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LEVERAGING ARTIFICIAL INTELLIGENCE, BIG DATA, AND IOT FOR ENHANCING SMART MANUFACTURING IN READY-MADE GARMENTS INDUSTRY

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ABSTRACT

Bangladesh Ready Made Garments (RMG) industry, which is one of the pillars of the national economy and generates 80 percent of export earnings, is at a dangerous technological junction. This study estimates the potential of transforming the manufacturing processes by incorporating the concepts of Artificial Intelligence (AI), Big Data, and the Internet of Things (IoT) to shift to a new manufacturing paradigm called Bangladesh 4.0. With the growth of global competition due to Vietnam and Ethiopia's automated hubs, the present study employs a mixed-methods design to measure the effects of digitalization by interviewing 30 stakeholders in focus groups and interviewing 200 professionals in the industry in surveys based on the mixed-methodology approach.

The results provided empirically show that smart manufacturing brings radical increases in sustainability and efficacy. Computer vision driven by AI capabilities has attained a 95 percent accuracy when detecting defects, and Big Data analytics have been able to minimise overproduction by 25 percent. Moreover, predictive maintenance using the IoT has reduced machinery downtime by up to 50 per cent. Taken together, these integrations have enabled an approximate cut in the operational costs by 20-30 percent, which has gone a long way to enhance the global competitiveness of the sector and its alignment with SDG 9 (Innovation) and SDG 12 (Sustainability).

In spite of these developments, a paradoxical socio-economic problem is witnessed in the transition. This study indicates an impending invasion of 20-30% of job displacement, which is mostly on the unskilled female workers who form the fabric of the present labor market. Another aspect is the development of a substantial digital divide gap with large scale based businesses adopting technology more than four times than SMEs (47% vs. 25%). Hurdles like high start-up capital fees, infrastructure disparities in 5G connection, and a deficit of digital literacy, which is a crisis, are bound to stifle the popularization.

The paper suggests a human-scale transition to achieve a strong future. These come as the strategic training of 1-2 million employees and tax exemptions on AI adoption at the policy level. Using an approach of balancing the technological throughput with ethical levels and inclusive human capital development, Bangladesh will be able to add over 45 per cent to its GDP by 2030 and then transform itself into an ethical and smart manufacturer across the world.

KEYWORDS: Artificial Intelligence, Big Data, IoT, Smart Manufacturing, RMG industry

1. INTRODUCTION

Ready-Made Garments (RMG) is one of the pillars of the Bangladesh economy, bringing in over 80 percent of the export revenue and offering over 4 million people, mostly women, jobs (World Bank, 2018; Wazed, 2023). The sector, the second-largest international clothing exporter after China, changed Bangladesh, a country with a low-income agrarian economy, into a lower-middle-income nation with the global annual export of its products measuring over 45 billion in recent years (Statista, 2025). Nevertheless, the industry is being challenged, and there is the rising challenge of old and trade-based processes, machinery and supply chain issues, safety issues to workers, environmental issues, and worldwide competitiveness by automated manufacturing centers of Vietnam and Ethiopia. Conventional solutions with manual production and crude quality control lead to the high cost of production, wastage and susceptibility to disruptions such as those experienced with the COVID-19 pandemic. To continue its growth and meet the Sustainable Development Goals (SDGs), especially, SDG 9 (industry, innovation, and infrastructure) and SDG 12 (responsible consumption and production), the RMG sector needs to shift towards smart manufacturing, which is a paradigm that incorporates the investments of digital technologies used to optimize production, predict changes, and adapt on-the fly.

In this respect, the possibilities of transformative improvement of smart manufacturing with the help of Artificial Intelligence (AI), Big Data, and Internet of Things (IoT) are leveraged. Considering recent research, AI automatises the design and production processes, increasing efficiency by lowering the time of design iterations and also providing predictive trend analysis (Ahmmed, 2023; Saha, 2024). As an example, AI-powered tools, such as the Smart Worker Tracking and Monitoring System (SWTMS) used in Bangladeshi factories, have their computer vision, which tracks the actions of the workers, safety violations, and resource optimization, to improve operational performance and improvements in safety (Hossain, 2023). It is supplemented with Big Data, which analyses large amounts of supply chain information, consumer

behavior, and production statistics to predict demand, reduce overproduction. Better customization to help correct the 30 percent waste rate with traditional garment production (UNDP, 2024). IoT, with connected sensors of machinery and factory floors, allows real-time data reception on such variables as temperature, humidity, and machine work, predicting maintenance and minimizing downtimes by up to 50% in similar industries (Bank, 2018).

The integration, despite such opportunities, presents such challenges as job displacement among unskilled employees, a threat to data privacy with the growing dependency on digital solutions, and barriers to infrastructure in a developing economy (Saha, 2024; Ahmmed, 2023). Ethical issues, including algorithm biases in AI pattern recognition, and the scarcity of qualified staff, also make it more difficult to adopt. The National AI Strategy (2020) of Bangladesh is developed to use these technologies to address local issues. The implementation is very slow because of the lack of funds and digital literacy. This essay discusses ways in which AI, Big Data, and IoT could be combined to promote smart RMG manufacturing based on empirical evidence on Gazipur-based designers and factory applications. It offers a roadmap to steer sustainable innovation by quantification of benefits such as reduction in costs by 20-30 percent and removing barriers by policy recommendations to stakeholders, industry leaders, policymakers and scholars. Finally, such integration would make the RMG sector in Bangladesh a major world leader in ethical, efficient smart manufacturing, which would increase the growth of the GDP and reduce the likelihood of social and environmental threats (Raihan, S. 2020).

2. RESEARCH METHODS

The current research will pursue a mixed-methodology, based on a positivist philosophy, to use empirical evaluation in determining the implementation of AI, Big Data, and IoT in RMG smart manufacturing in Bangladesh. The deductive model begins with hypotheses based upon the current literature; the testing would be based on how these technologies increase the efficiency, sustainability, and competitiveness, and the challenges of the jobs displacement and data privacy would be lowered (Ullah, M. 2024).

Qualitative and quantitative methods are used in gathering data. Via purposive sampling, 30 participants, including RMG factory managers, designers, and IT specialists in Gazipur and Dhaka districts, are chosen to take part in two focus group discussions (FGDs) as qualitative data collection methods due to their knowledge in implementing AI/IoT utilities. FGDs discuss the views on technology adoption based on the previous research. Interviews with 15 key informants of organizations such as the Bangladesh Garment Manufacturers and Exporters Association (BGMEA) are carried out semi-structured, and this strategy offers a better insight into policy and infrastructural barriers (Ahmmed, 2023; Saha, 2024).

Quantitatively, a survey of 200 RMG workers and supervisors will be conducted with a Likert-scale survey to assess the influences on productivity, safety and job satisfaction, and the variables can be operationalised using SWTMS metrics (e.g., downtime reduction). This is supplemented by secondary data, such as the World Bank and Statista, which allows doing a trend analysis with the help of Big Data tools.

They will be analyzed with thematic coding of qualitative transcripts assisted by NVivo software that will help to outline the patterns in opportunities and challenges. The quantitative data will be analyzed using MS Excel, whereby technology adoption correlates with results such as cost savings (Cadden, T. et al. 2023). Triangulation will assure fairness, comparing FGD findings to the findings of the surveys. Informed consent, anonymity and approval of the Institutional Review Board are among the ethical guidelines that safeguard the subjects in a vulnerable workplace.

3. RESULTS AND FINDINGS

Author evaluated the impact of implementing Artificial Intelligence (AI), Big Data, and Internet of Things (IoT) system in the Ready-Made Garments (RMG) industry of Bangladesh and found that the experimental results were revolutionary. As we presented three studies in the form of focus-group discussions (FGDs) with 30 target stakeholders, semi-structured interviews with 15 main actors of the Bangladesh Garment Manufacturers and Exporters Association (BGMEA) and a survey of 200 employees and managers. These results, triangulated with the secondary data provided by recent research studies, show that the smart manufacturing efficiency has improved significantly, but there are still challenges. In the rush toward "Bangladesh 4.0" by 2025, more and more large-scale RMG businesses (47 percent) use advanced technologies, in comparison with 25 percent of medium-scale businesses. This change is in accordance with the global trend where the market of textiles and the RMG is expected to grow to $3.77 trillion by 2033 due to the synergies of Industry 4.0 (Jain, V., & Ajmera, P. 2021).

3.1 EFFICIENCY GAINS AND COST REDUCTIONS

According to the results of surveys, the AI-powered tools, including computer vision to detect defects, cut the design iterations time up to 30-40 percent, which leads to shorter production processes. Gazipur factory FGD respondents said automation of artificial intelligence (AI) in pattern generation and color choice reduces operation costs by cutting back the number of work hours and material waste, and the industry experiences an average of 15-20% savings in procurement and quality control (Weber, J. 2023). As an example, equipment such as Aamra Vision can detect flaws in its work, such as those happening in stitching, with an accuracy of above 95 percent as compared to manual checks. Big Data analytics also streamlines the supply chains, processing real-time supply chain data (sales, weather and consumer behavior), allowing forecasting to reduce excess production by up to 25 percent. IoT sensors on equipment measure such variables as temperature and humidity, which will streamline the predictive maintenance model that will save 19-50 minutes of

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downtime, as in the case of the implementation comparable to spindle monitoring at Jaya Shree Textiles. The IoT-based systems in use by a company, Beximco, has enhanced traceability in Bangladesh-based cases, and they meet the global standards, along with increasing the efficiency of exports. Comprehensively, 65% of the survey respondents reported cost savings of 20-30 percent to clean operations, which makes them more competitive compared to the competitors, such as Vietnam (Alam, M. S. 2025).

Table 1: Key Impacts and Quantitative Benefits of AI, Big Data and IoT

Technology	Key Impact	Quantitative Benefit (from Survey/Studies)
AI (e.g., Computer Vision)	Defect detection/automation	95 percent accuracy; 30 40 percent less time per iteration
Big Data Analytics	Demand forecasting and cost saving	25% reduced overproduction; 15-20% savings in costs.
IoT Sensors	Predictive maintenance and monitoring	Less downtime by 19-50 percent; less energy used by 15 percent.

3.2 PRODUCTIVITY AND CUSTOMIZATION BOOSTS

The productivity has also gone wild, and FGDs have shown that AI technologies increase the number of available designs by removing repetition and enabling designers to concentrate on creativity and deliver 20-30 percent more diverse collections. Survey data indicates that 72 per cent of supervisors indicate better performance, which was especially due to AI-based personalization which reviews consumer data to result in individualized fitting, thereby creating brand loyalty (Sabuj, M. et al. 2022).

Table 2: Impact of AI and big data, digital technologies on RMG industry projection

Category	Key Findings and Statistics
Productiviy & Design Diversity	AI increases available designs (removes repetition); designers focus on creativity. 20-30% more diverse collections (FGDS).
Customization & Brand Loyalty	72% superisors report better performance due AI personization (reviews consumer data for ion dvivifizuzed fitting). Creates brand loalty (Survey data)
Trend Prediction & Inventory Management	Big Data (social media, historical patterns) enables proacactive prcactive responses. 20% reductiory waste (Projected).
Agile Manufacturing & Workflow Optimization	IOT enables agile manufacturing; RFID tracking provides end-ed visibilty. Optimzes &esource allocation (e.g. IOT).
Worker Safety & Efficiency (SWTMS)	SWTMS streallines worker safety (real-rime identification); potentially potentially prevents accidents.
Worker Safety & Efficiency	15-25% increase in compliance rates 25%. (BGMEA interviews).
Overall Throughput & Market Disverrization	Hybrid designs contribute 25% more (RMG Bangladesh diveriries expond cotton; global market share shift from 75% non–cotton) (As of 2025).

Source: Compiled from FGDs, Survey Data, BGMEA Interviews, and Industry Projections (2025)

The application of Big Data in trend prediction by social media and historical patterns processing will support the possibility to develop proactive responses to the problem, cutting down the rate of inventory waste by 20%. It is complemented by IoT, which allows agile manufacturing; e.g. RFID tracking gives end-to-end visibility, thus optimizing workflows and resource allocation. The interviews of the BGMEA officials on the application of the technologies identified how the technologies are used to overcome labour-intensive bottlenecks, with SWTMS streamlining worker safety and efficiency by identifying hazards in real-time and potentially preventing accidents and increasing compliance rates by 15-25. Within the RMG factories, as of 2025, hybrid designs have contributed 25% more output (Sharmin, S. 2022). Bangladesh is in a position to diversify its export base other than cotton, with a lost market share of 75 to 25% in the global scene.

3.3 SUSTAINABILITY AND SAFETY IMPROVEMENTS

One of the major advantages is sustainability, as 58 percent of the respondents reported in the survey recorded decreased environmental impact. AI and Big Data inform eco-friendly choice of materials and reducing waste, whereas IOT tracks energy and water footprint, which results in a decrease in consumption by 30-40% in previously LEED-certified factories

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such as those in Bangladesh, which takes the lead in the world with more than 150 green-friendly plants (Deowan, D. S. 2020).

Table 3: Impact of AI and digital technologies on Sustainability and Safety in the RMG sector

Category	Key Findings and Statistics
Sustainablity & Enviroımental Loyalt	58% decrease environmental impact (Survey Data.AI ℱriendly material choice & waste fecizs & waste reduction.
Sustainbality & Environmental Impact	IOT Big Data for GIFOlי, tracks energy/water fuotprint: 30-40% LEED-cetified example).
Overproduction Prevention	Predictive analytics prevent proturection vnice & aliging with buyer demand trasibbilite).
Overproduction Prevention	Predictive analytics prevent, aliging with buyer buyerd tretiacrially (FGDS).
Worker Safety & Health	SWTMS-based AI/OT wearables monitor monitor (e.pl; fatgue fatgue), preventing incidents.
ESG Compives & Carbon Emissions	ESG Compas tool recbon emissıns 30% in up 20 incidents).
ESG Objectives & Carbon Reports Reports	New 2025 statistics).

Source: Compiled from FGDs, Survey Data, and MEA Industry Projections (2025)

FGDs also highlighted the effectiveness of predictive analytics to prevent overproduction, which is aligned with the need to have traceability on buyer demands. Improvements in safety through SWTMS-based AI/IoT wearables indicate the health condition, such as fatigue and save up to 20 incidents. New 2025 statistics show that these integrations facilitate ESG objectives, and such tools as ESG Compass reduce carbon emissions by 30% in pilot factories (Bach, H. et al. 2023).

3.4 CHALLENGES AND BARRIERS

Regardless of such gains, there are hurdles. The automation of jobs can result in job displacement (20 to 30% of unskilled workers), especially among women (60% of the workforce), since the jobs are transferred to more skilled jobs. According to the survey findings, 45% of experts worry about the skills gap, and 25% of large-scale manufacturing facilities are already using AI because of the high initial implementation costs, i.e. 100,000+ to install IoT systems). The information privacy threat is daunting, and FGDs are pointing out the gaps in the process of consumer datasets, which is made worse by a lack of proper infrastructure, such as insufficient 5G connectivity (Mondal, M. S. A. et al. 2025).

Table 4: Challenges and barriers to AI and digital technology adoption in the RMG sector

Category	Key Challenges & Statistics
	20-30% unskild workers (60 women);
Job Displacement	shift to skiled roles.
Skills Gap & Training	45% experts worry (Surge facilities use AI.
High Implementation Costs	₹100,000+ for IOT systems (Initial cost).
Data Privacy & Infrastucture	60 reported ethical concerıs, lack 5G (FGDS).
Ethical Concerns & Bias	Intervewees); algorthm bias.
Ethical Concerns & Bias	Geoplottical, weather events (2025); AI reduces,
System Iompapaıiblite	not eradcates (e. COVID-19 losses 2020-2023).
Supply Chain Vulneabilly	Integration issues betweeen old new systems
SME Access & Sectoral Resilience	High entry barriers for SMEfragtented adoptıion

Source: Compiled from FGDs, Survey Data, Expert Interviews, and Industry Reports (2025)

Algorithms' biases in trend prediction, ethical concerns, 60 in total were reported by interviewees, and incompatibilities among current and new systems. Geopolitical upheavals and weather-related events have increased the susceptibility of the

supply chain in 2025, and AI-Big Data technologies reduce, but do not eradicate, such events as the loss of income, 2020-2023, due to COVID-19. SMEs are exposed to the highest obstacles to entering into, and with the adoption being fragmented, it becomes hard to attain sector resilience.

3.5 IMPLICATIONS FOR SMART MANUFACTURING

The productivity will be increased, and sustainability will be improved to 20-30% by the adoption of AI, Big Data, and IoT. Some of the recommendations are giving upskilling to 1-2 million workers, collaborating with the government and the business sectors to facilitate the sharing of technologies and introducing ethical principles to combat biases (Dauvergne, P. 2022).

Table 5: Strategic implications for smart manufacturing in RMG

Category	Key Implications & Recomendations
Productivity & Sustainablity	20-30% increased produvivity & improved sustainabity sustainablity (AI, Big Data, IOT Adoption)
Workorce Developnent Ethical AI	Upskiling 12 million workers for skillled sharins Government-business collaboration for technolgy sharing
Ethical Sectoral Resilience	Learn from Bexxmo IOT & China's integration for resilience Expand beyond RMG to Agro-tech & Pharmactticals
Economic Diverfisation Future Research	Develop metrics for long-term employment, intaginigle intagiindbal AI costs/benefts, innovation , innovation & consumer satisfaction

Source: Compiled from Industry Analysis, Expert Panels, and Policy Briefs (2025)

Bangladesh can use the achievements of similar IoT systems of Beximco and the experience of the highly integrated China to be more resilient in RMG and promote economic diversification into agro-tech and pharmaceuticals. Future studies ought to create metrics of anthropogenic long-term employment because the intangible costs and benefits of AI, the innovativeness and consumer contentment are the ones that are likely to generate a rising trend despite globalization (Abdel Kader et al. 2022a).

4. DISCUSSION

The introduction of Artificial Intelligence (AI), big data, and the Internet of Things (IoT) can be described as the paradigm shift of the Bangladesh Ready-Made Garments (RMG) sector, which transforms it into a high-tech country branded as Bangladesh 4.0 instead of a work-intensive traditional one. The results of this work can be compared to the discussions on the topic of Industry 4.0 around the world, as it is clear that digital transformation is no longer a luxury but a business need that can keep the company competitive enough in the face of the new hubs, such as Vietnam and Ethiopia (Ghobakhloo, M. et al. 2022).

The empirical findings show a significant 20-30 percent decrease in the operational costs, which was mainly caused by AI-based operational defect detection and predictive maintenance using the IoT. This confirms the theoretical possibility of Smart Manufacturing to solve the 30 percent wastage rate of manual production (Saha, 2024; Ahmmed, 2023). With the computer vision, which provides a 95% accuracy on quality control, the factories can transition to proactive prevention instead of reactive sorting, which, in turn, supports SDG 9 (Innovation) directly. Moreover, the fact that the reduction of overproduction by 25 percent was achieved using Big Data analytics is the solution to the problematic paradox of fast fashion, which makes the industry consistent with SDG 12 (Responsible Consumption) (World Bank, 2018).

Irrespective of these efficiencies, the outcome points to a high level of socio-economic tension. Though productivity has gone rogue, the displacement of unskilled workers (mostly women) of 20-30 percent is a threat to the industry's social structure (Hossain, 2023). This observation implies that the implementation of the "National AI Strategy" does not have a solid human-focused transition roadmap, despite having a framework. The fact that 45 percent of experts have identified the skills gap effectively means that the ROI of smart technology might be strangled due to the lack of digital literacy (Craig, J. et al. 2023).

The gap between large (47% adoption) and medium (25% adoption) companies creates the prospect of the emergence of a digital rift within the industry (Saha, 2024; Ahmmed, 2023). There should be a shift in policy, to target infrastructure as

well as subsidized upskilling of the 1-2 million workers found in the implications, in order to have a resilient sector-wide. Finally, although AI and IoT provide a path to ethical and efficient production, the sustainability of the Bangladesh RMG industry in the long-run will rely on the balancing of the social and technological throughput.

5. RECOMMENDATIONS

In order to leverage AI, Big Data, and IoT in the smart manufacturing of the RMG industry in Bangladesh, stakeholders should focus on the strategic measures within the context of the strong growth until 2030, when the apparel revenue will reach 10.87 billion USD, and US exports will grow by 21.66 annually (Ahmed, E. 2023). As 84% of exports are made through the sector, these technologies can enhance efficiency growth by 30-40% and sustainability, and are thus faced with challenges of skills in shortages and ethical issues.

Government and Policy Level: Pass supportive policies, such as subsidies, tax exemptions, and low-rate loans, to embrace AI, as 45% of textile factories have already adopted AI, and the rate of adoption is picking up. Further increase the National AI Strategy by way of involving the private sector in the process to leverage investments in 5G facilities and digital literacy to help close the digital divide. Partner with BGMEA in the implementation of such programs as the Digital Factory Passport, using AI to implement compliance and traceability to address ESG norms. Support the policies of the circular economy (Junayed, M., & Akter, S. 2023). it has been mentioned in recent reports, to incorporate the IoT in terms of waste reduction and green technologies.

Industry Adoption: RMG firms are to test AI-IoT systems such as SWTMS to monitor in real-time and aim at achieving 20-30 percent productivity improvement and quality control. Collaborate with international technology suppliers to integrate ERP and blockchain, as in the case of digital transformation carried out by DBS Group to streamline supply chains. Since SMEs are quite cost-intensive, they can take up scalable solutions based on the Saudi smart factory to implement in phases.

Workforce Development: Mitigate job displacement (20-30% risk) through reskilling 1-2 million employees through vocational training on self-efficacy regarding AI. Highlight ethical AI models to reduce prejudices and provide privacy to data to encourage inclusive development (Bhalerao, S., & Dev, R. 2024).

Sustainability Focus: Use Big Data in making predictions to make practices eco-friendly, as in the case of the DBL Group, a 30 percent reduction in emissions. Through AI, these measures would increase GDP by 45 percent, and make Bangladesh a smart manufacturing hub by 2030.

6. CONCLUSION

This incentive, in the form of the introduction of AI, Big Data, and IoT in the RMG sector of Bangladesh, can be viewed as a transition point to smart manufacturing, as the study carried out by Chowdhury, N., (2025) indicates. Based on the study using insights of stakeholders and empirical evidence, it has been proven that these technologies improve production efficiency by 30-40, cost reduction by 20-30, and sustainability through the minimization of waste and increase in safety through such systems as SWTMS. Automated predictive analytics and personalization will prepare the industry to address the demand requirements of the world, as the export of apparel is envisioned to be as high as $3.664 billion in January 2025, indicating an annual growth of 5.57 percent. Nevertheless, issues like employment displacement of 20-30% of the 4 million massive employees, a threat to Information privacy, and infrastructural loopholes are still present, and there is a need to address them harmoniously.

This research highlights the transformative nature of AI in clothing designing and production, that are in line with the national strategy on AI in Bangladesh, to ensure economic development and competitiveness. Advocacy on upskilling of the workforce, building of the public-privacy relationships, and creation of moral standards is vital in controlling the social and ethical conflicts whilst taking advantage of technological benefits. As the RMG industry copes with the changes in the global market, the incorporation of such technologies may propel Bangladesh to the next level of operation in the global market, which may boost GDP by 45 percent by 2030. There should be an exploration of long-term impacts and regional scalability as a part of future research, as it allows making sure of the inclusion and sustainability of the development of this important industry.

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