature Review. *Business Environment Horizons IV*, *IV*(2018), 64–75.
49. Kumar, P., Bhamu, J., & Sangwan, K. S. (2021). Analysis of Barriers to Industry 4.0 adoption in Manufacturing Organizations: An ISM Approach. *Procedia CIRP*, *98*, 85–90. https://doi.org/10.1016/j.procir.2021.01.010
50. Landherr, M., Schneider, U., & Bauernhansl, T. (2016). The Application Center Industrie 4.0 - Industry-driven Manufacturing, Research and Development. *Procedia CIRP*, *57*, 26–31. https://doi.org/10.1016/j.procir.2016.11.006
51. Lee, J. Y., Kang, H. S., & Do Noh, S. (2012). Simulation-based analysis for sustainability of manufacturing system. *International Journal of Precision Engineering and Manufacturing*, *13*(7), 1221–1230. https://doi.org/10.1007/s12541-012-0162-8
52. Lele, A. (2019). Industry 4.0. *Smart Innovation, Systems and Technologies*, *132*, 205–215. https://doi.org/10.1007/978-981-13-3384-2_13
53. Leurent, H., & Abbosh, O. (2018). Driving the Sustainability of Production Systems with Fourth Industrial Revolution Innovation. *World Economic Forum (WEF)*, *January*, 58. http://www3.weforum.org/docs/WEF_39558_White_Paper_Driving_the_Sustainability_of_Production_Systems_4IR.pdf
54. Mohamed Padayachee, K. (2017). *A total rewards framework for the attraction and by keshia mohamed-padayachee submitted in accordance with the requirements for the degree of doctor of business leadership at the university of south africa supervisor : dr m h r bussin november 2017*. *November*.
55. Mohamed, Y., & Jokonya, O. (2021). Factors affecting the adoption of technologies to improve fleet safety management. *Procedia Computer Science*, *181*(2019), 1011–1017. https://doi.org/10.1016/j.procs.2021.01.278
56. Nagy, J., Oláh, J., Erdei, E., Máté, D., & Popp, J. (2018). The role and impact of industry 4.0 and the internet of things on the business strategy of the value chain-the case of hungary. *Sustainability (Switzerland)*, *10*(10). https://doi.org/10.3390/su10103491
57. Narula, S., Puppala, H., Kumar, A., Frederico, G. F., Dwivedy, M., Prakash, S., & Talwar, V. (2021). Applicability of industry 4.0 technologies in the adoption of global reporting initiative standards for achieving sustainability. *Journal of Cleaner Production*, *305*(April), 127141. https://doi.org/10.1016/j.jclepro.2021.127141

58. Neugebauer, R., Hippmann, S., Leis, M., & Landherr, M. (2016). Industrie 4.0 - From the Perspective of Applied Research. *Procedia CIRP*, *57*, 2–7. https://doi.org/10.1016/j.procir.2016.11.002

59. Nienaber, R. (2010). The relationship between personality types and reward preferences. *Acta Commercii*, *11*(2). https://doi.org/10.4102/ac.v11i2.153

60. Nuttall, G. (2018). The Impacts of the Fourth Industrial Revolution on Jobs and the Future of the Third Sector. *Nicva*, *January 2016*, 1–25.

61. Oettmeier, K., & Hofmann, E. (2017). Additive manufacturing technology adoption: an empirical analysis of general and supply chain-related determinants. *Journal of Business Economics*, *87*(1), 97–124. https://doi.org/10.1007/s11573-016-0806-8

62. Oláh, J., Aburumman, N., Popp, J., Khan, M. A., Haddad, H., & Kitukutha, N. (2020). Impact of industry 4.0 on environmental sustainability. *Sustainability (Switzerland)*, *12*(11), 1–21. https://doi.org/10.3390/su12114674

63. Olarewaju, A. D., & George, O. J. (2014). Mamagement theories and its application in organisations: the Nigerian experience. *BAM2014 Conference Procedings*, 18. https://www.bl.uk/britishlibrary/~/media/bl/global/business-and-management/pdfs/non-secure/m/a/n/management-theories-and-its-application-in-organisations-the-nigerian-experience.pdf

64. Reza, M. N. H., Jayashree, S., Malarvizhi, C. A. N., Rauf, M. A., Jayaraman, K., & Shareef, S. H. (2021). The implications of Industry 4.0 on supply chains amid the COVID-19 pandemic: a systematic review. *F1000Research*, *10*.

65. Shamim, M. I. (2022). Exploring the Success Factors of Project Management. *American Journal of Economics and Business Management*, *5*(7), 64-72.

66. Shamim, M. I. (2022). IT Skills Development Project and Economic Development in Bangladesh. *Academic Journal of Digital Economics and Stability*, *19*(7), 13-21.

67. Tavakol, M., & Dennick, R. (2011). Making sense of Cronbach's alpha. *International Journal of Medical Education*, *2*, 53–55. https://doi.org/10.5116/ijme.4dfb.8dfd

68. Teitel, S. (2000). Manufacturing Industry. *Technology and Skills in Zimbabwe's Manufacturing*, 18–25. https://doi.org/10.1057/9780230514027_2

69. The Research Advisors. (2010). Sample Size Table. *Research-Advisors*.

70. Thoben, K. D., Wiesner, S. A., & Wuest, T. (2017). "Industrie 4.0" and smart manufacturing-a review of research issues and application examples. *International Journal of Automation Technology*, *11*(1), 4–16. https://doi.org/10.20965/ijat.2017.p0004

71. Trappey, A. J. C., Trappey, C. V., Hareesh Govindarajan, U., Chuang, A. C., & Sun, J. J. (2017). A review of essential standards and patent landscapes for the Internet of Things: A key enabler for Industry 4.0. *Advanced Engineering Informatics*, *33*, 208–229. https://doi.org/10.1016/j.aei.2016.11.007

72. Turkyilmaz, A., Dikhanbayeva, D., Suleiman, Z., Shaikholla, S., & Shehab, E. (2020). Industry 4.0: Challenges and opportunities for Kazakhstan SMEs. *Procedia CIRP*, *96*, 213–218. https://doi.org/10.1016/j.procir.2021.01.077

73. Tyrrell, A. (2009). 2009 IEEE congress on evolutionary computation (CEC 2009). *IEEE Computational Intelligence Magazine*, *4*(4), 17–18. https://doi.org/10.1109/MCI.2009.934571

74. Tzempelikos, N. (2015). Top management commitment and involvement and their link to key account management effectiveness. *Journal of Business and Industrial Marketing*, *30*(1), 32–44.

https://doi.org/10.1108/JBIM-12-2012-0238

75. Ugboro, I. O., & Obeng, K. (2000). Top management leadership, employee empowerment, job satisfaction, and customer satisfaction in TQM organizations: an empirical study. *Journal of Quality Management*, *5*(2), 247–272. https://doi.org/10.1016/s1084-8568(01)00023-2
76. Uglovskaia, E. (2017). The New Industrial era:Industry 4.0 & Bobst company case study [University og Applied Science]. In *SMT Surface Mount Technology Magazine* (Issue January). https://www.theseus.fi/handle/10024/123113
77. UNIDO. (2011). The new industrial revolution: Making it sustainable. *General Conference, December*, 32. https://www.unido.org/sites/default/files/2012-01/GC14_Forum report_0.pdf
78. UNIDO. (2018). *Industry 4.0 – the opportunities behind the challenge*.
79. Zhong, R. Y., Xu, X., Klotz, E., & Newman, S. T. (2017). Intelligent Manufacturing in the Context of Industry 4.0: A Review. *Engineering*, *3*(5), 616–630. https://doi.org/10.1016/J.ENG.2017.05.015