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Evaluation of the Main Barriers of RMG in Industry 4.0 Implementation by Using Analytical Hierarchy Process (AHP)

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EVALUATION OF THE MAIN BARRIERS OF RMG IN INDUSTRY 4.0 IMPLEMENTATION BY USING ANALYTICAL HIERARCHY PROCESS (AHP)

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Abstract- *Industry 4.0 is the oncoming ubiquitous new manufacturing technology. It is the current trend and age of new production process, of the smart factory where machines can communicate with each other as well as human beings. There is no doubt implementation of Industry 4.0 in the Ready Made Garments (RMG) sector of Bangladesh is the most effective step for inspiring the manufacturing companies and a great symptom to rise up economic spectrum. Nevertheless, the academics and policy makers' levels are still trying to contribute a complete guideline for the sector overcoming the barriers to meet with main stream of the new world. The study identified four main hurdles of Lack of Policy Makers' & Corporate Leaders' Support; Lack of ICT Based Knowledge; Lack of Ability to Meet up Initial Cost (Infrastructure & Smart Machineries cost) and Availability of Cheaper labour through review studies in RMG for implementing Industry 4.0 strategy. These main criteria for barriers are evaluated and analyzed by using an Analytical Hierarchy Process (AHP) observation and the relative weights and ranking of the criteria are calculated. For obtaining data from experts a set of pairwise questionnaire is developed. After analyzing the collected data a pairwise comparison matrix is formed for Criteria Weight Calculation and developed a consistency index and ratio checking system.*

Keywords: Industry 4.0; Digitalized factory; Ready Made Garments; Barriers; Analytical Hierarchy Process; Pairwise comparisons; Consistency Index and Ratio.

1. INTRODUCTION

Fourth Industrial Revolution (IR4.0) or Industry 4.0 became today's buzzword, in Bangladesh. University researchers, technical directors of industries and government level diplomats are participating in various seminars, conferences and round table discussions on IR4.0 & trying to find out the barriers, benefits and prospects. Scholars are trying to make stakeholders aware about Industry 4.0 concept and inspiring entrepreneurs to adopt newer technologies to get advantages out of it. Bangladesh has been gaining on the developing community with precocious stride that is technologies are remained up-to-date with concurrent market demands. On the other hand, the Finance Minister of Bangladesh Government stated in his budget speech 2019-20 that the whole world is poised to enter into the age of the Fourth Industrial revolution, and relied on the complete use of digital technology. He also added that the fourth industrial revolution is going to establish massive changes in industrial production, business, employment, administration, and on all fronts. Bangladesh could not afford to lag behind and would have to march forward keeping pace with the world. ICT-based human resource would be the driving force and the dream of attaining higher economic growth.

The significant criteria of Industry 4.0 is to utilize the potentials of new technologies, processing and ideas such as: Availability and use of the internet and IoT, Integration of technical methods and business managements in the industries, Digital design and virtual reality of the real world, the factory of real time frame and smart products [1].

Industries implementing to this new nomenclature, to center into manufacturing and production systems influence contest in the world competitiveness market and lead to intelligent maintenance processes [2]. The activities of the industries at optimum efficiency will be ensured with the minimization of the related costs and the minimization of the failures [3].

Ready Made Garments (RMG) is one of the main exporting apparel industries in Bangladesh which plays a vital role to an increasing development the economy. Implementation of Industry 4.0 in RMG sector faces few barriers which should be overcome through a sort of unitary wholeness. Presently, trade and commerce environments are quickly rising in order to integrate Industry 4.0 concepts. Guido Orzes et al the focus groups indicated various barriers and complications for Industry 4.0 implementation in SMEs [4]. They classified them in the following ways: economic/financial, cultural, competencies/resources, legal, technical and implementation process. Islam et al pointed out through the phenomenology design and after evaluation of all the experts' opinions [5]. The research highlighted five principal hurdles including some advantages to adopt Industry 4.0 in Bangladesh. The

primary risks such as poor infrastructure, availability of cheaper labour, expensive installation of technologies, lack of government supports and lack of knowledge. Furthermore, they suggested that the next research in Bangladesh can be made by the use of quantitative analysis taking substantive barriers as variable.

Jabbour et al, 2017 talked about opportunities in Industry 4.0 and despite having a huge prospect of adoption of industry 4.0 in Bangladesh, it has lots of challenges i.e. lack of awareness, labor skills, factory infrastructure, lack of enough investment, technology applications in production, etc. [6]. A review work finds to experiment the impact, challenges, and opportunities of the fourth industrial revolution based on experimental outcomes particularly and broadly in the context of Bangladesh [7]. The study finds irrespective of having immense capability, the application of the fourth industrial revolution is far lagging for some obstacles i.e. lack of awareness, insufficient capital, weakness of infrastructure, lack of expert manpower and some socio-economic barriers. Considering the last couple of decades, Hasan & Mahmud took into account several risks such as: finance/capital risk, employee turnover risks, militancy risks, building collapse risks, fire incident risks, labor unrest risks, political unrest risks, climate change risks, health safety risks, electricity and gas risks, sexual harassment risks, local politics risks, administration risks etc in RMG sector [8]. Along with the above mentioned discussions, it is observed that as a new technology adaption, implementation of Industry 4.0 in RMG sector could face few key barriers. In the context of Bangladesh, challenges can be accumulated as denoted below.

(i) Lack of Policy Makers' & Corporate Leaders' Support to Go Industry 4.0, (Criteria B1)
(ii) Lack of ICT Based Knowledge & Training regarding Industry 4.0, (Criteria B2)
(iii) Lack of Ability to Meet up Initial Cost (Infrastructure & Smart Machineries cost) (Criteria B3) and
(iv) Lack of Availability of Cheaper labour (Criteria B4)

The main focus of this study is to assess and prioritize these barriers that companies may face in the industry 4.0 implementation processes and to do this, an Analytical Hierarchy Process (AHP) has been used.

2. RESEARCH METHODOLOGY

2.1 Analytical Hierarchy Process

Analytical Hierarchy Process (AHP) is one of the methods that can be used in decision-making system by considering the factors of perception, preference, experience and intuition of experts. AHP can combine personal judgment and values into a logical way. AHP breaks down a complex decision making process into simple comparisons [9]. AHP is a method for multi-criteria decision making in which the relative weights of probable judgment criteria or outcomes are given a functional value based on a mathematical representation of pairwise comparisons [10]. Decision makers/experts can prepare actual and precise measurements on alternatives/criteria/sub-criteria for many problems.

The AHP technique was used to determine the priority weight of the list of barriers obtained in the qualitative data collection stage. By using this approach, the implicit responses given by both the researchers and the experts of the AHP can be minimized.

2.2 Steps of AHP

In this research an AHP model is developed based on the barriers of RMG which is generated from the literature and qualitative study. In the AHP survey instrument, assessment of each pairwise scoring was conducted. The calculation process was carried out according to the implementation steps define criteria, collect data, setup hierarchy, calculate the weights and check CR (consistency ratio) and final ratings of the AHP method.

2.3 Flow Chart

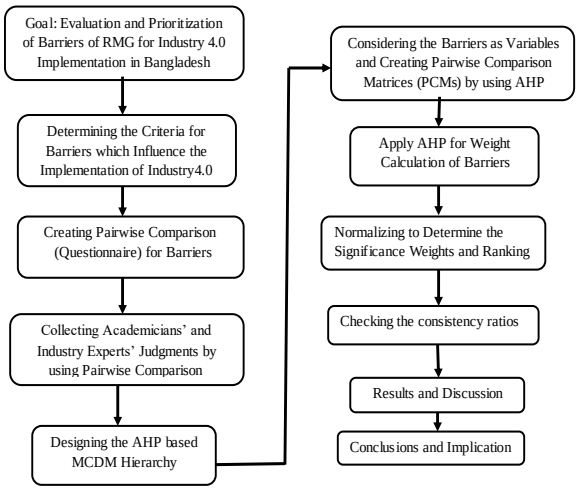

Figure 1: Flow Chart to implementation Industry 4.0 in RMG industry

2.4 Data Collection

Four pair of questionnaire of main four criteria evaluation for barriers are created which shown in the Appendix A. These factors for barriers are evaluated with 25 experts and management officials from different garments factory and institutions. The researcher visited RMG factory for getting industry experts' opinions and attended in related seminars for academics realization.

2.5 Pairwise Comparison and Relative Scale

A pairwise comparison matrix is defined as n by n matrix $A = [a_{ij}]$ where $a_{ij} > 0$ and the matrix A is named consistent if $a_{ij} . a_{jk} = a_{ik}$, for the value $i, j, k = 1, 2, .., n$. Generally a_{ij} denotes an expert's relative measurement of criterion. Each of the pairwise comparisons was evaluated based on the given relative scale (from 1 to 9) [11]. A scale of 1 represents the lowest score or equal weight of that pairwise, while a scale of 9 represents the highest score of the pairwise comparison. For creating comparison matrices between the criteria, it is needed to prepare the relative importance weights of criteria for barriers by binary comparisons through AHP. After completing the binary comparison, the relative scale created by Saaty [12] is applied for further calculation. The definition and its importance level of the scale are shown in Table 1.

Table 1: Scale of relative importance

Crisp Numeric Value	Linguistic Variable
1	Equally importance
3	Moderately importance
5	Strongly importance
7	Very strongly importance
9	Extremely importance
2, 4, 6, 8	Intermediate values importance
1/3, 1/5, 1/7, 1/9	Values for reciprocal comparisons

3. DATA ANALYSIS

3.1 Calculation for the Criteria Weights

After creating pairwise questionnaire and getting pairwise comparison answers/evaluation form the experts, it is analyzed for crisp value and then the pairwise matrix of the AHP method is obtained. Now Table 2 shows the importance weights obtained from the experts in a pairwise matrix.

Table 2: Pairwise comparison matrix among the criteria

Barriers as Criteria	Criteria B1	Criteria B2	Criteria B3	Criteria B4
Policy Makers' Support, (Criteria B1)	1	3	2	5
ICT Based Knowledge, (Criteria B2)	1/3	1	1/2	2
Ability to Meet up Initial Cost, (Criteria B3)	1/2	2	1	3
Availability of Cheaper labour, (Criteria B4)	1/5	1/2	1/3	1

Here, according to decision makers' judgments, Table 2 shows that Policy Makers' Support (Criteria B1) is of equal to moderately importance with respect to ICT Based Knowledge (Criteria B2) and similarly Policy Makers' Support (Criteria B1), is strongly importance with respect to Availability of Cheaper labour, (Criteria B4). So the Availability of Cheaper labour, (Criteria B4) is reciprocally importance than the criteria B1 and B3. The diagonal elements are taken a value of 1 because one element is of equal importance to the same element.

After a series of calculations of the AHP method in the analysis system is completed according to the comparison matrix in Table 2. Then obtained matrix is normalized to evaluate required weights of each criterion. The normalized matrix is shown in Table 3. Normalizing process is completed by dividing each column value separately by the respective column sum value. Now the criteria weights are obtained from the average of row values (all the criteria) of normalized matrix. The normalized weight values may be expressed as percentage weight for each attribute. The required weights of all key elements for barriers are shown in Table 4.

Table 3: Normalized Pairwise comparison matrix

Criteria	Criteria B1	Criteria B2	Criteria B3	Criteria B4
Criteria B1	0.4918	0.4615	0.5218	0.4545
Criteria B2	0.1638	0.1538	0.1304	0.1818
Criteria B3	0.2459	0.3077	0.2609	0.2727
Criteria B4	0.0984	0.0769	0.0869	0.0909

Table 4: Criteria Weights and ranking of the main Barriers

Criteria for Barriers	Criteria Weight	Ranking
Policy Makers' Support, (Criteria B1)	0.4824	1
ICT Based Knowledge, (Criteria B2)	0.1575	3
Ability to Meet up Initial Cost, (Criteria B3)	0.2718	2
Availability of Cheaper labour, (Criteria B4)	0.0883	4

B1= (0.4918+ 0.4615 + 0.5218 + 0.4545)/4= 0.4824

3.2 THE CONSISTENCY RATIO CHECKING

The consistency of criteria weights should be taken into consideration at that stage. If the comparison matrix is not consistent, the resulting weights cannot be used for further calculation. So, next step is the calculation of consistency that is to check whether the calculation steps of the comparison matrix values are correct or not. For this it has taken the same pairwise comparison matrix which is not normalized have multiplied each value in the column with the criteria value. The weighted sum value is calculated by taking the sum of each value in the row. The ratio of weighted sum value and criteria weight is calculated for each row on solving the value of lambda max ($\boldsymbol{\lambda}_{max}$) is shown in Table 5. $\boldsymbol{\lambda}_{max} = y_1 x_1 + y_2 x_2 + \ldots + y_k x_k \ldots + y_n x_n = \sum y_k x_k$ = Maximum Eigen value of matrix of order *n*. Where, $y_k = \sum a_{ij}$, sum of the element in a column and *i, j, k* = 1, …., *n*. Now, the vector $\boldsymbol{\lambda}_{max}$ is calculated by taking the average of all these ratios.

Table 5: The ratio of weighted sum value and criteria weight

Criteria for Barriers	Weighted Sum value	Criteria Weight	(Weighted sum/ Criteria weight)
Policy Makers' Support, (Criteria B1)	1.94	0.4824	(1.94/0.48240) = 4.0215
ICT Based Knowledge, (Criteria B2)	0.6306	0.1575	(0.6306/0.1575) = 4.004
Ability to Meet up Initial Cost, (Criteria B3)	1.0929	0.2718	(1.0929/0.2718) = 4.0209
Availability of Cheaper labour, (Criteria B4)	0.3541	0.0883	(0.3541/0.0883) = 4.0102

$\boldsymbol{\lambda}_{max}$ = (4.0215+ 4.004+ 4.0209+ 4.0102)/4= 4.0142,

Therefore λ_{max} = 4.0142,

$$Consistency\ Index\ (CI) = \frac{\lambda_{max} - n}{n-1}$$

$CI = \frac{4.0142-4}{4-1} = 0.00473$, here 'n' is the number of criteria.

$$Consistency\ Ratio\ (CR) = \frac{Consistency\ Index\ (CI)}{Random\ index\ (RI)}$$

Another value that needs to be obtained is the random index (RI). Random Index (RI) is the consistency index of randomly generated pairwise matrix. It is a technique for dimensionality reduction that was initially introduced by Kanerva et al (2000) [13]. The random index values for various matrix sizes are shown in Table 6.

Table 6: Random Index Chart

No. of Criteria(n)	1	2	3	4	5
Random Index (RI)	0.00	0.00	0.58	0.90	1.12
No. of Criteria(n)	6	7	8	9	10
RI	1.24	1.32	1.41	1.45	1.49

Number of criteria n equal to 4 and the corresponding RI value is 0.90.

$$So, Consistency\ Ratio\ (CR) = \frac{0.004733}{0.90}$$

$= 0.005259 < 0.10$, which is satisfactory.

4. RESULTS

In this study, the analysis of effective criteria for barriers of RMG sector in Bangladesh is done by the AHP methods. Obtained result of consistency ratio CR is 0.005259 which is less than 0.10, the degree of inconsistency existent in the knowledge funded in comparison matrix is favorable. This standard value can assume that the matrix is reasonably consistent and the research should sustain with the procedure of decision making using AHP or any other effective methods. The criteria weights can be used by the decision makers for the further calculation. Therefore, the research can be concluded here that the lack of Policy Makers' & Corporate Leaders' Support has been given 48.24% weight-age, lack of Ability to Meet up Initial Cost (Infrastructure & Smart Machineries cost) 27.18% weight-age, lack of ICT Based Knowledge and Training 15.75% and Availability of Cheaper labour, a weight-age of 8.83% regarding Industry 4.0. Figure 2 shows, top management commitment is the most lacking criteria for implementation of smart factory. The process of evaluation has guided only for the criteria level, and no sub-criteria and alternatives have calculated in the shaped AHP structure.

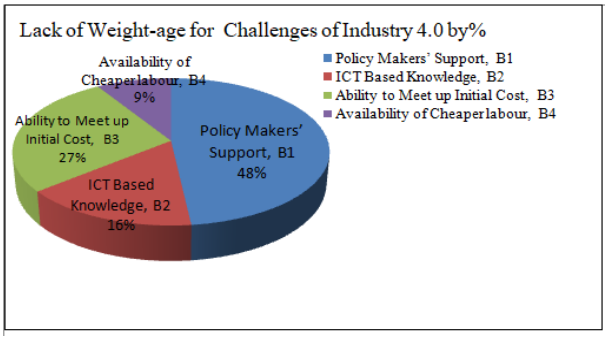

Figure 2: Percentage weight value of Lack of Criteria for Challenges in Industry 4.0 Application of a RMG factory

5. CONCLUSIONS

RMG industries believe firmly in the truth of more weighted cost criteria that is "Policy Makers' & Corporate Leaders' Support" as well as low weighted criteria 'Availability of Cheaper labour'. And that is why they are not convinced by the Industry 4.0 implementation process at that stage. Real understanding about the commitment of top management, investment of highly cost able technology, contribution and return of industry 4.0, easier business competitiveness and future economic spectrum are the important factors for company managements to make positive decisions.

All the opportunities in Industry 4.0 for sustainable production are increasingly attractive to consumers as well as the manufacturers. If Bangladesh is unable to adopt this new technology in time, owners have to lose their international market especially for RMG which are the most profitable at the present time. On the other hand, workers have a long experience and lot of skills and knowledge about this sector. So it is high time to study more, research more, gain ICT based knowledge and need in training regulations to link content from IT as well as integrated approach to create and confirm the favorable production environment by overcoming the challenges for implementing industry 4.0 on priority basis.

In this study, hurdles of the application processes are taken into account and their reasons are presented analytically. Related academicians, experts, researchers and industries can appreciate the factors that are feasible in these new technologies implementation processes and integrate their near future skillful destinations.

In future studies, considering the key elements and challenges as variables in the process of industry 4.0 implication the decision-making methods can be used as fuzzy multi-criteria level.

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7. NOMENCLATURE

Symbol	Meaning
RMG	Ready Made Garments
AHP	Analytical Hierarchy Process
ICT	Information and Communication Technology
IR4.0	Fourth Industrial Revolution
SMEs	Small and Medium-sized Enterprises
CR	Consistency Ratio
CI	Consistency Index

Conflicts of Interest: The author declares no Conflicts of Interest.

Appendix A: Questionnaire Table for Experts in support of Criteria Weight Calculation

There are 6 pairwise comparisons here. Please go through all.

Table 1: Scale of relative importance

Crisp Numeric Value	Linguistic Variable
1	Equally importance
3	Moderately importance
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7	Very strongly importance
9	Extremely importance
2, 4, 6, 8	Intermediate values importance
1/3, 1/5, 1/7, 1/9	Values for reciprocal comparisons

ICT Based Knowledge, B2									Policy Makers' & Corporate Leaders' Support, B1							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
Question 2:																
Infrastructure & Smart Machineries cost(Initial Cost),B3									Policy Makers' & Corporate Leaders' Support, B1							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
Question 3:																
Availability of Cheaper labour, B4									Policy Makers' & Corporate Leaders' Support, B1							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
Question 4:																
Infrastructure & Smart Machineries cost(Initial Cost), B3									Availability of Cheaper labour, B4							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
Question 5:																
Infrastructure & Smart Machineries cost(Initial Cost), B3									ICT Based Knowledge, B2							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
Question 6:																
ICT Based Knowledge, B2									Availability of Cheaper labour, B4							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9