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Own Brand Manufacturing (OBM) by Developing Country Suppliers: A Case Study on RMG Industry in Bangladesh

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Abstract

**Purpose:** The purpose of this study is to investigate how developing country suppliers upgrade themselves as own brand manufacturing (OBM) suppliers and what motivates and enables them to become OBM suppliers and how OBM suppliers enter into international market with their brands.

**Methodology:** Following qualitative research approach, multiple case study method has been applied for this study. Documentation, observation, and primary data collection were carried out through Focus Group Discussions (FGDs) and in-depth interview techniques and thereafter utilized for developing three cases. Through analysis of each case, summary findings have been derived.

**Results:** The study findings reveal that supplier firms’ vision, management capability, forecasting accuracy related to future market trends, as well as gaining experience due to working for a long-time with global garment buyers and retailers are the main driving factors that propel them into becoming own brand manufacturing (OBM) and international brand retailer.

**Research Implications:** This research would provide a clear and useful direction to the RMG suppliers of Bangladesh for their upgrading in the global supply chain.

**Limitations:** Due to time and resource limitations, we consider only three company cases to investigate the research problems. Future studies should consider more cases to explore better understanding as well as to make the findings more generalizable.

**Originality/Novelty:** A review of previous literature reveals that no previous study had addressed the mechanisms for Bangladeshi garment suppliers’ upgrading within the global supply chain. This study will open new research avenues for further studies in the field.

**Keywords:** Own Brand Manufacturing (OBM), Upgrading, RMG suppliers

*Corresponding Author*
Introduction:

Bangladesh is the second largest apparel exporting country in the world after China (WTO, 2018). Bangladeshi apparel manufacturers supply products for almost all of the leading global brands. The main market for Bangladeshi apparels is the US and Europe which constitutes more than 60% of the population (Khattak & Park, 2018). Though initially it was cheap labor that lured foreign buyers towards the Bangladeshi suppliers, several Bangladeshi apparel firms have taken this opportunity to further enhance their potential and strengthen their foothold by functional upgrading whereby they carry out more value added functions that give them a greater share of the profit as well as allows them to make their business model more sustainable. Moreover, in an increasingly competitive market place it has become imperative for Bangladesh apparel firm to follow the footsteps of many other firms from the developing countries that had earlier pursued functional upgrading and been able to establish themselves as international competitors. However, extant literature has given very limited attention to how garment suppliers of developing countries upgrade from one functional level to another functional level, and how their upgrading as own brand manufacturing (OBM) suppliers facilitate to become international brand retailers. Our study contributes to this less focused area.

The purpose of this paper is to investigate the functional upgrading and internationalization process of Bangladeshi apparel manufacturers through the case study method. Three cases from three apparel brands- Yellow, Sailor and Turaag has been selected to gain insights from their own brand development and internationalization efforts. BEXIMCO, Epyllion and Urmi Group are the parent organizations of these three brands respectively. These three companies’ are at three different stages of their functional upgrading. Similarly the three brands are also at different stages of their progression. Yellow had started its operations in 2004 went international in 2005. Sailor started in 2015 and has been targeting the local market and is yet to internationalize. Finally, Turaag on the other hand has launched itself as an international brand without considering the local market. Due to these diverse backgrounds of these three brands it would be useful to investigate their pathways and to understand the factors that contributed to the launch of their own brands i.e. functional upgrading as well as their journey into the overseas market i.e. internationalization.

The remainder of the paper has been structured into sections. The next section is literature review, then research design, description about case companies, followed by functional & operational upgrading, own brand manufacturing (OBM), and internationalization; that is followed by result & discussion, and in the final section concludes the study with implications.

Literature Review:

Although upgrading is a phenomenon found in every industry, it has a significant role in the apparel industry. The ability of every country to compete in the global arena primarily depends on its capability to innovate and upgrade (Porter, 1990). Upgrading allows apparel makers from the developing world to strengthen their foothold in the market. Even though most of them have mainly been focusing on cost competition, this is rather volatile as a competitive advantage (Tokatli & Kizilgün, 2004). Firms are under intense pressure to upgrade just to remain competitive (Humphrey & Schmitz, 2002). Kaplinsky (2000) and Porter (1990) both argue that upgrading is the best response to the competitive pressures. Despite being a lucrative opportunity, upgrading has still not been grasped by both hands by apparel firms in many parts of the world (Gereffi, 1997).

“Upgrading is an unending and complicated process that requires a consideration of the variety of ways in which firms can balance or replace manufacturing with higher value-added activities” (Tokatli, Toward a better understanding of the apparel industry: a critique of the upgrading literature, 2012). Moreover, making better products, making them more efficiently, or moving into moreskilled activities are also called upgrading (Kaplinsky, 2000) (Porter, 1990). Upgrading has also been defined as being a term to refer to the changing competitive position of the firm within the industry (Pickles, Smith, Bucék, Roukova, & Begg, 2006). Similarly, upgrading is also the
manner in which supplier firms and countries attempt to improve their standing in the global economy (Tokatli, 2006).

Humphrey & Schmitz (2002) classified upgrading along four dimensions: product, process, functional & inter-sectorial. The authors further elaborate that product upgrading takes place when firms offer more sophisticated product lines. Process upgrading implies the introduction of superior technology or production system. Functional upgrading refers to upgrading by acquiring new functions like designing and marketing. Finally, inter-sectorial upgrading is the application of competencies learnt from one sector to another sector. This has also been termed as chain upgrading (Kaplinsky & Morris, 2007).

Functional upgrading can further be typified into CMT (Cut, Make, Trim), OEM (Original Equipment Manufacturer), ODM (Original Design Manufacturer) and OBM (Original Brand Manufacturer) (Gereffi, Fernandez-Karina, & Frederick, 2011). Upgrading has been observed to follow mostly a common trajectory (Kaplinsky & Morris, 2007) (Gereffi G., 1999) (Lee & Chen, 2000). Firms have been found to move gradually from OEA (Original Equipment Assembling) to OEM to ODM to OBM (Kaplinsky & Morris, 2007). Accordingly, designing and branding are competencies which, if acquired, push the firms up the chain.

**Table 1: Different Stages of Functional Upgrading (Source: Gereffi et al, 2011)**

<table>
<thead>
<tr>
<th>Firm Role</th>
<th>Other names</th>
<th>Functions/Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sub-contractor</td>
<td>Assembler</td>
<td>Export-Platform Manufacturer Component supplier</td>
</tr>
<tr>
<td></td>
<td>Cut-Make-Trim (CMT) producer</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Jobber</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Second or Lower Tier Supplier</td>
<td></td>
</tr>
<tr>
<td>Original Equipment Manufacturer (OEM)</td>
<td>Commercial (Sub) Contractor Full package supplier Contractor Turn-key Supplier</td>
<td>Process and Production specialization</td>
</tr>
<tr>
<td>Original Design Manufacturer (ODM)</td>
<td>Supplier-Subcontractor</td>
<td>Independent supplier with full control over the development, design and fabrication of its product Design, Process and production specialization</td>
</tr>
<tr>
<td>Original Brand Manufacturer (OBM)</td>
<td>Independent exporter</td>
<td>OBM designs, markets, and even sometimes retail own brands, actual production often becomes less important Product and Marketing specialization</td>
</tr>
</tbody>
</table>

The foremost necessity for upgrading is for the firm to have a strategic intent to move up the value chain (Humphrey Schmitz, 2002) (Bell, 1984). Another issue of utmost importance is the capability of the upgrading firm to make financial investments (Humphrey & Schmitz, 2002). In addition, Organizational learning provides the vital impetus to firms for upgrading (Gereffi, 1999). Porter (1990) argued that countries qualify as upgrading candidates once they achieve comparative advantages in capital as well as in skill intensive industries. In this regard, Gereffi, et al (2011) have emphasized on the need for workforce development in order to avail the upgrading opportunities that are on the offer especially for the developing economies. Knowledge transfer has been found to be a significant enabler for facilitating upgrading in the developing countries (Zhu & He, 2018). Zhu & He(2018) identified that local untraded interdependencies and systems of social interaction along with local institutions enable firms to upgrade. Large and mature firms are the likely ones to upgrade and establish the trend in their industry (Zhu & He, 2018). Interestingly
Zhu & He (2018) questioned the role of export market in facilitating upgrading. They rather argued that in order to carry out functional upgrading, being a participant in both the local and the global market is highly significant.

Upgrading can be attributed to a large part on the historical, political, institutional and economic backgrounds amidst which the production networks are typically located (Zhu & He, 2018). Zhu & He (2018) further argues that adopting market orientation by the government allows “A stable and transparent business environment, characterized by low institutional barriers and bureaucratic costs as well as efficient market competition”. This also opens up the globalization of the country’s economy. Moreover, such policies facilitate knowledge spillover from foreign to domestic firms (Zhu & He, 2018). In the process it lowers the barriers for upgrading. Nevertheless, firms need to take into consideration the potential barriers to upgrading as well.

Previous studies have identified the existing power relationships as the major hurdle in upgrading (Tokatli & Kizilgun, 2004). Upgrading efforts except the functional upgrading ones are also in the interest of the buyers (Tokatli, 2012). In fact in many cases production upgrading is a demand made by the buyers (Giuliani, Pietrobelli, & Rabellotti, 2005).Lead firms have been found to have considerable power in global sourcing which plays arguably one of the most crucial roles in determining the global value chain (Zhu & He, 2018). Firms with greater power do not facilitate emergence of competitors through the process of upgrading. Studies have also revealed that buyer resistance as well as resource requirements both act as barriers to upgrading. Even though global buyers are typically a highly prospective starting point for apparel manufacturers in the developing economies (Habaradas & Tolentino, 2010) studies have also revealed that buyers very protective of their intangible assets that makes them the dominant player in the value chain (Tokatli, 2006).

Despite existing power relationships, apparel firms in Slovakia have been able to upgrade into OBM (Smith, 2003). Therefore, understanding dynamic and fluid power relations is the key to overcoming the power resistance in upgrading (Smith, 2003). Nevertheless, global buyers have been found to be the key force in accommodating upgrading efforts by supplier firms (Gereffi, 1997). This is also substantiated by Schmitz (1999) when he found footwear manufacturers in Brazil too reliant on a handful of buyers who constituted the bulk of orders received. Zhu & He (2018) has also reported that quasi-hierarchical chains act as a barrier to upgrading. Such relationships locks up their exit option limiting chances to move upwards in the chain (Humphrey & Schmitz, 2002). Firms from the developing world also find it challenging to undertake functional upgrading due to substantial financial requirements which also come along with considerable risks (Bair & Gereffi, 2001). Government initiatives can lessen risks in functional upgrading (Kaplinsky & Morris, 2007).

There is a significant role of the government in establishing both local and national systems of innovation and human resource development that enables firms to take the opportunities for upgrading that come their way (Habaradas & Tolentino, 2010). Supporting role played by the government has allowed firms to undergo industrial upgrading and in the process made them more competitive in the world market (Hsu & Chiang, 2001). Not only does the role of the central government policies contribute to the national upgrading efforts; local governments have also emerged as a catalyst for upgrading efforts in countries where they exist (Zhu & He, 2018). Establishing and funding R&D centers and sharing their findings with the private sector for commercialization has been a cornerstone of the Taiwanese government’s contribution to industrial upgrading (Hsu & Chiang, 2001). Moreover, lifting of government restrictions to facilitate free market principles has allowed firms in China to enhance their upgrading initiatives (Zhu & He, 2018). Zhu & He (2018) has also found that local government supports accelerates the pace of upgrading. In China, government has paved the way for firms to relocate in order to reduce their space costs and invest these savings into upgrading efforts (Zhu & Pickles, 2014). Government initiatives in the form of decentralization, allows firms to take advantage of cost cutting opportunities (Zhu & He, 2018). In addition, smaller firms are more reliant on government support than larger firms (Zhu & He, 2018). Furthermore, governments are the decision makers in macro policies and institutional linkages which are different from measures taken to enhance firm-level competitiveness (Kaplinsky & Morris, 2007). At the same suppliers have to proactively initiate upgrading measures to move up the chain.

Suppliers carry out a key role in the global apparel value chain. Buyers from developed world have become more and more vulnerable to failures on part of the suppliers due to more and more emphasis being given to factors like quality, response time and reliability of delivery (Humphrey & Schmitz, 2000). Large and mature firms are blessed with both tangible and intangible assets compared to smaller firms; this enables them to take upgrading measures
and a more likely contender to functional upgrading (Brock & Evans, 1989) (Mayo & Murray, 1991). Zhu & He (2018) argues that firm specific characteristics have a significant role in moderating the effects of various forces that impact upgrading. They further found that global linkages have lesser impact on upgrading for larger firms; in some rare occasions larger firms even had to downgrade from OBM/ODM to CMT to supply global buyers (Zhu & He, 2018).

Research Design:

This paper follows the case study method of qualitative research to examine three cases from the Bangladeshi apparel sector firms to investigate the factors that had contributed to their functional upgrading as well as their motivation for internationalization. These cases have been developed by conducting a Focus Group Discussions (FGDs) comprising representatives from the selected garment supplier firms. Few in-depth interviews with responsible managers have taken from each case company. Different levels of managers from the same supplier firm had been interviewed to ensure data triangulation. The interviews were recorded and took live notes. Interview records were transcribed to report them accurately. Previous studies in the field have also been reviewed to gain a better understanding of the phenomenon of functional upgrading. Collected qualitative data analyzed and results presented in tabular form.

Description about case companies:

Case Company One: BEXIMCO

BEXIMCO group is the largest private sector group in Bangladesh. It was founded in the 1972 by two siblings-Ahmed Sohail Fasirur Rahman and Salman Fazlur Rahman. From being a commodity trading company in the early years, it now has established its strong foothold in a host of industries. This includes textiles, trading, marine food, real estate development, hospitality, construction, information and communication technologies, media, ceramics, aviation, pharmaceuticals, financial services and energy. The Group consists of four publicly traded and seventeen privately held companies. It is also the largest private sector employer in the country with a total of 70,000 employees across the globe.

BEXIMCO encompasses one of South Asia's largest vertically integrated textile and garment companies. Having commenced its commercial production in 1990, the textile division BEXIMCO Textiles (Bextex) is a fully integrated manufacturer of cotton and polyester blended garments for men, women and children, both for domestic and export markets. Currently with a 5181 strong manpower Bextex is equipped with the latest state of the art technologies and also boast of being the most modern composite mill in the region.

Case Company Two: Epyllion

Epyllion Group started its journey as a house of Readymade Garments (RMG) engaged in manufacturing and exporting of Knit Apparels since 1994 and has been considered today as one of the biggest conglomerates with substantial establishment of its backward linkage of all kinds of knit garments, textile, wet processing & garments accessories. It has state of art vertically integrated garments manufacturing facility.

Founded by a banker turned entrepreneur Mr. Reazuddin Al Mamoon, Epyllion started its journey in 1994 through Dekko Knitwears Limited. Since its inception it has focused more on apparel manufacturing to cater to the needs of the foreign buyers. In 2013, in an attempt to diversify its portfolio, it has also ventured into the food and beverage market through Epyllion Food & Beverage Limited (EFBL). The bulk of its exports go to Europe (89.03%) but the US, Asia as well as Africa is also its destination markets. Currently round 17000 people work at Epyllion.

Case Company Three: Urmi Group

Currently headed by Mr. Asif Ashraf, Urmi group comprises of textiles, garments, shipping, embroidery, printing and washing units. Established in 1958 as a brick field company, it entered into the apparel industry in 1984 with the introduction of Urmi Garments Limited. Since then the company has grown into a trusted supplier of a number of
global brands. It currently employs over 8000 people including 250 professionals. It acquired seamless technology in 2016 and thus reached an important milestone in the history of the company.

Table 2: BEXIMCO, Epyllion and Urmi at a glance (Source: Compiled by the authors)

<table>
<thead>
<tr>
<th></th>
<th>Beximco Textiles</th>
<th>Epyllion Group</th>
<th>Urmi Garments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year of Incorporation</td>
<td>1984</td>
<td>1994</td>
<td>1958</td>
</tr>
<tr>
<td>Commencement of Commercial Production</td>
<td>1990</td>
<td>1994</td>
<td>1984</td>
</tr>
<tr>
<td>Number of Employees</td>
<td>5181</td>
<td>17000(Approx)</td>
<td>8667</td>
</tr>
<tr>
<td>Annual Turnover (2018)</td>
<td>$500m (approx)</td>
<td>$180million</td>
<td>$168million</td>
</tr>
<tr>
<td>Production Capacity</td>
<td>28 Million Linear Meters per year</td>
<td>Knitting 30,000 kg/day Dyeing 30,000kg/day Finishing 30,000 kg/day 92000 pieces of garments per day</td>
<td>30 tons of Fabrics &amp; 160,000 pieces of apparel per day.</td>
</tr>
<tr>
<td>Key Clients</td>
<td>Phillips Van Heusen, JC Penny, Zara, H&amp;M, etc.</td>
<td>C&amp;A, G Star, Celio, Marks &amp; Spencer, S.Oliver, etc.</td>
<td>Marks &amp; Spencer, S.Oliver, H&amp;M, Puma, etc.</td>
</tr>
<tr>
<td>Export Destinations</td>
<td>N/A</td>
<td>N/A</td>
<td>Europe-77%, Japan-9%, Australia-4%</td>
</tr>
</tbody>
</table>

**Functional & Operational Upgrading:**

**BEXIMCO:**

Since its inception, BEXIMCO had relentlessly endeavored to achieve both operational and functional upgrading. Realizing the potential of increased profit from upgrading it had invested in the purchase of state of the art production machineries that helped it to upgrade its operations and serve new global buyer segments. In 1994, it established BEXIMCO Synthetic that gifted it with the opportunity to meet the needs of new buyers. However, its major breakthrough for functional upgrading came when in order to serve the foreign clientele. BEXIMCO established a dedicated design team with offices in Dhaka and Barcelona. Furthermore it also had partnered with some of the world’s renowned design institutes, including Fashion Institute of Technology, Parsons, London School of Fashions, NIFT and NID, for access to talented designers. This design capability enriched BEXIMCO with the requisite skills to eventually launch its own brand Yellow.

**Epyllion Group:**

Epyllion group started off its operations in 1994 with only two sewing lines and two hundred workers. Later on it moved up the value chain and became an Original Equipment Manufacturer (OEM) firm. It acquired machineries to enhance its capabilities to manufacture synthetic apparels. Moreover, it established its own packaging, printing units that not only serve its own requirements but also outsource for other apparel manufacturers. One key aspect of Epyllion’s upgrading has been the establishment of Epyllion Testing Lab Limited (ETLL) in 2012 which is a hallmark to the quality maintenance that the company is committed to. Environmental upgrading has also been
prioritized by Epyllion and Effluent Treatment Plant (ETP) is evidence to that. Epyllion’s functional upgrading was boosted by the launching of a design studio for Sailor in 2016 that promoted it to become an ODM.

**Urmi Group:**

Urmi launched its journey in 1984 as a CMT firm. For a number of years it served as an OEM for the global buyers. In 2006 Urmi started their own synthetic manufacturing that opened up new avenues for global opportunities. It also achieved LEED certificate that highlights its environmental upgrading. Furthermore it initiated its in house printing unit with foreign collaboration. Urmi focuses a lot on training their employees in order for them to enhance their productivity. Its giant leap came in 2016 when it imported forty Santoni machines from Italy to manufacture seamless apparels for a huge segment of global buyers. This ultimate led to the emergence of their own brand of active wear.

**Table 3: Operational & Functional Upgrading at Bextex, Epyllion & Urmi (Source: Compiled by the authors)**

<table>
<thead>
<tr>
<th></th>
<th>Bextex</th>
<th>Epyllion</th>
<th>Urmi</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CMT/OEM</strong></td>
<td>1984</td>
<td>Started as a sub-contractor/CMT in 1994 with 2 (two) sewing lines and total of 200 workforce.</td>
<td>1984</td>
</tr>
<tr>
<td><strong>Synthetic</strong></td>
<td>Beximco Synthetics Limited in operation since July 1, 1994</td>
<td>Manufactures various tapes from cotton, polyester and synthetic yarn.</td>
<td>Synthetic unit in operation since 2006.</td>
</tr>
<tr>
<td><strong>Packaging</strong></td>
<td>18 million pieces of high quality cartons capacity per year.</td>
<td>Carton 21,600,000 pcs/year (auto &amp; semi-Auto) Duplex Board : 197,436 doz/year Poly: 1,440,400 kg/year</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Printing</strong></td>
<td>In house flatbed printing facility</td>
<td>High definition printing &amp; embroidery services since 2014.</td>
<td>Dots &amp; Marks Printing Facility (2008)</td>
</tr>
<tr>
<td><strong>Environmental Upgrading</strong></td>
<td>The company uses only AZO-free dyes and is dedicated to ensure a healthy and eco-friendly environment.</td>
<td>Effluent Treatment Plant (ETP)(Chlorine, Chemical &amp; Biological ETP)</td>
<td>LEED certified green factory (2015)</td>
</tr>
<tr>
<td><strong>Unique Products</strong></td>
<td>Wrinkle free product CORTEK 2000 COTRA DP 3.5+</td>
<td>N/A</td>
<td>Went seamless in 2016 with import of Santoni Machines from Italy.</td>
</tr>
<tr>
<td><strong>Design Capability Leading to ODM</strong></td>
<td>In-house design capabilities with teams based in Bangladesh and Spain (BEXIMCO Barcelona design studio).</td>
<td>launched dedicated design Studio for Sailor in 2016.</td>
<td>Started offering design to buyers from 2016. Design team headed by an expert from abroad.</td>
</tr>
<tr>
<td><strong>OBM</strong></td>
<td>2004: Yellow</td>
<td>2015: Sailor</td>
<td>2018: Turaag</td>
</tr>
</tbody>
</table>
Own Brand Manufacturing (OBM):

**Yellow:**

Yellow is an initiative by BEXIMCO that started in 2004. It is the pioneer in introducing a brand by an apparel exporter. It was established to cater to the need of the upper middle class customers by providing them with high quality international standard fashion wear locally. It has defined its market segments into men, women and kids categories. Moreover, its product line includes a wide range of fashion clothing, fragrance, and accessories for men, women and children; textiles for home decoration; avant-garde ceramic items; paintings as well as books. It offers ethnic, formal and casual wears to its customers with the ethnic wear market being the most dominating. Yellow manufacturers all its apparels in house using their own resources. Yellow currently has 19 retail outlets of which 15 are in Bangladesh and 4 are in Pakistan. It had also had a brief retail presence in South Korea. Apart from its retail outlets operating at carefully chosen attractive locations, Yellow has a strong online presence with a 24 hour online store that offers customized clothing for its customers. Yellow has its own design studio of which 30% are foreign designers to cater to the fashion needs of its customers.

**Sailor:**

Epyllion group launched its own brand Sailor with the slogan „Sailing life” in 2015 eyeing to have a share of the $5billion local fashion industry (Mirdha, 2015). It opened two retail outlets in Dhaka on successive days at two prominent locations in the city to draw the attention of the fashion industry. Sailor offers high-end cloths and accessories for men, women and children. They have four product lines called labels to cater to the needs of four different segments. The Black Label offers formal and luxurious clothing, Orange Label offers casual wears that complies with the latest trends and appeals to the youth. Heritage Label offers traditional dresses to serve those who prefer traditional attires. Finally, Green Label offers fashion wears for kids with a carefree and youthful theme. Sailor established a design studio for itself in 2016 to add more creativity to the pattern of clothing that they offer to the market (UNB, 2016). It has a local pool of designers to meet the fashion demands of the local market. Sailor manufactures only a part of its total production in-house while it has to depend on outsourcing for the remaining production. Sailor is now focused on country wide expansion having a total of thirteen outlets of which there is one each in Chittagong, Comilla and Mymensingh.

**Turaag:**

Turaag is an activewear brand offered by Urmi using the online platform keeping in mind the needs of a Western audience. The focus is on offering an international standard product at a better price to the target market. It was launched in late 2018 is still in its very early days. It does not have any outlets to sell its products and also do not have a different design studio separate from Urmi garments. It is manufacturing its batches of products in-house.

**Table 4: Yellow, Sailor & Turaag at a glance (Source: Compiled by the authors)**

<table>
<thead>
<tr>
<th></th>
<th>Yellow</th>
<th>Sailor</th>
<th>Turaag</th>
</tr>
</thead>
<tbody>
<tr>
<td>Launch</td>
<td>2004</td>
<td>2015</td>
<td>2018</td>
</tr>
<tr>
<td>Manpower</td>
<td>900(approx)</td>
<td>200</td>
<td>N/A</td>
</tr>
<tr>
<td>Target Audience</td>
<td>Both Local and International</td>
<td>Local</td>
<td>International</td>
</tr>
<tr>
<td>Product Type</td>
<td>Formal, Casual, Ethnic and Kids wear</td>
<td>Formal, Casual, Ethnic and Kids wear</td>
<td>Activewear</td>
</tr>
<tr>
<td>Competitive Priority</td>
<td>Quality</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distribution Strategy</td>
<td>Through Retail Outlets and 24/7 online service</td>
<td>Through Retail Outlets</td>
<td>Online only</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>In-house</td>
<td>In-house and sub-contracting</td>
<td>In-house</td>
</tr>
</tbody>
</table>
Internationalization:

Yellow:

Realizing the limited growth opportunities in the US and European buyer markets as well as due to the low profit margin while acting as suppliers to global brands had propelled BEXIMCO to launch their own brand Yellow. Parent company patronage plays a pivotal role in upgrading (Humphrey and Schmitz, 2002). Yellow did not take too long to expand their business largely due to the fact that the parent firm BEXIMCO had huge resources and was willing to commit resources for Yellow (Ahmed et al, 2016). Moreover, the huge potential in the east rather than in the west was also played a role in focusing on markets eastward. After opening local outlets in 2004, BEXIMCO entered the Pakistani fashion market by opening their own Yellow retail outlet in 2005. It had opened its first outlet in Karachi and later expanded to Islamabad and Lahore. In order to adapt to the Pakistani audience Yellow had extended its product line to include a line of modest clothing called Mariamah. One key motivation for Yellow was the availability of cheap fabric from Pakistani suppliers which made it easy for Yellow to produce in Pakistan. Moreover, the rich supply of lawn cloths allowed it to introduce the Luxury Lawn product line. Keeping in line with its focus on the East Asian market, Yellow expanded their retail operations to South Korea through opening an outlet in Seoul. But they later withdrew from the market for mainly two factors. Firstly, Korean customers preferred online stores which Yellow did not have. Secondly, there was a clear psychic distance between Korean and Bangladeshi customers’ fashion preferences which Yellow could not address (Ahmed et al, 2016).

Turaag:

Having been a supplier for globally acclaimed activewear brands, Urmi group was motivated to launch their own brand in this particular product category. This also provided them with an opportunity to diversify their business and move towards business sustainability. Achieving operational upgrading in the form of seamless technology proved to be a decisive factor that equipped them with the technical know-how. Moreover, the preference of global customers to purchase online was a fact that boosted their chances of being successful. Online strategy cuts down cost to a great extent. This is primarily because it was difficult for them to commit resources for physical retailing. Furthermore, online strategy has allowed them to overcome overseas trading barriers that are in place. In addition, due to the higher price of the global brands they are able to locate a niche comprised of price sensitive customers.

<table>
<thead>
<tr>
<th>Number of Outlets</th>
<th>19 (15 in Bangladesh, 4 in Pakistan)</th>
<th>13</th>
<th>None</th>
</tr>
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Table 5: International Strategies of Yellow, Sailor and Turaag (Source: Compiled by the authors)

<table>
<thead>
<tr>
<th>Start of Operations</th>
<th>Yellow</th>
<th>Sailor</th>
<th>Turaag</th>
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<tbody>
<tr>
<td>Internationalization</td>
<td>2004</td>
<td>2015</td>
<td>2018</td>
</tr>
<tr>
<td>Entry Mode</td>
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<td>Online</td>
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<tr>
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<td>N/A</td>
<td>USA</td>
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<tr>
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<td>Ethnic wear, Casual wear, Formal wear, Kids wear</td>
<td>N/A</td>
<td>Activewear</td>
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<tr>
<td>Differentiation Strategy</td>
<td>Quality</td>
<td>N/A</td>
<td>Price</td>
</tr>
</tbody>
</table>
Results & Discussion:

Own Brand Manufacturing (OBM) is an essential requirement to move up the value chain and a right step towards business sustainability. Bangladesh has a long history and reputation of being a reliable supplier of almost all reputed global brands. However, catering to the needs of the foreign buyers does not guarantee functional upgrading by itself unless the firm undertakes conscious efforts to develop their capabilities. This is evidenced by the fact that most of the suppliers in Bangladesh have not yet developed themselves into Own Design Manufacturing (ODM), let alone developing their own brands.

Firms that have been able to introduce their own brands have been able to do so because they have taken initiatives not only for functional upgrading but also because they had incorporated operational upgrading in the form of improving their production capabilities through purchase of up-to-date technologies. Firms that have imported machineries specific for synthetic fabric production or for seamless fabric production, had through such measures opened up a whole plethora of opportunities. Firstly, this allowed them to manufacture products that they could not supply earlier. Secondly and most importantly, the operational upgrading efforts enable them to upgrade functionally as well. This is particularly evidenced by the launch of Turaag activewear.

Similar to decisions to achieve operational upgrading, functional upgrading also depends heavily on the farsightedness, commitment and support provided by the top management. In most cases it is the visionary leadership skills that allow a firm to launch a brand on their own. Sailor is a good example of where the entrepreneur’s personal vision led to the emergence of an own brand. Moreover, Epyllion envisions Sailor to emerge as its flagship brand and accordingly considers it as a very valuable part of its business. Likewise, BEXIMCO group has from the very beginning committed resources to the introduction, branding and internationalization of Yellow. Despite the high risk associated in expanding to foreign market especially through brand owned retail outlets, BEXIMCO has gone ahead with Yellow’s internationalization efforts.

Internationalization by Bangladeshi firms present diverse models with intriguing insights. Yellow had expanded through their own retail operations into Pakistan which is culturally more akin to Bangladesh because of having a Muslim population. On the hand Korea is different culturally but was targeted mainly because East Asia is considered to be the emerging market for apparel brands. In terms of their distribution strategy of being reliant on their own retail outlets, Yellow has added online retailing to their retailing repertoire. On the contrary, Sailor has concentrated on the local market and is primarily focused on local expansion through their own retail outlets. Nevertheless, they have launched their own brand and have achieved functional upgrading. In contrast Turaag did not attempt to enter the local market at all and launched their activewear product keeping in mind the foreign customers as the target segment. Moreover, quite distinct from the Yellow model of expansion through retail outlets, they have gone for online retailing. This speeds up the internationalization efforts of firms willing to take their brands overseas.

Foreign buyers have not been found to be hostile to functional upgrading of Bangladeshi suppliers unlike previous studies where buyers have been found to be particularly hostile towards functional upgrading though accommodating to operational upgrading (Tokatli, 2012). This also maybe partly attributed to the preventive measures taken by the Bangladeshi suppliers. Suppliers that have developed their own brands have in most cases established separate design studios for the buyers and for the brand. This ensures that buyer’s terms and conditions are maintained and buyers do not feel threatened to lose their intellectual property. In addition, due to the lack of skilled manpower, buyers also do not foresee Bangladeshi suppliers as being their competitors in the global market. This also contributes to their secured feeling.

Conclusion and Implications:

Functional upgrading has been taken up by several Bangladeshi firms through establishing their own design units and subsequently launching their own brand. This paper investigates the functional upgrading efforts by selected
Bangladeshi firms and their internalization strategies. The case studies presented in this paper delineates three different apparel manufacturing firms pursuing three different models of internationalization. Firms in this sector contemplating functional upgrading would find these models very useful to consider them as alternatives. Moreover, the paper also highlights the necessity to upgrade operationally as it complements the efforts for functional upgrading.

References


**Biography of the Authors:**

Mahmudul Hasan Fouji, Assistant Professor, Department of Marketing, Jagannath University, Dhaka, Bangladesh completed MBA and BBA with major in marketing from the University of Dhaka and has more than twelve years of teaching experience in the field of marketing at both the under graduate and the graduate level.

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A Case Study on the Improvement of Working System in a Garment Industry using 5S Methodology

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Abstract- The improvement of an organization depends on the various way of conducting business policy. The old business models no longer work in the new economy. Using 5S in an organization, the improvement of any working system has occurred through time management and cost optimization. This paper deals with the improvement, benefits, and challenges of 5S and identified the key factor influencing the successful implementation of 5S methodology in the Garment industry. The objectives of this paper are to improve the working system of Garments, applying the 5S methodology and satisfying anticipated demand. In twelve weeks survey in a garment industry, by using 5S methodology at that industry the improvement shows that 5S reduces waste in all forms, cuts down employee frustration, improve safety, and creates a visually attractive environment and finally results in state that the improvement of production system efficiency varies 10-15% from its present efficiency.

Keywords: 5S, Time management, Cost optimization, working condition, Efficiency improvement.
1.0 Introduction

5S is an approach to organize, order, clean, standardize and continuously improve a work area. It is one of the applied working elements of Lean Manufacturing. The program gets its name from five activities beginning with the letter S, which were resulting from five Japanese words. The words are Seiri, Seiton, Seiso, Seiketsu, and Shitsuke, which translated mean Sort, Set in Order, Shining, Standardize, and Sustain, respectively. Sort helps to remove all unneeded items; only what is needed stays. Set establishes locations and quantities needed for efficient operation. Shine represents cleaning through inspection. Standardize implements visual displays and controls. Sustain helps to keep the organization effort in place through training and total employee involvement. [1]

Many manufacturing facilities have opted to follow the path towards a “5S” workplace organizational and industrial methodology as part of continuous improvement or lean manufacturing processes. 5S is a system to reduce waste and optimize productivity through maintaining an orderly workplace and using visual cues to achieve more consistent operational results. 5S programs are usually implemented by small teams working together to get materials closer to operations, right at workers’ fingertips and organized and labeled to facilitate operations with the smallest amount of wasted time and materials. The 5S system is a good starting point for all improvement efforts aiming to drive out waste from the manufacturing process, and ultimately improve a company’s bottom line by improving products and services, and lowering costs. Many companies are seeking to make operations more efficient, and the concept is especially attractive to older manufacturing facilities looking to improve the bottom line by reducing their costs.

“A place for everything and everything in its place” is the mantra of the 5S method, and storage and workspace systems such as those provided improved organization and maximum use of cubic space for the highest density storage. The result is an improved manufacturing process and the lowest overall cost for goods produced. [2]

2.0 History of 5S Methodology

5S was developed in Japan. It was first heard of as one of the techniques that enabled what was then termed ‘Just in Time Manufacturing’. The Massachusetts Institute of Technology’s 5-year study into the future of the automobile in the late 1980s identified that the term was inappropriate since the Japanese success was built upon far more than components incoming only at the time of requirement. John Krafcik, a researcher on the project, ascribed Lean to the collective techniques being used in Japanese automobile manufacturing; it reflected the focus on waste in all its forms that was central to the Japanese approach. Minimized inventory was only one aspect of performance levels in companies such as Toyota and in itself only arose from progress in fields such as quality assurance and Andon boards to highlight problems for immediate action.

5S was developed by Hiroyuki Hirano within his overall approach to production systems. Many Western managers coming across the approach for the first time found the experience one of enlightenment. They had
perhaps always known the role of housekeeping within optimized manufacturing performance and had always known the elements of best practice. However, Hirano provided a structure for improvement programs. He pointed out a series of identifiable steps, each building on its predecessor. Western managers, for example, had always recognized the need to decide upon locations for materials and tools and upon the flow of work through a work area; central to this is the principle that items not essential to the process should be removed – stored elsewhere or eliminated completely. By differentiating between Seiri and Seiton, Hirano made the distinction explicit. He taught his audience that any effort to consider layout and flow before the removal of the unnecessary items was likely to lead to a sub-optimal solution.[3]

3.0 Garments Sector’s prospect in Bangladesh

Garments sector plays an important role in the total economy of Bangladesh. Now-a-days Ready Made Garments (RMG) sector is a multi-billion-dollar earning business and export industry in Bangladesh. Therefore, this sector is number one earner of foreign currency in Bangladesh. The journey of garments sector in Bangladesh has been started in 1980s since then; this sector did not require for looking back. Garments sector improves our GDP, which makes us new rising countries on the earth. [7]

4.0 Improvement Methodology

5S is also known as technique of reducing waste, improving productivity and clear visibility of none Conformances at workplace. Changed in Japan, 5S has been adopted worldwide to transform the working condition towards excellence. The procedure has 5 key steps each of the step starting with a Japanese word which gives a sound of “S” therefore known as 5S. Those steps are as follows-

1- SEIRI means SORTING
2- SEIKETSU means STANDARDIZE
3- SHITSUKE means SUSTAIN
4- SEITON means SET IN ORDER
5- SEISO means SHINE

4.1. Seiri (Sorting)

Seiri is sorting through the contents of the workplace and removing unnecessary items. This is an action to identify and eliminate all unnecessary items from the workplace.

- Look around the workplace along with colleagues to discover and identify items which are not needed and not necessary to complete work.
- Develop criteria for disposal for not-needed items.
- Take “before” photographs wherever it is required.
- An effective method for recording progress is to tag the items not needed. This visual control of the not-needed items is often called red tagging.
- Find a holding area to put red tagged items.
- Classify the items by frequency of use.
- Items or equipment used once a week should be kept within the work area.
- Items or equipment used less frequently should be stored in a more distant location.
- Unneeded or unnecessary items should be stored in the holding area.
- Individual departments should each have a holding area.
- Dispose all items which are broken or have no value.
- Take “after” photographs wherever it is required.
To sort and classify means to divide and arrange according to type, size, categories or frequency are use, labeling with different colors (green, yellow, red, blue) and place in special locations.

- Make sure that all unnecessary items are eliminated from the workplace.
- Taking into account of the work flow, decide which things to put where.
- Take “before” photographs wherever necessary.
- Also decide with colleagues about which things to put where from the point of view of efficient operations.
- Make a plan based on the principles and locate things accordingly.
- Use 5Whys to decide where each item belongs.
- Locate needed items so they can be retrieved in 30 to 60 seconds with minimum steps.
- Make sure to inform everybody at the workplace about positioning of the items.
- Make a clear list of items with their locations and put it on lockers or cabinets.
- Label each locker/drawer/cupboard to show what is kept inside.
- Identify all needed items with labels.
- Take “after” photographs.

4.3. **Seiso (Shining)**

Seiso involves cleaning everything, keeping it clean daily, and using cleaning to inspect the workplace and equipment for defects. This is an action to clean the workplace daily.

Workplace daily clearing before sewing in garments

Clean workplace during production process

- Take “before” photographs.
- Adopt cleaning as a daily activity and as a part of inspection. Clean the workplace before starting the job and before closing the job.
- Put aside 10 or 15 minutes for the same activity per day.
- Cleaning indirectly helps to check or inspect each and every part and place. Hence, it should be a habit.
- Find ways to prevent dirt and contamination.
- Clean both inside and outside on daily basis.
- Identify and tag every item that causes contamination.
- Develop a plan, activity chart and distribute responsibility.
- Take “after” photographs.
- In addition to 10 to 15 minutes for Seiso every day, owners should have a weekly 5S time.

4.4. **Seiketsu (Standardize)**

Standardize is the process of ensuring that what we have done within the first three stages of 5S become standardized; that is we ensure that we have common standards and ways of working. Standard work is one of the most important principles of Lean manufacturing.

- Take “before” photographs.
- Check that the first three S’s are implemented properly.
- All team activity documents should be publicly displayed on a 5S board.
- Create procedures and forms for regularly evaluating the status of the first three S’s.
- Standardize red tag procedures and holding area rules.
- Standardize procedures for creating shadow boards, position lines, and labeling of all items.
- Standardize cleaning schedules using the “5S Owner Check Sheets”
- Create a maintenance system for housekeeping. Make a schedule for cleaning of the workplace. A common approach is to ask a cross-functional team to do it.
- Assign responsibility to individuals for a work area and machinery.
- Regular inspection/audit and evaluation by a special team to be continued.
- Instead of criticizing poor cases, praise and commend good practices or good performers.
- Take “after” photographs and post them on the 5S board(s)

4.5. **Shitsuke (Sustain)**

The final stage is 5S Shitsuke or sustain, ensuring that the company continue to continually improve using the previous stages of 5S, maintain housekeeping, and conduct audits and so forth. 5S should become part of the culture of the business and the responsibility of everyone in the organization.

- Everyone in the workplace should treat it they would their own home.
- Periodic facility management involvement is required to check that the first four S’s are implemented perfectly.
- Employees must make it a part of their daily work and not an action forced upon them.
- Dedication, commitment, devotion and sincerity are needed in implementation of 5S on daily basis.
- Senior management should initiate a celebration for the total 5S implementation, and be an active part in the total process in initiating and carrying forward the program.
- Senior management should do a periodic review of the status of 5S.
- Inspections of first three S’s should be done and the results displayed on 5S board regularly.
5.0 Data Calculation

- Single point lessons should be used to communicate the standards for how 5S work should be done.
- Root causes because problem-solving process should be in place where root causes are eliminated and improvement actions include prevention.
- Owners conduct 5S Kaizen activities and document results. Owners complete daily check sheets to control factors that accelerate deterioration of equipment, and to keep clean workplaces that help build pride.

5.1 Improvement of Sewing Section by Applying 5S Methods

We take two renowned garments in Bangladesh for our paper work. One is viyellatex another is saver textile. Here we try to show that how to improve an export order production procedure by the help of 5S application.

5S Concept

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<th>Buyer</th>
<th>Order No</th>
<th>Item</th>
<th>SMV</th>
<th>FOB</th>
<th>Cost/ M/C</th>
<th>Operator</th>
<th>Helper</th>
<th>Total Manpower Hour</th>
<th>Production Value</th>
<th>M/C Cost</th>
<th>Efficiency</th>
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Analysis

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6.0 Graphical Analysis

Here we try to show by graphically major key point such as helper, total man power, production, production value, sport, defects, efficiency etc. By this graphical representation we can easily analysis the total process improvement. Initially we don’t apply 5S and get results after then we used 5S methods and get improvements as follow diagrams.
Here we see that, by using 5S in the garment industry, the improvement of total production working system is occurred through time management and cost optimization. As above production data analysis, we can easily find out the improvement of working system in a garment industry by using 5S methodology.

8.0 Conclusion

9.0 Future Recommendation
10.0 References


Identification and Analysis (ANOVA) of Occupational Safety and Health Problems of Workers in a Ready Made Garment (RMG) Industry – A Case Study

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Abstract

Occupational health and safety (OHS) conditions improving are the major concerns, especially in RMG sectors in Bangladesh. Mismatch among worker task, environmental condition, ergonomics and workplace system design as well as unsuitable management succession which leads to workstation chancy, poor workers’ health and safety, equipment injuries, incapability, as a result reduces workers’ productivity and quality. Environment, Task and Management and Ergonomics or Human factors solicitation have been found to improve worker productivity and reduce cost of Production. These three factors have both direct and indirect effects on overall performance of workers and productivity. That’s why it would be enormously ponderous to achieve a company’s profit and benefit without giving proper consideration to these three factors. The primary study of this investigation was to conduct an assessment of occupational health and safety related problems in a ready-made garments industry. To find out the possible causes of poor working environment, besides different checklist as well as physical audit and different medical reports were used in the research to identify the problems. The results showed significant ergonomics, environment, task and management related problems that could be the major issues for the workers. Some major issues identified were hard physical work as a result suffering of back pain, headache, allergy, fatigue, besides hot environment, long working shift, poor management and variegated schedule etc. An interview with managing of different questionnaire were asked then risk analysis, and measured working covenant to find out the possible causes of the problems. This research has some limitations as data have collected within a short time but there has lot of opportunity to further improvements in future work. This research is a case study and survey has been performed on Karim Textiles Ltd; Noorbag, Kaliakoir Gazipur, Dhaka.

Keywords OHS, ergonomics, environmental conditions, productivity, identify problem, risk, safety
Introduction

The Ready Made Garments (RMG) industries are playing as a key role for the economic development of Bangladesh. This industries have made crucial contribution for the development of the economy of Bangladesh. The Ready Made Garments (RMG) industries are bringing about more than 81% of the total export earnings for this country [1]. But sudden collapse of RANA Plaza in 2013 and then fire at Tazreen Garments it had come out strongly about the safety of workers to sustain this sector. All the people has realized that assuring safety and wellbeing of workers are the primary concern and it shared by the owners, buyers, government, international community as well as workers have to work hand in hand to assure a secure and sustainable progression of garment industry in this country [2]. The aim of the research was to find out the root causes that workers are suffering. During investigating the major issues were find out were ergonomic issues, OSH, environmental issues, task and management related issues deficiencies in industry. Workplace health, danger, low levels of security, demotivation, adequate lighting, ventilation, inter conflict among workers to management level, facilities are used etc. are reducing worker productivity and quality [3]. If Ergonomics issues, OSH policy and environmental issues properly be applied, these can eliminate or reduce problems in the workplace and enhance performance and productivity as well as safety. Lower lesion and heath means less medical indemnity besides less loss of productive hour this bring more production and financial benefited to the company. The installation of ergonomics, environmental factors and task and management related issues in improving OHS required to be investigated for the Garments industry. Here it was tried to show major issues how much related and risky to workers so that management can improve these to ensure the safety of workers as well as improve productivity.

2. Research Methodology

In this study, occupational safety and health related problems of garments worker are mainly focused. Other variables such as working conditions, working hour, environments conditions, task and management conditions and workers satisfactions and dissatisfactions about their works also considered. The study was conducted on Karim Textiles ltd at Noorbag, Kaliakoir Gazipur. The garments is 12 hour shift each day. A total of 100 workers were surveyed for the task analysis. While research study carried out, a set of questionaries’ were asked on interview, for collection and evaluation of data, and then risk analysis of workers’ in each job duties were determined and a rating was provided to list out which job was more critical to take immediate action. All workshops were visited and the questionnaires were completed by interviewing the weavers. In order to estimate the reliability of the responses to questions in the questionnaire, test-retest method was applied. The methodology for investigating ergonomics, and OHS in the selected industry involved development of and conducting a checklist that included questions on: (1) demography of the unit, (2) Environment related problems (3) Human related problems, (4) Task and Management related problems. The data were analyzed in terms of frequency of positive or negative response to each question. Analysis indicated that specific ergonomic problems, task and management related problems, environmental issues are exist in most of the garment.
Follow diagram of methodology for different steps are given below:

- **Step 1: Identifying the health and safety Problems**
- **Step 2: preparing questionaries’**
- **Step 3: Key information interview**
- **Step 4: Basic work function study**
- **Step 5: Risk Analysis of Workers’ Job Duties**

**Figure 1.0: Flow diagram for research methodology**
3. Basic Work Function among Different Factors

3.1. Environment related problem

There was a clear presentation of environmental problems in the industry [4]. Figure 5.0 showed the major environmental problems these are Dust, Noise, noise and hot environmental conditions appeared to be a major concern to the workers. Many of the workers suffer more than one problems in the workplace. Some conditions have reached beyond their tolerable limits. Workers showed their problem on the basis of suffering the problems and it’s were represent as magnitude of problems. Percentage of workers working conditions are given below.

![Figure 2.0: Environmental related problems of worker](image)

3.2. Human Related problem

Common human and ergonomics related problems have collected from the workers in cutting, sewing and finishing departments. Though ergonomics and human related information were available to the officers, it was not used properly or in formal procedure in all the section [5]. As it was required to provide a safe workplace, ergonomics is must to be considered in all work and resource design. The results are indicating that ergonomics were not widely applied in the workplaces accurately. This is probably due to lack of awareness and skills in ergonomics, and communication and resource constraints. It is found that most of the workers suffering diseases after starting work in the garments. Major problems related to different body parts are back pain, lower back pain, upper back pain, muscle pain, shoulder pain. Besides headache, skin diseases, asthma and allergy were significant to the workers. Some of the workers problem have reached severe but not yet taken proper treatment. The medical report show that major problems the workers bring out are result of either environmental nor task related problems or both. Lot of workers claimed that there were not proper treatment and medical facilities to them even sometimes they harassed to get initial or primary treatment. Data collected from cutting, sewing and finishing section of the industry is given below.
3.3. Task and Management related problems

While investigating and collecting information, it was found a clear task and management related issue in the industry. Bellow figure shows the major Task and Management related problems. These are indicating that there were most of the problems were behavior, work station condition and equipment they used were not comfortable to them. Workers pull different manual equipment’s but that were not considered in this section as they provided training because of they were unable to operate automatic machines.

4. Risk Analysis and Calculation

The ANOVA represent significant differences among problem areas of environmental factors, human factors and Task and management related factors into three major groups with eight elements of each factors. Variance found maximum on Environmental related factors and minimum on Task and Management related factors. Total sum of square has found about 3945 but mean square between and within the group is closed is 17029 and 171.67 that’s why F value found .9919. Degree of freedom between the groups is 2 and within the group is 21 so the total value is
& The $F_{crit}$ value is found 3.4668. Where $F$ value is .99192 which is less than $F_{crit}$. The resultant syndromes with $p$-values as present in Table is .3875 which was not so high. The results indicated that there were no meaningful difference among the problems of these three factors. These three factors are interrelated to each other.

### Table 1: ANOVA analysis for different factors

<table>
<thead>
<tr>
<th>Groups</th>
<th>Count</th>
<th>Sum</th>
<th>Average</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental factors</td>
<td>8</td>
<td>475</td>
<td>59.375</td>
<td>211.4107</td>
</tr>
<tr>
<td>Human Factors</td>
<td>8</td>
<td>429</td>
<td>53.625</td>
<td>129.1250</td>
</tr>
<tr>
<td>Task and management related factors</td>
<td>8</td>
<td>402</td>
<td>50.25</td>
<td>174.500</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>$F$</th>
<th>$P$-value</th>
<th>$F_{crit}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>340.5833</td>
<td>2</td>
<td>170.2917</td>
<td>0.99192</td>
<td>0.38755</td>
<td>3.4668</td>
</tr>
<tr>
<td>Within Groups</td>
<td>3605.25</td>
<td>21</td>
<td>171.6786</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>3945.833</td>
<td>23</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5. **Comparison and Correlations**

To parallel among facilities in terminology of problems, an analysis of variance (ANOVA) was carried out using as independent variable. The three problem areas environmental factors, human factors and Task and management related factors are considered in the analysis.

- Environment related factors (EF)—question related to environment, such as ventilation, heat, noise, light and dust, pollution etc.

- Human related factors (HF)—problems area to Human related factors, such as complaints of back pain, stress, muscle pain, upper body or neck pain, dissatisfaction, hand and wrist pain, headache, fatigue, ,

- Task and Management factors(TMF)—this factor related to Task and Management , such as manual materials handling, hand tools, machines, workstations, workers, worker motivation, facility and resources, and worker training. A correlation analysis with the survey attributes was conducted to identify if there was any relationship among these variables. The results showed highly positive and significant correlations between average number suffered by the individual area and problems related to Human factors, Task and Management factors, Environment factors related attributes. Table shows the correlation parameters between different three factors for individual problem areas.
Table 2: Significant correlations among different factors

<table>
<thead>
<tr>
<th></th>
<th>Environmental Factors (EF)</th>
<th>Human Factors (HF)</th>
<th>Task &amp; Management Related Factors (TMF)</th>
<th>EF+HF</th>
<th>HF+TMF</th>
<th>EF+TMF</th>
<th>EF+HF+TMF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental Factors</td>
<td>1</td>
<td>-0.2939</td>
<td>0.8920</td>
<td>0.7179</td>
<td>0.5542</td>
<td>0.9752</td>
<td>0.8756</td>
</tr>
<tr>
<td>Human Factors (HF)</td>
<td>-0.2939</td>
<td>1</td>
<td>0.2382</td>
<td>0.4545</td>
<td>0.5393</td>
<td>-0.2749</td>
<td>0.1503</td>
</tr>
<tr>
<td>Task &amp; Management</td>
<td>0.8920</td>
<td>0.2382</td>
<td>1</td>
<td>0.6579</td>
<td>0.6890</td>
<td>0.9698</td>
<td>0.89419</td>
</tr>
<tr>
<td>Related Factors (TMF)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EF+HF</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HF+TMF</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EF+TMF</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>EF+HF+TMF</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>

6. Risk Analysis of Workers Job Duties

The tool used ergonomically, RULA [6] [7] and risk of effect on body parts concept were used to check the environment of various job duties in Garments industry. It shows the observed rating of musculoskeletal load of job where worker face a risk of body. The risk, showed in a score of 1 (low) to 10 (high), which will then be categorized into five action levels to assess whether it is needed to initiate risk control.
Table 3: Risk analysis of workers job duties

<table>
<thead>
<tr>
<th>SI No.</th>
<th>Types of Work</th>
<th>Neck &amp; Shoulder</th>
<th>Arm &amp; Wrist</th>
<th>Upper &amp; Lower Back</th>
<th>Hips &amp; Thighs</th>
<th>Knees &amp; Ankles</th>
<th>Stress &amp; Fatigue</th>
<th>Final Score</th>
<th>Action Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lifting</td>
<td>8</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>5</td>
<td>8</td>
<td>45</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>Pulling &amp; Keeping</td>
<td>7</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>7</td>
<td>8</td>
<td>46</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>Washing on machine</td>
<td>6</td>
<td>7</td>
<td>6</td>
<td>6</td>
<td>7</td>
<td>6</td>
<td>38</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>Cutting</td>
<td>8</td>
<td>7</td>
<td>9</td>
<td>6</td>
<td>5</td>
<td>8</td>
<td>43</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>Labeling</td>
<td>5</td>
<td>5</td>
<td>2</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>26</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>Sewing</td>
<td>7</td>
<td>8</td>
<td>7</td>
<td>4</td>
<td>4</td>
<td>8</td>
<td>38</td>
<td>3</td>
</tr>
<tr>
<td>7</td>
<td>Ironing</td>
<td>7</td>
<td>8</td>
<td>6</td>
<td>5</td>
<td>5</td>
<td>8</td>
<td>39</td>
<td>3</td>
</tr>
<tr>
<td>8</td>
<td>Checking</td>
<td>5</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td>20</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>Packaging</td>
<td>7</td>
<td>4</td>
<td>6</td>
<td>5</td>
<td>3</td>
<td>5</td>
<td>30</td>
<td>2</td>
</tr>
</tbody>
</table>

Action levels have divided into five categories. According to severity of impact. The maximum score is five and from the risk analysis table we have found minimum level were 1. The action level and its impact is explain bellow.

Table 4: Action level and impact on worker

<table>
<thead>
<tr>
<th>Action level</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐</td>
<td>If it is not maintained or repeated for long time, then posture is acceptable indicated by score 1</td>
</tr>
<tr>
<td>☐</td>
<td>If it is not maintained or repeated for long time, then posture is partially acceptable indicated by score</td>
</tr>
<tr>
<td>☐</td>
<td>Investigation is Needed when indicated by score 3</td>
</tr>
<tr>
<td>☐</td>
<td>Changes required very quickly when indicated by score 4</td>
</tr>
<tr>
<td>☐</td>
<td>Investigation as well as changes are needed as soon as possible when indicated by score are required immediately</td>
</tr>
</tbody>
</table>
7. Conclusion

This study was conducted in Karim Textiles Ltd. Noorbag, Kaliakoir, Gazipur to identify the occupational health and safety of the garments worker. A detail research was carried out through the workers to find out the possible problems they suffer with rote cause analysis. For this research, more than hundreds workers were asked different questionnaires for research purpose. The result initially shows the problem are suffering the workers like environmental, human related problems and task and management related problems. After collecting all the Data from the workers then ANOVA analysis and significant co-relation were done to find out if there was any similarities or differentiation among these three factors. This shows that there is closely inter related to each other as $F<F_{crit}$. Finally risk analysis for different task were done to find out which task is more critical, causes damage to body and which one have to take necessary steps in order to find out which job is more critical and causes damaged to body. That’s why action level was given to different task of this job.

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Biography

Md. Mahdi Islam have recently graduated from Khulna University of Engineering & Technology. He is now working in a renowned garments industry in Narayanganj, Dhaka.

Md. Ariful Alam is working as a Graduate Teaching Assistant at Khulna University of Engineering & Technology (KUET). He recently completed his graduation from KUET. He is now conducting various researches. His research interest includes ergonomics, OHS, data science, text classification related to industrial engineering.

Nayan Chakrabarty is now working as Reasearch Assistant at Ohio University, USA. He also Assistant Professor at at Khulna University of Engineering & Technology (KUET).
Minimum wage rate and minimum required to live for RMG Workers in Bangladesh: Beyond the two minima

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Abstract
By nature, Ready-made garments industry is labor intended and that’s why, the mass presence of such industry in the countries like Bangladesh where cheap labor is abounded in is observed. But the existence of cheap labor makes another concern of provision of least salary by which they can meet their necessary demand for living at least beyond the poverty level. For this concern, Government of Bangladesh enact a standard of wage that is considered as the minimum wage rate for this industry. The aim of this paper is to reexamine this minimum wage with respect to their minimum needs to spend. This paper would first revisit this two minima of wage rate and amount required to sustain beyond the poverty level. In order to revisit this two minima, data regarding the earnings of RMG Sectors and their disposal spending by sector would be collected as well. Descriptive statistics would be formulated by rational calculation of what they need actually in response of what they earn from this sector. Later an inferential analysis would confirm the facts obtained from descriptive statistics. Initial analysis demonstrates that what they earn from this sector by virtue of minimum wage is far behind the actual need to exist beyond the poverty level. Lastly, this paper recommends that minimum wage rate should be increased to cover the minimum required and this wage should vary with respect to family member condition as law of large number can generalize but never be able to provide solution for everyone.

Keywords
Minimum wage, RMG, Cheap labor, Labor exploitation

1. Introduction:
Due to being an over populated country as well as a developing state, Bangladesh is abounded with labor and most of them including both male and female are ready to work with the minimum they are offered. The development of Ready Made Garments sector in this country is closely associated with such abundance of cheap labor as well. And such association needs to revisit as the continual poverty of these working class cannot be continued. Beside the stand point of morality, the labor unrest and violence should be revisited unless the entire sector can be on the face of destruction by different ways simultaneously. So it is imperative to make a close look how these workers are maintaining their lives with what they are being provided. And this close look would be made possible of their personal balance sheet for maintaining their lives can be considered to examine through reexamining their wage to lead a life rationally. And this is the point in where this paper is aimed to make an inquiry.
2. Current scenario and Literature Review:

The current scenario of this sector is both frustrating and optimistic. The frustration comes when we are taking the lives of these workers in consideration and the optimism comes when we are taking the growth of this sector into consideration as well. And a clear imbalance is observed in the midst of this two. Current scenario of this industry can be divided into following sections for the sake of rigid representation:

- Growth of the industry
- Workers condition
  - Vulnerability of workers
  - Labor unrest
  - Poor condition of relevant Trade union
  - Profit maximizing motive of the industrialist
  - Some optimism
- International market situation
  - Before market Quota
  - After market Quota
- Cross country comparison

2.1 Growth of The industry:

Readymade Garments industry is one of the fastest growing industry of Bangladesh. The UK (Parker, 2011) is one of the most important markets for this industry from Bangladesh including but not limited to Marks and Spencer, H&M, Next. Eighty percent import of UK (Parker, 2011) is generally done from south Asian region. Initially when this industry has been started to be in operation total share of export is just .0.02 (Bhattacharya & Rahman, 1999) percent but that share has become 67.92 (Bhattacharya & Rahman, 1999) percent within only twenty years and this rise demonstrates the growth of this industry simultaneously. Despite of this growth due to the nature of our economy or other heterogeneous reason, this industry is viewed as smaller (Saxena, 2014) in the south Asian region. And this to be in the smaller can be well linked with the take of condition (M. R. I. Khan & Wichterich, 2015) of our economy.

2.2 Workers condition:

Despite some optimistic news regarding this, the workers condition is too much vulnerable. RMG sector employs about 2.5 million workers of whom 80 percent (Al Faruque, 2009) is women but to establish adequate number of trade union is seemed to be missing.

And the workers condition can well be evaluated under following sections:

2.2.1. Vulnerability of workers: Almost workers are women and they are found to join in this industry (Kibria, 1998) for following reason:

1. work for family’s survival
2. Improve family’s condition and prospects.
3. Take care of myself, to make my own way in the world.

But this entry is not safe as the work place is hazardous and this entire hazardous situation (Campaign, 2012) has made entire garment industry of Bangladesh is unsafe. This hazardous situation is well understood while we are viewing the evidence of women workers rapidly affected with different disease or suffer for different health complexion (Paul-Majumder, 1996) as well. The opportunity cost of working in the garments in the terms of health complexion is too much high. Socio economic transformation (Paul-Majumder & Zohir, 1994) for women brought down by this industry has been seemed to narrowed down to a large extent by some negative implication such as exploitation in terms of low wage, irregular wage payment, job insecurity, gender discrimination in earnings etc. Hazardous situation is seen to be more hazardous when the evidence of harassment and exploitation (Khosla, 2009) persists.
Despite this hazardous situation, some industrialists are seen to provide as much as low wages as possible as these have no other option where to be employed. The story does not end here as they have to compete to be employed within that low compensation. At least the story of Kanon (Wahra & Rahman, 1995) confirms this scenario as well. This low wage pushes women (Absar, 2002) to be vulnerable for migrated women coming in the search of job as they cannot afford safe housing and other necessary utilities within these wage they received for actually. One of the reason that can be linked with custom of viewing formal as informal (Kabeer & Mahmud, 2004). In this industry, everything acts as formal way of employment is but acts oppositely and it can be well defined as here opportunities provided to them is informal in general but the jobs are formal. The entire situation for the workers are seemed to be more serious when the wage received by them is compared with commodity such as rice (Arndt et al., 2002) and the situation becomes more vulnerable due to the fluctuation of the rice as well.

Income earned (Kibria, 1995) from this industry by women is not decided to spend according to the will of that women who are earning that and the degree of making economic decision is found to be varied over the time and other aspects as well. Some cases, they have been seen free and not free at all in the other cases as well.

Globalization (F. E. Ahmed, 2004) can be blamed for the entire situation on the stand point of political economy. As the window of globalization powered by profit motivation is letting the things happen where labor exploitation accompanied with creating new multimillionaire is a sort of bi product. On the contrary, this blame to globalization or neo-liberalism (Absar, 2002) can be relaxed if we can concentrate on the stakeholder analysis as stakeholder analysis would show us that every stakeholder is equally likely to be responsible.

2.2.2 Labor Unrest:
Labor unrest or uprising in the readymade garment industry has been a regular phenomenon and this starts to appear eventually after its entering to the size of being considered as well. This frequent unrest regarding this industry can be reasoned (S. Ahmed, Raihan, & Islam, 2013) through the inclusion of lack of minimum facility and safety at work, substandard living condition , international conspiracy and coercive role of the law enforcing agency, too much dependency on buyers, pressures from the workers and local terrorists, use of workers by others and rumors, un-fulfillment of education demands of their children, distorted minded workers, political instability of the country, too much workload, lack of promotion opportunity, insufficient wages to survive etc. But minimization of such unrest is a feasible case though at least. Absence of mutual understanding between workers and managers (Hossan, Sarker, & Afroze, 2012) is another reason for such unrest.

2.2.3 Poor condition of relevant Trade union:
The relevant trade unions which are supposed to stay as a safe guard for protecting the rights of workers as well as to advocate it are found too weak to make its statement in this regard continuously. Though trade unions in this sector is the result of labor in 1994 (Al Faruque, 2009) and the total number of such union is just 271 (Al Faruque, 2009) and that is not enough at all. Moreover, workers (Bhuiyan, 2013) are found to be made warned for very silly reason and it can be also linked to the absence of working status of this sector as well. All stockholders including donors (Safiqul, n.d.) can assist mutually in this phenomenon. But Membership of a union (Dasgupta, 2002) is a necessary — but not a sufficient — condition for representation security. Linking international trade and industrial upgrading (Gereffi, 1999) could come forward in this regard. But it is a matter of degradation that globalization (Muhammad, 2011) has taken the sake of local capitalist but not the working class.

2.2.4 Profit maximizing motive of the industrialist:
Another influential culprit in this sector is the profit maximizing motive of the industrialist. The profit maximization motive (Z. R. Khan & Rodrigues, 2015) that may lead to the very poor lifestyle are being questioned by different consumer movements and making pressure to use CSR as a way of mitigation of this phenomenon. They are being more (Adams, 2002) concerned what the retailer sells or at what price, also under what conditions those apparels were produced. But the new regime of accumulation (Khanna, 2011) is observed through entrance into export processing zones. Rather Global brand-named companies and retailers (Merk, 2010) are being more profited through capitalizing the poverty from outsourcing production to the low wage countries.
Public-policy choices and lean-retailing model (Abernathy, Volpe, & Weil, 2006) can assist us to tackle this aspect at least minimally. Beside all these issues, state education for girls, better public safety for women, and to change their own management practices to better retain and raise productivity of skilled women workers can be the concerns of the shareholders or the respective factory owners due to the pressures (Hossain, 2012) coming from different dimension as well.

2.2.5 Some optimism:
CSR in the RMG sectors by practice (Nasrullah & Rahim, 2014) is being concerned with following issues:
1. labor rights and workplace conditions;
2. environmental management, and
3. involvement in social and community development and philanthropic activities

And this CSR movement towards the workers can be viewed as a positivity of the globalization (Haque & Azmat, 2015) at least for the developing countries. Double Consciousness (Zaman, 2001) regarding workplace and home management is being observed that is allowing women to work outside and the poor women especially in this sector. Rising number of working women in this sector (Heath & Mobarak, 2013) is decreasing the number of drop out female student or preventing the early marriage as well and that can be stated through following points:
- young girls becoming more likely (Heath & Mobarak, 2014) to be enrolled in school after garment jobs (which reward literacy and numeracy) arrive, and
- older girls becoming more likely to be employed outside the home (Heath & Mobarak, 2014) in garment-proximate villages

And women due to this trend (Amin, Diamond, Naved, & Newby, 1998) are getting more time for being in the adolescence. Their children (Farhana, Syduzzaman, & Munir, 2015) are also observed to be more in the favor of obtaining formal education simultaneously. Organizations like ILO (Bolle, 2014) can make more working steps though they are active as well. Bangladesh has a shortage of skilled labor and this shortage (Anisul Huq, Zorzini, & Stevenson, 2014) has made a probability that upgradation of workers through self-motivated can upgrade the vulnerable situation for who is upgrading own self. Rather not only for this sector, but also for other sectors real wage for rural women is rising due to more scope of job.

Despite low wages and vulnerability in other measure, the workers in the RMG sectors are found to be more self-awareness (Karim, 2014) compared with their rural counterparts who are engaged in microfinance. Rather women (Feldman, 2013) are increasingly viewed as disposable and redundant even as their labor is becoming central to imaginings of family maintenance and sustainability.

2.3 International market situation:
International market situation can be divided into following two sections and they are:
- Before market Quota
- After market Quota

Before market quota, it was feared that Bangladesh might lose its market in Europe and north America or other exporting jones in the terms of balance of payments (Yang & Mlachila, 2007), output, and employment. And this quota opportunity was backed by MFA (Rock, 2001) for the major importing industrialized countries such as the US, Canada and the EU. But this elimination has done almost nothing as after elimination, Bangladesh progressed more in this sector and the worriedness did not work.

2.4 Cross country comparison:
For comparing Bangladesh and Cambodia, Cambodia has achieved more compliance (Berik & Van der Meulen Rodgers, 2008) in the comparison with Bangladesh and this can be reasoned due to the direct associated contract with The USA. Technical efficiency (Fukunishi, 2009) of both Bangladesh and Kenya is almost same but unit cost is higher than that of Kenya with comparison of Bangladesh and this variation is due to the labor cost of Bangladesh.
3. Literature Gap and research question:

From the literature review section, it is evident that the poor as well as the vulnerable condition of the workers exist and different steps are recommended and enough blaming in this regard is also well reported simultaneously. In the midst of all these approach it is seriously absent to evaluate what they get is enough to survive beyond the poverty line or not. They are poor is being a claim but how much poor in the terms of what they need is totally absent in this regard. And this point is the research inquiry of this paper. And this paper is aimed to compare two minima in terms of what they need and what they get actually in this regard. More precisely this paper is addressing the depth of the poor economic condition in the terms of what they actually need.

4. Minimum amount needed:

The minimum one person or a family needed is a matter of perception and this paper until this version has calculated this minimum in the terms of their perception. Here the perception is as they feel how much they need to be out of the poverty level exactly or in other terms what they need actually. In this case, we have taken a sample of 61 and the descriptive statistics is as follow:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Observation</th>
<th>Mean</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earning</td>
<td>61</td>
<td>9024.918</td>
<td>5800</td>
<td>25000</td>
<td>19200</td>
</tr>
<tr>
<td>Total Needed</td>
<td>61</td>
<td>58800</td>
<td>15255</td>
<td>58800</td>
<td>58800</td>
</tr>
<tr>
<td>Deficit</td>
<td>61</td>
<td>15168.16</td>
<td>9189.167</td>
<td>39488.33</td>
<td>30299.16</td>
</tr>
</tbody>
</table>

From the table, it is evident that Earning is ranged between about 5800 to 25000 with a mean of 9024 and the difference between these two extremum is 19200. The point to be noted that here the median wage received is approximately rounding toward the minimum salary declared by the government as well. Again, total amount needed is ranged between about 15255 to 58800 with a mean of 58800 and the difference between these two extremum is 58800. The minimum here found is 15255 is far above the minimum fixed by the government as well. The fact of imbalance is more severe when we consider deficit separately. Deficit is ranged between about 9189.167 to 39488.33 with a mean of 15168.16 and the difference between these two extremum is 30299.16. The median deficit received is approximately rounding toward the minimum salary declared by the government as well.

5. Inferential Analysis:

Deficit can be considered as a function of Earning and total needed. Rather it can also have treated as function of the sectorial division relevantly. This paper would limit its analysis by considering deficit as a function of earning and total needed where the latter figure has been estimated from their respective individual perception. And such assumption provides us following table of coefficients:
Table 2. Inferential statistics of Earning and Total Needed

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1) deficit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total expenses</td>
<td>1.000*** (2.47e-08)</td>
</tr>
<tr>
<td>Earning</td>
<td>-1.000*** (6.83e-08)</td>
</tr>
<tr>
<td>Constant</td>
<td>0.000403 (0.000257)</td>
</tr>
</tbody>
</table>

Observations 61
R-squared 1.00

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

This table of coefficients illustrate us that total expenses as perceived too much high that it can alone explain deficits though earning is statistically signified simultaneously but the coefficient is not enough large comparatively to compare for. And no other factor remains as residuals too much significant that can affect this deficit. This calculation does not stand for to determine level of influence but only stands for understanding the statistical significance.

Interestingly this regression is Ordinary least square model and this OLS regression fulfills the basic assumption of the regression as well.

7. Policy suggestion and Concluding Remarks:
This paper clearly establishes that the minimum wage rate fixation has almost nothing to do with real world poverty. As the poverty of a family or a group of people does not depend upon only what is fixed as wage, we need to revisit the minimum wage procedure and we need to fix it flexible so that it can be adjusted according to the number of dependencies. Unless the rise of minimum wage rate would possess simply nothing to deal with the poverty patronized from this loophole. As we know what is sufficient for four must not be always sufficient for eight as well. Rather it can be never sufficient.

Acknowledgements
We are acknowledging the great effort attained from the students of economics department of Notre Dame University who have been involved entire surveying and till now they are working relentlessly in this regard.

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30. Ethical manufacturing or lack thereof in garment manufacturing industry. World, 5(1).

Biography

Samirah Mustafa

Samirah Mustafa was born in Dhaka, Bangladesh and completed her primary education from Dhanmondi Government Girls High School, Dhaka. She got the primary govt. scholarship in class five. She was also a debater in school and won her first Best Debater in parliamentary debate on BTV when she was in class eight. She had completed her B.Sc. and M.Sc. in Economics from Jahangirnagar University. In both B.Sc. and M.Sc. examinations she secured first class third position in her class.
After graduation she worked as a lecturer in Green University of Bangladesh in the department of Business Administration for two years from 1st January 2013 to 31st December 2014. Then she joined department of Economics in the Notre Dame University, Bangladesh.

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MD. Rafiqul Islam is currently enrolled in graduate program in Department of Economics in Jahangirnagar University. I was enrolled in debating (Both Bangla and English) from my early days of study and had worked as president (Bangabandhu Hall Debating Club), Joint Secretary (Communication), Organizing secretary (Debating Society of Economics) and so on. I had organized Arthrasatra Path Chakra of economics department. I have been involved in research after my bachelor and my first work is regarding bitcoin and that got featured in a satellite television as well as presented in Turkey. After that I have presented my work in different international conference simultaneously. And my primary focus of research is Crypto currency, Demography, Post development phenomenon etc. Currently I am working in LCS Study project for coastal area.
English Proficiency for Sustainable Career Development in Fashion Industry

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Abstract

English has become a via-media between people’s life and their professions in current day world. Being competent user of English in academic life leads to better understanding of study materials, like books, journals, class lectures, the internet, and so on. Again, better understanding of study materials means better results in formative tests as well as summative assessments. Eventually, the continuous better results lead to gaining cumulative grade point average (CGPA). Anyone who has been able to obtain an honourable grade in his university degree will get lucrative job offers if he wants to enter into the professional life. Moreover, if he wants to further his academic career, he may be blessed with a scholarship abroad. Likewise, knowing English language enhances the possibility of one’s getting hired by high paying firms. For this purpose, this paper aims at finding out the role of English language played in the careers of people working in the fashion industry, and through a survey and review of literature, this paper has found that proficiency in English is a must for sustaining one’s job in the fashion industry in the 21st-century globe

Key words: competent user of English, sustainable career, fashion industry

Introduction

The role of English language cannot be denied in our life. English is a must for all sectors of life, like career development, scholarship, education, creative and critical research writing. In this regards, Locker & Kaczmarek (2009) state that in the present day highly competitive global economy and business world good English communication skills in workplaces are essential. Those who complete under-graduate and graduate programs from any subjects of any university of the globe must be conversant in the English language; otherwise he will fail to come out successful in his pursuit. Nowadays, the importance and necessity of English language is on the increase everywhere of the world. The current generation of the non-English speaking countries are very inclined to learn English for getting lucrative jobs, or for fulfilling his aim and plan. With the passage of time English language has been recognized as a global language; it is also being used as an official, or a semi-official language in many countries of the world. The organizers of the International games and sport, the International Conference and so on are giving English language priority. As fashion industry is known as “the multibillion global business devoted to the work of making and selling clothes” (Britannica.com), English is a must for the successful business communication in English to operate the industry home and abroad. So, to build up a career in any sector of the fashion industry people have to be proficient in English. In a word, we can say that the role of English language in one’s career in the industry in discussion is indispensable.

Importance of English in the business world

In the national and international business world English speaking skills and writing skills are equally important. Conrad & Newberry (2011) point out that speaking and writing skills are termed as „soft skills” that are essential for any profession. Crosling & Ward (2002) supporting the same assert that deficiency of these skills is a „disadvantage in the workplace”.

Retention and accuracy of English is the most important aspect of the success in the global business. The European Commission (2010) reported that the levels of English proficiency of the European workforce are low. In a study, they found the proficiency of the workforce was below the required average for effective communication in the global economy. Moreover, they mentioned that the English proficiency of the workforce is significantly below the average level required for effective communication in the global economy.

Thus, the importance and necessity of English language is on the increase everywhere of the world. It is being used as an official, or a semi-official language in many countries of the world. The organizers of the International games and sport, the International Conference and so on are giving English language priority. In a word, we can say that the role of English language in one’s career in the industry in discussion is indispensable.
It means that people who are able to communicate by speaking and writing English are more successful in getting jobs, and those who are in already jobs can perform well, while those who fail to speak and write English for communication are not successful in the business world.

For business communication in the fashion industry English is used in many countries. Researchers have found out that in Hongkong the merchandisers of textile and clothing businesses use English in their workplace (Somui & Mead, 2000). Moreover, Ehrenreich (2010) opines that English is used as lingua franca in a multinational corporation. Moreover, Erling & Walton (2007) say that English is used in workplace in Berlin. So, it can be assumed that English is used home and abroad as a common language among businesses including the fashion industry.

**Importance of English in fashion industry:**
Fashion industry is a global business that „encompasses the design, manufacturing, distribution, marketing, retailing, advertising and promotion of all types of apparel (Britannica.com)”. Fashion industry, that is also known as the Readymade Garments Industry in Bangladesh, is the largest national industry which is a remarkable export-oriented business in the world supply chain where English is used as the medium of communication for day to day business (Roshid, 2014). Hassan (2010) says that about 40 million people rely on the RMG sector in Bangladesh. The overall contribution of the RMG sector to Bangladesh is extra ordinary. It provides large scale employment to the people of Bangladesh, and contributes greatly in the empowerment of women. In this way, this industry is assisting the attainment of Millenium Development Goals (MDGS) (Islam, 2010)

Roshid (2014) points out that Bangladesh is the third largest garments exporting country in the global market. He adds that Bangladesh exports clothing items to over fifty countries including the USA, Canada, the European Union, and may other countries in Asia. So, there is no doubt about the fact that the RMG sector in Bangladesh is a huge one, this huge sector requires a heavy amount of communication with the people of those countries. As a result, English has become a crucial „communication tool” for the RMG industry.

**RMG fields that require communication in English**
According to the partial findings of a major research work on “English Communication Skills in the Ready-Made Garments Industry in Bangladesh undertaken by Roshid (2014), and their analysis it is revealed that English is considered „the most powerful language” in global business. The researcher reports that in the RMG sector the people working in the Marketing, Merchandising and Commercial sections use English for communicating with the people involved in exports, imports and recruiting employees and for various other purposes. On the basis of the survey he carried out on the various sections of people in the RMG industry, the researcher expressed his perception about the needs of English in the following way:

Hence, it seems that English is the life-blood of this business. Without English RMG business cannot sustain its place in the global market; it is even „unthinkable” in the contemporary world (Roshid, 2014)

The researcher investigates the functions of the English language in this sector. As per him, the marketing section explores markets for goods in different countries and communicates orally or by writing with buyers or their representatives. Regarding Merchandisers So-mui & Mead (2000) say that merchandisers are the main users of English in RMG sector. They communicate with buyers and suppliers of accessories. Kothari (2013), who deems communication as the backbone of merchandising, opines that merchandisers have to communicate with existing and new buyers; the concerned departments such as production, quality control, accounts, suppliers of fabrics and accessories etc. That is why he says that merchandisers ought to be skilled for making effective communication. And this communication is in English no doubt. Commercial personnel deal with the shipping of products and payments. They also maintain liaison with related organizations and agents like BGMEA and BKMEA for the sake of business. Their communication is done „almost always in English (Roshid, 2014). So, to sustain one”s career in RMG sector one has to be proficient in English no doubt.
Significance of the study

It is a widely known fact that there is an acute shortage of competent human resources to run the fashion industry in the country. Mizan (2013) reports that for communicating with foreign stakeholders of the industry, a remarkable number of garments industries have to depend on „middle management“ who are mostly foreigners. He mentions that in 2013, 25000 foreigners were working in different RMG businesses in Bangladesh.

For the dependence on foreign workers Bangladesh suffers two fold. Firstly, a lot of foreign exchange goes away as salaries and allowances paid to the foreigners. Moreover, because of the shortage of the skilled manpower in the country, foreign workers are being employed depriving the local job seeking graduates (Roshid, 2014). In this regards, the Economist (2014) reports that Bangladesh lacks in adequate number of academic institutions that provide training to make competent work force for the fashion sector. It adds that many RMG businesses want the local universities to solve this problem by offering fashion business related courses to make skilled employees for this emerging fashion industry.

The demand for competent workforce capable of communicating in English in the fashion businesses is growing day by day. In the same way, new jobs of the same nature are being created and getting vacant worldwide. Even in Bangladesh also there are many university graduates who are devoid of English communication skills as a result of which they are suffering from the curse of unemployment. Regarding the language communication needs of the personnel working in the RMG sector there is very little research. So, I have embarked on the current study.

Importance of communicating in English

Recent literature has suggested that the relationship between globalization and the English language implicates employability in the job market. Although the effects are uneven in different occupational groups and in different countries, such relationship is growing in significance to policy makers. This paper wants to explore the hitherto unstudied relationship between English language proficiency and employment and the success of Bangladeshis abroad to establish how English language skills influence the employment mechanism in the global job market for the people from a non-English speaking South East Asian country. The study would be carried out following an interpretive approach as its overall aim is to understand the role of English language skills of the younger generation in determining their employment opportunities and career prospects in the globe. It is found that in various ways one’s English language skills influence prospects of employment, especially in contributing to the possibility of secure and better jobs. The research may inform educational policy planners, teacher educators, employers and career advisers to optimize the English language learning programs that support increased employability through English. (Crystal, 1997)

Enhanced communication skills in English can result in not only an improved social life, but also better job opportunities in the future. From job interviews to the actual professional world, communication skills are very crucial, and being proficient in English means being able to communicate clearly and effectively. In job interviews, most interviewers conduct interviews in English. Interviewers quickly make judgments and give importance to first impressions. Poor skills in the language can mean smaller chances of landing in jobs. On the other hand, being proficient in English can help one leave a good first impression which means higher chances of getting the position one is applying for. Most business contracts are written in English. Handling international business deals require effective skills in English. However, using incorrect tenses, prepositions, and the like will make one’s statement less accurate. So, in order to have an increased competence in the professional world, one should have a very good grasp of the English language. (Roshid, 2014)

A competitive employment market requires good communication skills in workplaces. Proficiency in English therefore, is needed for employees to advance in both local and international companies and to improve their technical knowledge and skills. It provides a foundation for what has been called “process skills,” problem-solving and critical thinking skills that are needed to cope with the rapidly changing environment of the global workplace, where English plays an increasingly A positive attitude to English as a national language is essential for the integration of people into society. There would appear to be virtually no disagreement about the importance of English language. By using English one can become a citizen of the world almost naturally. English plays a dominant role in the media.
It has been used as medium for inter-state communications and broadcasting. The impact of English is not only continuing but increasing (Babcock, 2001).

English language is transforming its multidimensional communicative structure day by day, and in the process has enhanced its utility quotient in Bangladesh. English is available to us as a historical heritage in addition to our own language. We must make the best use of it to develop ourselves culturally and materially so that we can compete with the best in the world of mind and matters. Many organizations have started training their employees in English from time to time. This has ameliorated the life styles of people who consider their future block forever if they fail to make it to teaching or some other traditional jobs. In fact, the knowledge of English pays for the people for all times (Baker, 2009).

English communication is to communicate effectively in English, and no communication is possible if one doesn’t get a chance to communicate. It is natural that the demand for communication is high in this ever changing world. English plays a crucial role in communication and is no doubt the foremost and most important tool of communication all over the world. Individually, everybody should strive hard to acquire very good communication skills which are the most important prerequisites to excel in one’s career (Imam, 2005).

**Present Scenario in Bangladesh**

The need for English in Bangladesh has become a new necessity to meet global and local demands. English is an asset, necessary for the national development. The government seems more concerned than ever to promote the English language to build the nation and its skilled-manpower, ready to meet the challenge of globalization. Since the existing proficiency level is unable to meet the needs of the employment market, especially corporate sectors getting involved in fashion industry on a global scale, it is necessary to explore the need for communication skill in English in global and local perspective through investigating workplace communication needs, comprehensive feedback from major stakeholders in workplaces to address the present shortfall in English communication skills of people in Bangladesh. This is a powerful justification for conducting research in fashion industry in Bangladesh, even in any employment sector where English is being used. (Hamid, 2010)

Against the backdrop of globalization and trade liberalization, the fashion industry of Bangladesh has turned into a huge industry in the global market. Being interconnected with other portion of the globe through the flow of capital, goods and movement of people, fashion industry has become is on the increase day by day; and this industry has become the workplace for the younger generation. Over time, the fashion industry in Bangladesh is gradually getting the national industry and highly export-oriented business sector in the global supply chain, where the medium of communication is English. The sharp incline of the fashion industry in Bangladesh has been quite dramatic. (Ford, 2016)

**Literature Review**

Thavabalans (2018) says that for exporting their goods in the competitive world, the business people need to have good business English communication skills. The businessmen should emphasize the need of business communication in English for the sake of the success of the business.

Ferguson (1983), for instance, relates the spread of English with that of communication technology. Computer technology has transcended the language barrier and accelerated the spread of English for the global communication.

The necessity of business English communication is high for running a successful garments industry (Thavabalans et al 2018). Here the importance of business communication in English has been emphasized. To bring success in a garments industry, competent communication in English should be given priority.

English communication skills in this study refer to the mastery of English language code and the subsequent use of this code appropriately and effectively in the international and intercultural business contexts. Communication skills also involve the ability to understand and produce contextualized language in the spoken and written texts, and knowledge of using different kinds of strategies to express something when language resources are lacking. (Hedge, 2000)

Harigharasudan et al. (2017) point out that being able to succeed in business, the attention of various groups of people needs to employ English for any enterprise. They also mention that in the age of globalization, language has become increasingly focused on the needs of global markets.

The Fashion business is defined as all companies and individuals concerned with the design, production, and distribution of textile and apparel goods. Frequently included under the discussion of the fashion business are components of the industry such as accessories, jewelry, and perfume. (Dickerson, 2003)

According to Crystal (2003), „English is a global language” because English gives access to connecting people globally more than any other language. And it is needed for communication, particularly for international academic and business communities. Global language works as a lingua franca, a common language. He adds that in the world of business, English is used in marketing and negotiation.

Seidlhofer (2004) points out that when people consider English as a preferred means of communication among people from different first language backgrounds, they encounter English through different names or terms, such as English as an international language (EIL), a lingua franca (ELF), a global language (EGL), a world language and a medium of intercultural communication.

The relevance of stylistic innovation is so transparently obvious in the fine fashion industry that its analysis may lead one to draw insights that go beyond this industry to develop concepts that might be applied to other industries where the role of style is likely to be somewhat more latent. (Cappetta, Cillo, & Ponti, 2006, p. 1274)

Producing creative, high-priced apparel and presenting it in high-profile fashion shows has been recognized as the foundation for fashion brand development. (Grumbach, et. al., 2007)

While proficiency in English is seen as significant in BELF discourse, the concept of proficiency is considered a very pragmatic aspect closely associated with competence in business and communication and business know-how overall. (Kankaanranta & Louhiala-Salminen, 2010)

In Bangladesh, English is considered and taught as a foreign language for sociopolitical reasons. Despite theoretically being a member of an outer circle country, the RMG business professionals of Bangladesh are employed in business interactions with people from all three circles. Their learned/acquired English knowledge and communication skills are used as a communication tool with people from all three circles regardless of their English as a mother tongue, as a second language, or as a foreign language. (Chowdhury & Farooqui, 2011)

English is the most popular and powerful language in the world for international communication. Today 1.75 billion people speak English at a useful level. (Neeley, 2012)

With the upsurge in worldwide trade as a consequence of economic globalization, the need for English is growing rapidly. More people than ever before are involved in international business communication. Every day, there are many millions of business professionals from different parts of the world engaged in thousands of business transactions and negotiations, communicating in English. (Nickerson, 2012).

So, from the review of the literature regarding fashion industry and the use of the English language there, it is evident that English proficiency is an integral part of the career of the people involved in the business sector.

**Objectives of the Study**

English is essential for the people who work or want to work in the fashion industry for sustainable career development in any country of the globe. The objectives of the study are to find out the obstacles that hinder the attainment of the capability of using the English language by the people who aspire to develop career in the fashion industry, and to seek the probable solutions to the problems.
Method:

A survey by questionnaire was conducted to collect relevant data from people involved in the garments sector. They were students studying MBA in merchandising, textile engineering, and academics teaching garment and textile related courses. The total number of respondents was 95. Among them 22 were faculty members teaching garments and textile related subjects, 32 were students studying MBA in apparel merchandising at BGMEA University of Fashion and Technology, Dhaka, 27 were students studying B. Sc. in Textile Engineering at Ashanullah University of Science and Technology, Dhaka and 14 were employees working in different RMG related organizations.

A questionnaire containing the following propositions was circulated among the subjects: “English Proficiency is Essential for Sustainable Career Development in Fashion Industry”. Following it there were five options to choose from which are mentioned below (following Likert scale (1932):

<table>
<thead>
<tr>
<th>Options</th>
<th>Number of respondents</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Strongly disagree</td>
<td>Nil</td>
<td>0%</td>
</tr>
<tr>
<td>b. Disagree</td>
<td>Nil</td>
<td>0%</td>
</tr>
<tr>
<td>c. Neither agree nor disagree</td>
<td>Nil</td>
<td>0%</td>
</tr>
<tr>
<td>d. Agree</td>
<td>23</td>
<td>24.21%</td>
</tr>
<tr>
<td>e. Strongly agree</td>
<td>72</td>
<td>75.79%</td>
</tr>
<tr>
<td><strong>Total respondents</strong></td>
<td><strong>95</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

Table 1: The table shows the result analysis of the survey

Among the respondents 72 opted for strongly agree, 23 for agree, and no respondent opted for any other options. Statistically, about 76% respondents strongly agreed that “English Proficiency is essential for sustainable career development in fashion industry”, whereas 24% opted „agree“. However, in both categories of responses whether „strongly agree“ or „agree“ 100% have voted for the English language requirement for sustainable career development in the fashion industry.
This paper surveyed the essentiality of English proficiency for sustainable career development in fashion industry. In order to clear the conceptual framework of the research there is a diagram of the research concept given below in figure 1:

- Proficiency in English
- Better job opportunities
- Better performance of employees
- Employers’ gain by more profit from industry
- Employees’ gain by promotion and emoluments from employers. Established job (sustainable career)

Figure 1: Proposed Conceptual Model for the study

Figure 1 indicates that people who learn and can use better English, get better job opportunities. Next, as they know English well, they will perform better in their jobs. Their better performance will lead to better employer-gains by profits and good will. If the employers get benefitted, the employees get promotions and better emoluments. And this is how a sustainable career is built up in the RMG sector through knowing English language well.

**Discussion**

As evidenced in the literature and the findings in the survey carried out for this research, it is seen that to execute an international standard business sector like RMG smoothly, the manpower in the industry must be skilled in communication in English. The RMG professionals should comprehend every aspect of their foreign business counterparts. If both the parties miscomprehend or partially understand each other, there is a risk of misconception between the business partners which might lead to a breakdown in the business relationships. As RMG sector in Bangladesh is a prospective and promising industry, it is imperative that the professionals understand their counterparts’ English. So, it can be assumed that if communication in English is proper, it along with other professional accomplishments will make RMG people successful in their career ultimately contributing to the national economy.

**Suggestions**

The government as well as the people at the helms of affairs in the RMG sector in Bangladesh ought to come forward to boost up the English language learning and teaching in the country. Public and private universities in the country can play a good role in this regard. Apart from this, some specialized English language institutes may be established for those people who want to build up career in the fashion industry.

**Conclusion**

As a common language English, which is used and understood around the world, is crucial to cooperation and coordination among businesses around the world. Trading and business are built on good relationships, and relationships depend on communication. So, studying and being efficient in using the English language in communication in writing and verbally is a rewarding option for those who aspire for enhancing their prospects in developing a sustainable career not only in fashion industry but also in numerous other fields of business.

**Acknowledgement:**

First of all, I would like to thank Professor Dr. Lal Mohan Boral, currently, the Head of the Department of Textile Engineering, Ahsanullah University of Science and Technology, Dhaka for inspiring me to embark on this study. I also express my appreciation and thanks to my colleagues and students who generously participated in my survey. My special thanks are due to Mr. Muhammad Sajjad Hossain, Assistant Professor of Mathematics, Department of Arts and Sciences, Ahsanullah University of Science and Technology, Dhaka for his enthusiastic help in the use of technology required for the writing this paper.
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**Author’s biography**

Mohammad Rukanuddin is Assistant Professor of English at Ahsanullah University of Science and Technology, Dhaka, Bangladesh. He has more than 20 years of experience in teaching English in different institutions and a number of publications in the areas of his choice. His areas of interests are ELT, English for Academic Purposes, syllabuses, academic assessments and educational research. Currently, he is a Ph.D. fellow at the Department of English in Jahangirnagar University, Dhaka, Bangladesh.
Assessing the Impact of Green Human Resources Management on Environmental Performance in the Context of Bangladeshi Garment Industry

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Abstract

Environmental Management (EM) is one of the most effective tools to achieve sustainable development. Thus, there is an emerging need for the integration of Environmental Management into Human Resource Management (HRM) which is called Green Human Resource Management (GHRM). Consequently, GHRM is attracting the increased concentration among the recent management scholars towards achieving sustainable Environmental Performance (EP). This paper presents an empirical assessment and measurement of the impact of GHRM practices on Environmental Performance of Ready-Made Garment industry in Bangladesh context. Furthermore, it identifies the variables that could affect the GHRM implementation from the perspective of the respondents. In order to analyze the impact of GHRM on Environmental Performance the research used both qualitative and quantitative aspects. An exploratory research was conducted by using structured questionnaires to collect data from employees of different garments. The statistical analysis revealed that there is a statistically positive and significant relationship between GHRM practices and Environmental Performance. The contribution of this paper lies in extending the scope of GHRM in the actualization of sustainable environmental performance of organizations. The implications of the research offer constructive insights on how ready-made garments should strategically link their HR functions to support their EP crucial for achieving competitive advantage.

Keywords: Environmental Management, Green Human Resources Management, Environmental performance, RMG

Introduction

Environmental sustainability is the most emerging issue in the present segment of industrialization as the industrial revolution caused a boost in the degradation of the environment (Jabbour and Santos, 2008). Now, organizations generally are expected to be responsible for environmental management (EM) (Rondinelli and Berry, 2000) and also both developed and developing countries became more alarmed about the significance of environmental issues and sustainable development (Sharma and Gupta, 2015). Environmental management has to consider “triple bottom line”, which incorporates social, environmental and financial aspects (Elkington, 2006). Definitely, all organizations are now responsible to make more effort in balancing they're economic, social, and environmental performance,
especially for which community, competitive and regulatory pressures (Ayuso et al., 2014; Russo and Foutus, 1997). The efficacy of any strategic measure is reliant on the availability and capability of its people (Boselie et al., 2001; Paauwe and Boselie, 2003; Jiang et al., 2012). Organizational strategies for environmental management and sustainable development should be properly aligned with its human resource practices to get success. (Ichniowski et al., 1997; Mendelson and Pillai, 1999; Collins and Clark, 2003). As mentioned by Mandip (2012) HR is considered as a crucial player in achieving sustainable development in the organization.

Some researchers (e.g. Renwick et al., 2013, Daily and Huang, 2001; Jackson et al., 2011;) emphasized the significance of employees' green activities in the workplace. Green Human Resource Management (GHRM) is the combination of EM into HRM practices is known as Green Human Resource Management (GHRM), which targets to benefit organizations to improve Environmental Performance (EP) through increasing positive employees' involvement and commitment towards environment (Renwick et al., 2008; Jackson et al., 2011) and help to bridge the deviation between available and required technically and managerially skilled workforce for successful implementation of environmental management systems (Daily and Huang, 2001; Renwick et al., 2013). Many researchers supported that GHRM practices are the greatest strategy of environmental performance programmes and GHRM practices provide a fundamental structure that allows organizations to better govern the organization’s environmental impacts (Sudin, 2011). According to Sheopuri and A. Sheopuri (2015), GHRM is responsible for lower costs, greater efficiencies, and better employee retention and engagement ad thus help organizations to decrease employee carbon footprints.

In the late 70’s the journey of the RMG industry started and within a very short period of time, it has become the largest export earner of the country (Shahriar et al., 2014). Despite of being a major driver of Economy, workers safety and welfare, poor infrastructure, lack of training and research, low productivity, lack of skilled workforce are the major challenges and thus immense competition from the rival country (Rakib & Adnan, 2015). With intense competition and changing environmental conditions it is crucial for the RMG sector of Bangladesh to reconfigure its directions strategically for achieving environmental performance.

In Bangladesh, GHRM practice of RMG sector is an under-researched area. Hence, it has become important to explore the impact of GHRM on Environmental Performance this sector. This study seeks to provide a better understanding of the relationship between the green HRM practices and environmental performance of both RMG and Non-RMG sectors in Bangladesh.

**Literature Review**

According to Kolk *et al.* (2002) Environmental Management models have limited suitability for specific situations, and insufficiently consider the organizational and strategic complexities. Since these models could not fulfill the growing business need to obtain more detailed insight into their environmental performance and to gain competitive advantage, this led to the emergence of environmental performance evaluation systems.

Ilinitch et al. (1998) have developed a two by two ‘corporate environmental performance’ matrix to categorize the large variety of possible indicators which differentiates between internal and external components, and also between process and outcome variables. The process dimensions include audits, number of environmental staff, mission statements, communications etc. and outcomes usually include more quantitative data on toxic releases, spills, violations of regulatory standards and penalties.


Recently, to achieve competitive advantage many organisations in most of the industries are implementing strategic environmental performance programs (Rodríguez-Antón, del Mar Alonso-Almeida, Celemín, & Rubio, 2012). This is because environmental performance programs lead to quite a lot of benefits, such as more well-organized business practices, operational cost savings, increasing image, compliance with the regulations and improved competitiveness (Quazi, 1999) and also the reduction of emissions, greenhouse gases, hazardous waste and solid waste (Daily et al., 2012). The number of organizations applying and developing the concept of environmental performance into their business strategies is growing (Aragón-Correa & Sharma, 2003). It seems possible that integrating environmental performance programs into their business strategies can lead to improved organization’s performance (Melville, 2010). Therefore, organizations themselves have developed a variety of measures that consist of several basics of environmental performance (Ilinitch, Soderstrom, & Thomas, 1998).

The effective implementation of environmental performance can only be achieved when the organization has the right people with the right skills and capabilities (Daily & Huang, 2001). Therefore, HR practices must be aligned with business strategic goals. Hence, organizations are able to outline the skills, behavior, and attitudes of the individual as well as influence them to execute their work and accomplish the organization’s goals (Collins & Clark, 2003).

Renwick et al. (2013) concise three core components of the HR aspects of EM. The first core component is associated with the development of green abilities and implies practices such as selecting, recruiting, training and developing environmental knowledge, and encouraging EM leadership. The second core component is related to the motivation of green employees and denotes appraisal and rewards. The third core component is related to the stimulation of employee involvement and implies valorizing tacit knowledge, empowering employees, and creating a green organizational culture. It means, in GHRM various human resource practices are designed in a manner to create a workforce that understands and promotes green behavior in the organization (Mathapati, 2013). In general, this requires talent, skill and employees’ motivation for sustaining the organization’s environmental performance programs (Brammer, Millington, & Rayton, 2007). Based on some evidence, green HRM practices increase employees’ engagement, reduce costs and enhance efficiency. Furthermore, green HRM practices help organizations to lessen the carbon footprint of employees by carpooling, virtual training, job sharing, teleconferencing and online interviews and recycling (Mandip, 2012).

According to Jabbour (2011), the selection and recruitment processes have an impact on environmental performance. Therefore, to attract an increasingly environmentally aware talent in selection organizations should build an environmental reputation and images inspired by the thought that these organizations are environment responsive (Kapil, 2015a; Guerci et al., 2016). Organizations should reflect their environmental sustainability agenda on the organization's website and other public channels accessible so that applicants can clearly view the organization's greening focus (Kapil, 2015a; Arulrajah et al., 2015) and should make sure that environmentally enthusiastic applicants have higher probabilities of being selected (Jabbour, 2011). Green recruitment ensures the understandings of the new recruits about organization’s green culture and sharing its environmental values (Jackson and Seo, 2010) through drawing out candidate's environmental knowledge, values and beliefs (Renwick et al., 2013). Wehrmeyer (1996) recommends few ways organization can follow in order to enhance GHRM through recruitment and selection process such as job descriptions should specify the relevant environmental issues; interview should be tailored to measure the potential compatibility of the candidate with the organization’s green
goals; and orientation programme should be designed to provide new recruits with information about sustainable development policies and commitments, and green goals of the organization. Therefore, searching best green recruitment practices is essential to organizations and environmentally responsible employers can help to attract talented green people to implement corporate environmental management initiatives and ultimately it contributes to achieving organization’s environmental goals with increase sustainability EP.

Employee training is crucial for the successful implementation of the environmental management system and the creation of an environment-friendly culture in the organization (Teixeira et al., 2012). With regards to green training, the organization should update the employees about the green policies and procedures, the advantage of the environmental performance and the organization’s initiatives to improve its environmental performance (A. Sheopuri & A. Sheopuri, 2015). Employee training and development programs should include social and environmental issues at all levels (Mandip, 2012; Mehta and Chugan, 2015) and should be based on training needs (Cherian and Jacob, 2012). Renwick et al. (2013) suggest certain green training and development practices such as training staff to produce a green analysis of workspace, energy efficiency, waste management, recycling, and development of green personal skills. According to Jackson, Renwick, and Muller-Cames (2011), providing training to encourage recycling and waste management, supporting flexible schedules and telecommuting, and reducing long-distance business travel are very useful to reduce the negative environmental impacts of the organizations. In addition, the common benefits gained by the organizations and employees from green training are competitive advantages and helps sustaining high standards of the organization’s services (Murthy, 2008).

Performance management is considered as one of the key human resource practices for promoting environmental behavior and sustainable development, thus advocating green performance management (Gholami et al. (2016). As mentioned by Sharma and Gupta (2015) and Kapil (2015) HRM should integrate EP into PMS by setting EM objectives, responsibilities, monitoring EM behaviors, and evaluating achievement of environmental objectives by using green work rating as the key indicators of job performance. This green work rating should be included in managers' and employees' appraisals record (Ramus, 2002; Prasad, 2013; Renwick et al., 2013). Renwick et al., (2013) suggested that green performance appraisal includes topics such as the use of environmental responsibilities, environmental incidents and the knowledge about the environmental policy and issues, as these issues that are involved in environmental performance appraisal concern the requirement for managers to be responsible for environmental performance. Furthermore, a regular feedback to the employees or teams about their role in achieving environmental goals should be provided by the managers to improve employees’ EP (Arulrajah et al., 2015; Jackson et al., 2011) and to enhance their knowledge, skills and ability and consequently their motivation and engagement in EM responsibilities (Govindarajulu and Daily, 2004). Harvey et al. (2013) and Kapil (2015b) also suggested the organizations to institute an online information system and audits that will enable employees to track their own EP and to participate and suggest in practical ways of making the organization greener.

While performance management system ensures evaluation of green behaviors, a green compensation system ensures that the result of the assessment is linked with rewards and benefits. It is supported by Arulrajah, Opatha, and Nawaratne (2015) that in order to motivate managers and employees on corporate environmental management initiatives, green reward management has significant contributions. In this context, EM could benefit from reward and compensation systems if it focuses on avoidance of negative behaviors and encourages eco-friendly behavior (Zoogah, 2011). Employees should be rewarded with bonuses for their efforts in creating an environment-friendly culture (Liebowitz, 2010). Renwick et al.(2013) and Opatha, (2013) had suggested several ways to promote GHRM practices as monetary-based EM rewards (e.g. bonuses, cash, premiums), non-monetary based EM rewards (e.g. leave, gifts etc.), recognition-based EM rewards (e.g. awards, dinners, publicity, praise etc.), and positive rewards in EM (e.g. feedback) and Personal rewards plan(e.g. gain green citizenship, linking suggestion scheme with rewards system and linking participation in green initiatives with career gains). From the study of Ramus (2001), it was found that recognition-based rewards, in the form of praise letters and plaques, had a better impact on employees' commitment to environ- mental practices more than other types of rewards. Furthermore, organizations may use green reward management practices through linking employees participation in green initiatives to encourage eco-
friendly practices (Jabbar and Abid, 2014; Prasad, 2013) and also through asking them to share innovative green ideas to inspire green creativity and innovation (Ahmad, 2015).

Green employee empowerment is key to improving an organization’s consequence, where employees are motivated to pursue green goals more effectively and efficiently (Tariq et al., 2016). Research has shown that empowerment stimulates self-control, innovative thinking and problem-solving and is directly related to productivity and performance (Renwick et al., 2013; Wee and Quazi, 2005). As suggested by Jabbour and Santos (2008a) and Ahmad (2015), HR managers should inspire employees to participate and initiate green and eco-friendly ideas through empowering them as the part of EP enhancement practices. For this purpose, the HR staff can high-light the necessity to create a participative work environment to top management. The study of Rothenberg (2003) concluded that allowing employees to provide suggestions and to be early involved in problem-solving tasks is the main vehicle for enhancing workers’ participation in EM initiatives. Improving organizational mechanisms for empowerment and participation of employees in the workplace enable hearing the voice of employees to help shape environmental objectives (Harvey et al., 2013), create entrepreneurs within the organization who are socially or ecologically oriented (Sudin, 2011), enhance a tacit knowledge inside people, which has great impact in identifying pollution sources, handling emergency circumstances, and expanding preventive solutions (Boiral and Paille, 2012), encourage employees to work with the organization that has concern towards environmental issues and find greater job satisfaction (Chan & Hawkins, 2010) and thus resulting in improved EP (Renwick et al., 2013).

Green organization culture is the set of assumptions, values, symbols, and organizational objects that reflect the desire or requisite of being an environmentally oriented organization (Harris and Crane, 2002) and it is a factor of either promotion or inhibition to employee’s motivation and willingness to adopt responsible environmental behaviors (Govindarajulu and Daily, 2004). However, the institutionalization of a green culture requires the understandings the environmental values by all level of employees in the organization (Ahmad, 2015; Bhutto and Auranzeb, 2016). Hence, top management should communicate environmental programs, initiatives, and goals constantly to all employees (Ramus, 2001; Govindarajulu and Daily, 2004), provide them feedback on EP in order to maintain proper values, reinforce them through education and training (Fernandez et al., 2003), define penalties for violating environmental regulations and rules (Renwick et al., 2008; Mandip, 2012), give employees time for experimentation towards EP. This would ultimately increase their enthusiasm towards EM (Daily and Huang, 2001; Daily et al., 2007; Govindarajulu and Daily, 2004), and will eventually promote EP innovation (Govindarajulu and Daily, 2004; Ramus, 2001; Ramus and Steger, 2000).

Based on the aforementioned discussion, the research proposes the following hypotheses

H1. Green Human Resource Management (GHRM) has a positive impact on Environmental Performance (EP) of the RMG industry in Bangladesh

H2. Green Human Resource Management (GHRM) has a positive impact on Environmental Performance (EP) of Non-RMG industries in Bangladesh

H3. Significance difference exists between the Environmental Performance (EP) of the RMG industry and the Environmental Performance (EP) of Non-RMG industries in Bangladesh

Objectives

This study attempts to examine the impact of Green HRM (GHRM) practices (Green Recruitment and Selection, Green Training, Green Performance Management, Green Pay and Reward, Green Empowerment and Participation, Green Culture) on the Environmental Performance of Garments industry of Bangladesh.
Research Methodology

An exploratory research inquiry using a mixed methods approach, covering both qualitative and quantitative aspects sequentially (Creswell, 2004), has been used to empirically assess the impact of GHRM on EP in RMG and non-RMG industries in Bangladeshi context. In the data collection phase, a combination of primary and secondary data has been used to enrich this research.

A structured questionnaire was used as primary data collection tools. A five-point Likert Scale was used for all items ranging from ‘1’ “strongly disagree” to ‘5’ “strongly agree”. The study population consists of organizations from Ready Made Garments (RMG) industry and Non-RMG industries like banks, Multinational Companies (MNCs), insurance companies, manufacturing and service companies of Bangladesh. Judgmental sampling technique was used to collect data from 60 mid and top-level employees (30 from Garments, 12 from banks,3 from MNC,5 from service providing organizations,2 from universities,7 from manufacturing companies and 1 from the insurance company) within the time period from June 2018 to January, 2019. The secondary form of data was used to support and provide additional information to the primary data (Creswell, 2012). The questionnaire contained three sections where the first section contained the demographic information of the respondents, the second section contained the current GHRM practices by the company and the last part contained the environmental performance of the company.

Data were analyzed through descriptive statistical methods with Pearson correlation coefficient, T-test, and regression, ANOVA Test performed by SPSS. EP was considered as Dependent Variable and Green Culture (GC), Green Recruitment and Selection (GRS), Green Training (GT), Green Performance Management (GPM), Green Pay and Reward (GPR), Green Empowerment and Participation (GEP) were used as independent variables.

Data Analysis and Findings

Impact of GHRM practices on EP of RMG industry

To check the reliability of collected data Cronbach’s alpha was used. Cronbach’s alpha indicates overall reliability for a set of variables.

Table 2: Reliability Statistics for GHRM in RMG industry

<table>
<thead>
<tr>
<th>Cronbach's Alpha</th>
<th>Cronbach's Alpha Based on Standardized Items</th>
<th>N of Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>.755</td>
<td>.768</td>
<td>7</td>
</tr>
</tbody>
</table>

The standard value of Cronbach’s alpha is 0.70. In this study, Cronbach's Alpha value of GHRM practice of RMG sector is 0.755 which demonstrates a high level of internal consistency for the scale of this sample.

Table 3: Model Summary in RMG industry

<table>
<thead>
<tr>
<th>Model</th>
<th>R</th>
<th>R Square</th>
<th>Adjusted R Square</th>
<th>Std. The error of the Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.803a</td>
<td>.644</td>
<td>.547</td>
<td>.27036</td>
</tr>
</tbody>
</table>

a. Predictors: (Constant), GEP, GRS, GC, GTT, GPR, GPM

Table 4: ANOVA in RMG sector

<table>
<thead>
<tr>
<th>Model</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>2.915</td>
<td>6</td>
<td>.486</td>
<td>6.646</td>
<td>.000a</td>
</tr>
</tbody>
</table>

a. Predictors: (Constant), GEP, GRS, GC, GTT, GPR, GPM
From it has been found from the regression analysis that the value of R square, which refers to the coefficient of determination, is 0.644. That means that the model fits the data appropriately as the dependent variable EP is explained by 64.4% by independent variables. The statistical significance of the regression model is 0.000, which is less than 0.05. That means all the independent variables can significantly predict the dependent variable EP. Therefore, hypotheses H1 is accepted. That means Green Human Resource Management (GHRM) has a positive impact on Environmental Performance (EP) of the RMG industry in Bangladesh.

Regression equation

\[ EP = 0.791 + (0.537 \times GC) + (0.153 \times GRS) + (0.218 \times GTT) - (0.434 \times GPM) - (0.084 \times GPR) + (0.449 \times GEP) \]

The value of b coefficient from the above-mentioned coefficient table indicates that how many units of dependent variable increases or decreases for a single unit increase in each independent variable. Here, “1” point increase in Green Culture (GC), corresponds to the “0.537” unit increase in Environmental Performance (EP). Similarly “1” point increase in Green Recruitment and Selection, Green Training, and Green Empowerment and Participation will correspond to “0.153”, “0.218” and “0.449” unit increase in Environmental Performance (EP) of RMG industry of Bangladesh respectively. But “1” point increase in Green Performance Management and Green Pay and Reward will correspond to “0.434”, “0.084” unit decrease in Environmental Performance (EP) of RMG industry of Bangladesh respectively. Here, Green Culture (GC), Green Performance Management and Green Empowerment and Participation have a statistically significant effect.

According to this table, there is no Multicollinearity in this regression model as the values of VIF for all independent variables falls within the range of 1 to 10. That means there is no interdependency among the independent variables.

### Table 6: Correlations (In RMG sector)

<table>
<thead>
<tr>
<th></th>
<th>EP</th>
<th>GC</th>
<th>GRS</th>
<th>GTT</th>
<th>GPM</th>
<th>GPR</th>
<th>GEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>EP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pearson Correlation</td>
<td>1</td>
<td>.451*</td>
<td>.309</td>
<td>.443*</td>
<td>.350</td>
<td>.501**</td>
<td>.518**</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.014</td>
<td>.103</td>
<td>.016</td>
<td>.062</td>
<td>.006</td>
<td>.004</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>29</td>
<td>29</td>
<td>29</td>
<td>29</td>
<td>29</td>
<td>29</td>
<td>29</td>
</tr>
<tr>
<td>GC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pearson Correlation</td>
<td>.451*</td>
<td>1</td>
<td>.061</td>
<td>.115</td>
<td>.745**</td>
<td>.439</td>
<td>.066</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.014</td>
<td>.749</td>
<td>.546</td>
<td>.000</td>
<td>.015</td>
<td>.731</td>
<td></td>
</tr>
</tbody>
</table>
From Pearson correlation coefficient table, it is clear that Green Culture, Green Training, Green Pay and Reward, and Green Empowerment and Participation have a moderate positive relationship with Environmental Performance for RMG industry. Conversely, Green Recruitment and Selection and Green Performance Management have low correlation with Environmental Performance for RMG industry which are not significant.

Impact of GHRM practices on EP of Non-RMG industry

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### Table 7: Reliability Statistics (Non-RMG industry)

<table>
<thead>
<tr>
<th>Cronbach's Alpha Based on N of Items</th>
<th>Cronbach's Alpha Based on Standardized Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>.871</td>
<td>.871</td>
</tr>
</tbody>
</table>

In this study, Cronbach's Alpha value of GHRM practice of Non-RMG sector is 0.871 which is higher than the standard value of 0.70. It demonstrates a high level of internal consistency for the scale of this sample.

### Table 8: Model Summary for Non-RMG industry

<table>
<thead>
<tr>
<th>Model</th>
<th>R</th>
<th>R Square</th>
<th>Adjusted R Square</th>
<th>Std. The error of the Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.862&lt;sup&gt;a&lt;/sup&gt;</td>
<td>.744</td>
<td>.677</td>
<td>.35267</td>
</tr>
</tbody>
</table>

<sup>a</sup> Predictors: (Constant), GEP, GC, GRS, GPM, GPR, GTT

### Table 9: ANOVA<sup>b</sup> for Non-RMG industry

<table>
<thead>
<tr>
<th>Model</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Regression</td>
<td>8.306</td>
<td>6</td>
<td>1.384</td>
<td>11.131</td>
</tr>
<tr>
<td></td>
<td>Residual</td>
<td>2.861</td>
<td>23</td>
<td>.124</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>11.167</td>
<td>29</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>b</sup> Predictors: (Constant), GEP, GC, GRS, GPM, GPR, GTT
a. Predictors: (Constant), GEP, GC, GRS, GPM, GPR, GTT

b. Dependent Variable: EP

Table 10: Coefficients\(^{a}\) (Non-RMG)

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>Collinearity Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
<td>Beta</td>
</tr>
<tr>
<td>I (Constant)</td>
<td>1.334</td>
<td>.415</td>
<td></td>
</tr>
<tr>
<td>GC</td>
<td>.651</td>
<td>.112</td>
<td>.843</td>
</tr>
<tr>
<td>GRS</td>
<td>-.243</td>
<td>.108</td>
<td>-.293</td>
</tr>
<tr>
<td>GTT</td>
<td>-.113</td>
<td>.166</td>
<td>-.139</td>
</tr>
<tr>
<td>GPM</td>
<td>.072</td>
<td>.139</td>
<td>.078</td>
</tr>
<tr>
<td>GPR</td>
<td>-.142</td>
<td>.139</td>
<td>-.194</td>
</tr>
<tr>
<td>GEP</td>
<td>.441</td>
<td>.143</td>
<td>.497</td>
</tr>
</tbody>
</table>

a. Dependent Variable: EP

From, it has been found from the regression analysis that the value of R square, which refers to the coefficient of determination, is 0.744. That means that the model fits the data appropriately as the dependent variable EP is explained 74.4% by independent variables which are higher. The statistical significance of the regression model is 0.000, which is less than 0.05. That means all the independent variables can significantly predict the dependent variable EP. Therefore, hypotheses H2 is accepted. That means, Green Human Resource Management (GHRM) has a positive impact on Environmental Performance (EP) of Non-RMG industry in Bangladesh.

Regression equation

\[ EP= 1.334+ (0.651 \times GC) - (0.243 \times GRS) - (0.113 \times GTT) + (0.072 \times GPM) - (0.142 \times GPR) + (0.441 \times GEP) \]

The value of b coefficient from the above-mentioned coefficient table indicates that how many units of dependent variable increases or decreases for a single unit increase in each independent variable. Here, “1” point increase in Green Culture (GC), corresponds to the “0.651” unit increase in Environmental Performance (EP). Similarly “1” point increase in Green Performance Management and Green Empowerment and Participation will corresponds to “0.072” and “0.441” unit increase in Environmental Performance (EP) respectively. But “1” point increase in Green Recruitment and Selection Green Training and Green Pay and Reward will corresponds to “0.243”, “0.113” and “0.142” unit decrease in Environmental Performance (EP) respectively. Here, Green Culture (GC), Green Recruitment and Selection Green Performance Management and Green Empowerment and Participation have a statistically significant effect on Environmental Performance (EP) of Non-RMG industry.

According to this table, there is no Multicollinearity in this regression model as the values of VIF for all independent variables falls within the range of 1 to 10. That means there is no interdependency among the independent variables.

Table 11: Correlations (Non-RMG)

<table>
<thead>
<tr>
<th></th>
<th>EP</th>
<th>GC</th>
<th>GRS</th>
<th>GTT</th>
<th>GPM</th>
<th>GPR</th>
<th>GEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>EP</td>
<td>1</td>
<td>.744**</td>
<td>.218</td>
<td>.457*</td>
<td>.481**</td>
<td>.309</td>
<td>.536**</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.000</td>
<td>.246</td>
<td>.011</td>
<td>.007</td>
<td>.097</td>
<td>.002</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Pearson Correlation</td>
<td>.744**</td>
<td>1</td>
<td>.505**</td>
<td>.627**</td>
<td>.436</td>
<td>.458</td>
<td>.385**</td>
</tr>
</tbody>
</table>
From the Pearson correlation coefficient table, it is clear that Green Culture has strong and Green Training, Green Performance Management, Green Empowerment, and Participation have a moderate positive relationship with Environmental Performance for the RMG industry. Conversely, Green Recruitment and Selection and Green Performance Management have Low Correlation with Environmental Performance for Non-RMG industry which is not significant. Conversely, Green Recruitment and Selection and Green Pay and Reward have Low Correlation with Environmental Performance for Non-RMG industry which is not significant.
The result of ANOVA shows that significance is 0.001 which is lower than 0.05. That means the null Hypothesis for H3 is rejected. Therefore, there is a significance difference exists between the Environmental Performance (EP) of the RMG industry and the Environmental Performance (EP) of Non-RMG industries in Bangladesh.

Conclusions

This study has presented a survey analysis of the impact of Green HRM Practices on Environmental Performance in both RMG and Non-RMG industries existing in India. Data analysis reveals that in both RMG and Non-RMG sector there is a positive association between GHRM Practice and Environmental Performance (EP). In both sectors, Green Culture and Green Empowerment and Participation play a great role in increasing Environmental Performance (EP) of the organizations. In the RMG sector Green Culture is strongly and Green Training, Green Performance Management, Green Empowerment and Participation are moderately correlated with EP. Similarly, in Non-RMG sector, Green Culture, Green Training, Green Empowerment and Participation and also Green Pay and Reward are moderately correlated with EP. On the other hand, in both sectors, Green Pay and Reward have negative impacts on Environmental Performance (EP). This study provides some insights into the implementation of GHRM Practices by certain RMG and Non-RMG companies in Bangladesh which should help HR practitioners to acquire a better understanding of the current status to the implementation of GHRM Practices. Further research can be taken by considering other factors like the firm's size, types of training etc.

References


Biography

Nazma Akhter is a Senior Lecturer of Management at the Department of Business Administration. Ms. Nazma earned her 1st Master’s degree on ‘Human Resource Management’ from the University of Dhaka. And the 2nd Masters on ‘Macroeconomic Policy’ from National Graduate Institute for Policy Studies (GRIPS), Japan. She earned her bachelor’s degree in Business Administration from University of Dhaka with a major in Management. She has been working at NDUB since November, 2014. Before that, she worked other two universities.

Besides teaching, Ms. Nazma Akhter is also involved in research, particularly in the area of Management and Human Resource Management, Sustainability, Economics. Her research interest has led her to several publications and she continues to look for new research opportunities in these areas. She has completed several certificate courses on Advanced Research Methodology, and Teaching and Learning.
Impacts of the Level of Women Empowerment on Ready Made Garments Industry in Bangladesh

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Abstract:

Ready Made Garment industry is an emerging industry in Bangladesh, which made it the second largest RMG exporting country in the world. At present, the scope of employment in this sector is over 4 million people the majority of which are women. However, the majority of people involved in this sector are women but the level of women empowerment in this sector has been barely seemed satisfactory. This paper is aimed to identify the level of women empowerment in Bangladesh RMG industry and its impact on this industry. In this paper, data has been collected by conducting a survey by using a questionnaire. This research is a descriptive research where qualitative and quantitative both types of analysis have been used. This study has validated some facts as women are more preferred as a worker but downcast in the managerial position, by default abolition of women from mid-level management, lack of empathy in management decision because of male-dominated management. This study may provide a concise idea of the level of women empowerment in the RMG sector and their participation in decision-making and its impacts on the productivity of the Blue-collar women workers and the RMG sector of Bangladesh. This study can be a way forward for further rigorous study of these impacts and their significance on the RMG sector of Bangladesh.

Keywords:

RMG (Ready Made Garments), Empowerment, Women Empowerment
1. Introduction

Bangladesh is a developing country with few emerging export sectors and Ready Made Garments is the pioneer of them. Bangladesh Ready Made Garments industry has been mounting with an expansionary route exporting $28 billion in 2016-2017. (Export.gov, 2012) RMG industry is a source of employment for approximately over 4 million people and most of them are female. However, RMG sector of Bangladesh is a women-driven industry but male dominates it. 60.8% of the total workers are female but there are only about 0.5% of managers in RMG enterprises are female, and only about 9.3% of HR managers in the RMG sector are female. (Centre for Policy Dialogue, 2018)

It seems that, despite of being a female-driven industry, women do not seem that much in the managerial positions. Therefore, very few women seem to participate in decision-making and organizational policy making of RMG sector, which results the male dominance in the management level of RMG sector, which might affect the women workers.

2. Literature Review

2.1 Status of female leadership in RMG sector

However, the blooming of RMG sector enhances the level of women empowerment in the society by creating scope of employment for the unskilled or semiskilled women but the level of women empowerment within the industry does not give the impression of satisfaction.

After interviewing eight (8) women from different organizations from RMG sector, some indicators like Organizational Behavioral Influences and Cultural Influences have been identified as the reasons behind the low number of female in the leading position of RMG. (Islam M. A., Jantan, Hashim, Chong, & Abdullah, 2018) Besides these Social Structure & Culture, Organizational Culture and Less number of Encourager are also identified as the indicators of having low number of female leaders in RMG from the interviews of ten (10) prospective female respondents. (Islam & Jantan, 2017) Social culture is supportive to male leaders than female leaders, which may provoke denial of female leadership and their contribution, sometimes, even harass them. (Islam & Jantan, 2017)

Organizational behavioral influences can be explained by several factors like Lack of Work-life Balance, Negative perception about women leadership and Bias Employment Process. (Islam M. A., Jantan, Hashim, Chong, & Abdullah, 2018)

Low use of Succession planning and flexibility can also be considered as organizational influences behind low female participation in leading position in the RMG organizations of Bangladesh. (Islam, Jantan, & Saimoon, 2017) These authors have also validated these factors by conducting a survey where 98.2% and 96.7% participants have supported the existence of low use of succession planning and less flexibility in work process respectively. Male managers get 21% higher payment than their female counterpart does. (Mahmud & Afrin, 2017) Cultural influences can be explained by gender stereotyping, cultural expectations from women, unwillingness of male leaders to include women in managerial positions (Islam M. A., Jantan, Hashim, Chong, & Abdullah, 2018)

The social structure can also become an obstacle of women leadership. Women leaders or prospective leaders usually find very small number of career encouragers in their professional and personal life. Many women have been discouraged to peruse leading positions because their families think they will become busier with their professional life and will be unable to perform their responsibilities to their families as women have more strong family ties and more responsibilities to their families because of the social structure of Bangladesh. (Islam & Jantan, 2017)
2.2 Current scenario of Women workers in RMG sector

Women workers in Bangladesh RMG sectors are suffering for Long Working Hour, Discrimination in Wages and Promotions, Absence of Maternity Leave, Lack of Medical and Lunch Facilities, Sexual Harassment, Lack of Transportation, Termination without any Notice. (Mahmud & Afrin, 2017)

Long Working Hour, Lack of Medical, Transportation and Accommodation Facilities have also been supported by the research of (Sikdar, Sarkar, & Sadeka, 2014). Moreover, wrong mindset of the industry owners regarding the level of commitment of married female workers for work has also been found as a reason of sufferings of women workers. Besides Low and Irregular Wages, Job Insecurity, Sexual Harassment, Communication Problem and Housing Problem, Women workers of RMG sector have to go through Misbehaviors of the Co-workers, Pattern of Diseases

- Illness and Substandard Payment for overtime. Moreover, they are not only becoming the victim of harassment inside the factory premises but also outside the factory by the local goons and police. (F. Begum, 2010)

Poor activation or introduction of female labor union, hazardous working environment, workplace stress and replacement of aged-experienced workers with low paid fresh workers are also behind the distress of women workers of RMG sector. (Chowdhury & Ullah, 2010)

2.3 The paradox: Female Manager Vs Female Workers

Ultimately, male middle managers and female garment workers often conform to the same patriarchal structure found in many family settings and within the social structure of Bangladesh, which sometimes even provokes abusive behavior and harassment of the women workers by the male managers. (Saxena, 2014)

According to research, 80% of machine operators in the ready-made garment industry in Bangladesh are female. However, only about 5% to 10% of the supervisors are women. This may confine communication and leads to quality defect and delays. Reduction of this gender disparity in managerial positions might play a significant role in enhancing productivity.

Appointing more Female officers and well-trained male officers may reduce the torture and harassment towards female workers. (Chowdhury & Ullah, 2010)

The relationship between women empowerment and garment factory productivity output has been found correlated while conducting research on the work forces of two garments. The average productivity scores of empowered workforce are around 22% higher than that of the less empowered workforce. (Chakrobarty, 2017)

3. Conceptual Frameworks

After reviewing the existing literature, the following conceptual frameworks have been developed for this paper from two perspectives; one is from women managers’ perspective and other is from women workers’ perspectives.
Conceptual Framework -2: Productivity of Blue-collar Women Workers

Objectives of the study:

To explore the level of women empowerment in RMG sector of Bangladesh.
To identify the factors behind the existing level of women empowerment in RMG sector of Bangladesh and their impacts.
To understand the impacts of the existing level of women empowerment on the blue-collar workers working in RMG sector of Bangladesh.

Research Hypothesis:

H1 Women empowerment in the managerial positions of RMG sector of Bangladesh is satisfactory.
H2 Women empowerment in the managerial positions of RMG sector of Bangladesh is not satisfactory.
H3 There is no positive relationship between the Empowerment of Women Managers in RMG of Bangladesh and the level of productivity of Blue-collar women workers.
H4 There is a positive relationship between the Empowerment of Women Managers in RMG of Bangladesh and the level of productivity of Blue-collar women workers.

6. Research Methodology

However, after reviewing the literature several methodological approaches have been found for identifying the factors affecting the Level of Women Empowerment on Ready Made Garments Industry in Bangladesh and their impacts on RMG but in this study descriptive research has been adopted. For the purpose of this study, both primary and secondary data have been used. As secondary data sources, previous research reports, journals, books, websites etc have been used. However, many of the researchers, for example, (Islam M. A., Jantan, Hashim, Chong, & Abdullah, 2018) and (Islam & Jantan, 2017) have used Qualitative techniques like in-depth interviews, case studies for collecting data from women managers instead of using quantitative measures but here survey method has been used for quantifying the effects of the independent variables on the dependent variable. Two surveys have been conducted for collecting primary data by using two structured questionnaires. 16 women managers of RMG have participated in one survey and 25 women workers have participated in the other one. Five-point Likert Scale was used for the second section ranging from “1= Strongly Disagree” to “5=Strongly Agree”. Respondents have been selected by using judgmental sampling technique in accordance with convenience sampling technique. In this paper, Multiple Regression Analysis and Pearson Correlation have been used for analyzing the data.
7. Analysis and Findings

7.1 Analyzing the factors influencing the level of Women Empowerment in the managerial position of RMG sector in Bangladesh

At first to check the reliability of the collected data from women managers, reliability test has been done. **Reliability Statistics**

<table>
<thead>
<tr>
<th>Cronbach’s Alpha</th>
<th>N of Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>.908</td>
<td>5</td>
</tr>
</tbody>
</table>

To check the reliability of the collected data Cronbach’s alpha was used. Cronbach’s alpha indicates overall reliability for a set of variables. The standard value of Cronbach’s alpha is **0.70**. In this study, the value of Cronbach’s alpha is **0.908**, which demonstrates high level of internal consistency for the scale of this sample.

**Multiple Regression Analysis**

To test the research hypothesis one (**H1**), a multiple regression analysis has been done. It predicts **Empowerment of Women Managers** (dependent variable) with independent variables like **Organizational Behavioral Influence**, **Social Structural Influence**, **Cultural Influence** and **Threats of Harassment**. The following table (Table-7.2) shows the model summary.

<table>
<thead>
<tr>
<th>Model</th>
<th>R</th>
<th>R Square</th>
<th>Adjusted R Square</th>
<th>Std. Error of the Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.872</td>
<td><strong>.761</strong></td>
<td>.674</td>
<td>.51090</td>
</tr>
</tbody>
</table>

From the table 7.2, it has been found that the value of R square, which refers to coefficient of determination, is **0.761**. It means that the model fits the data appropriately as the dependent variable is explained **76.1%** by the independent variables.

<table>
<thead>
<tr>
<th>Model</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Regression</td>
<td>9.129</td>
<td>4</td>
<td>2.282</td>
<td>8.743</td>
</tr>
<tr>
<td></td>
<td>Residual</td>
<td>2.871</td>
<td>11</td>
<td>.261</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>12.000</td>
<td>15</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. Predictors: (Constant), TOH, SSI, OBI, CI

b. Dependent Variable: **Empowerment of Women Managers**
The table 7.3 indicates that the statistical significance of the regression model is **0.002**, which is less than 0.05. That means all the independent variables can significantly predict the dependent variable *Empowerment of Women Managers*. Therefore, H0 is rejected. That means Women Empowerment in the managerial positions of RMG sector of Bangladesh is not satisfactory.

### Table-7.4: Coefficients

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>Collinearity Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
<td>Beta</td>
</tr>
<tr>
<td>1 (Constant)</td>
<td>-1.070</td>
<td>1.002</td>
<td>-1.068</td>
</tr>
<tr>
<td>OBI</td>
<td>.019</td>
<td>.272</td>
<td>.020</td>
</tr>
<tr>
<td>SSI</td>
<td>.311</td>
<td>.253</td>
<td>.237</td>
</tr>
<tr>
<td>CI</td>
<td>.367</td>
<td>.305</td>
<td>.254</td>
</tr>
<tr>
<td>TOH</td>
<td>.611</td>
<td>.396</td>
<td>.491</td>
</tr>
</tbody>
</table>

*a. Dependent Variable: Empowerment of Women Managers*

**Regression equation**

Empowerment of Women Managers = -1.070 + (0.019* Organizational Behavioral Influence) + (0.311* Social Structural Influence) + (0.367* Cultural Influence) + (0.611* Threats of Harassment)

According to table 7.4, the value of b coefficient from the above mentioned coefficient table indicates that, how many units of dependent variable increases or decreases for a single unit increase in each independent variable. Here, “1” point increase in Organizational Behavioral Influence, corresponds to “0.019” unit increase in the level of Empowerment of Women Managers. Similarly “1” point increase in Social Structural Influence, Cultural Influence and Threats of Harassment will corresponds to “0.311”, “0.367” and “0.611” unit increase in the level of Empowerment of Women Managers respectively. Here, all significant values are more than 0.05, which means that no b Coefficients are statistically significant.

According to this table 7.3, there is **no Multicollinearity** in this regression model as the values of VIF for all the independent variables fall within the range of 1 to 10. Therefore, it can be said that independent variables of the model are not similar and this regression model is a standard regression model.

**Pearson Correlation:**
Pearson correlation has also been conducted to check the correlation between the dependent and independent variables. Pearson correlation shows the degree of relationship between the dependent variable and the independent variable. Correlation output of this study illustrates that level of significance are less than 0.05 for all the independent variables. That means there is a significant relationship between all the independent variables (Organizational Behavioral Influence, Social Structural Influence, Cultural Influence, and Threats of Harassment) and the dependent variable (Empowerment of Women Managers).

Moreover, Organizational Behavioral Influence, Social Structural Influence and Cultural Influence are Highly Correlated with the level of Empowerment of Women Managers. On the other hand, Threats of Harassment is perfectly correlated with the Empowerment of Women Managers.
7.2 Analyzing the impacts of Women Empowerment in the managerial position of RMG sector on the Blue-collar women workers

At first to check the reliability of the collected data from women workers, reliability test has been done.

**Reliability Statistics**

<table>
<thead>
<tr>
<th>Table-7.6: Reliability Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cronbach's Alpha</td>
</tr>
<tr>
<td>.775</td>
</tr>
</tbody>
</table>

To check the reliability of collected data Cronbach’s alpha was used. Cronbach’s alpha indicates overall reliability for a set of variables. The standard value of Cronbach’s alpha is 0.70. In this study, the value of Cronbach’s alpha is 0.775, which demonstrates high level of internal consistency for the scale of this sample.

**Multiple Regression Analysis**

To test the research hypothesis one (H2), a multiple regression analysis has been done. It predicts Productivity of Women Workers (dependent variable) with independent variables like Organizational Policy, Empathy, Organizational Culture and Safety& Security.

The following table (Table-7.7) shows the model summary.

<table>
<thead>
<tr>
<th>Table 7.7: Model Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>a. Predictors: (Constant), OP,EP, OC, SS</td>
</tr>
</tbody>
</table>

From the above table, it has been found that the value of R square, which refers to coefficient of determination, is 0.956. It means that the model fits the data appropriately as the dependent variable is explained 95.6% by the independent variables.

<table>
<thead>
<tr>
<th>Table 7.8: ANOVA&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>a. Predictors: (Constant), OP,EP, OC, SS</td>
</tr>
<tr>
<td>b. Dependent Variable: Productivity of Women Workers</td>
</tr>
</tbody>
</table>

The above table indicates that the statistical significance of the regression model is 0.000, which is less than 0.05. That means all the independent variables can significantly predict the dependent variable Productivity of Women Workers. Therefore, H0 is rejected. That means there is a positive relationship between the
Empowerment of Women Managers in RMG of Bangladesh and the level of productivity of Blue-collar women workers.

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>(Constant)</td>
<td>-14.502</td>
<td>2.593</td>
<td>-5.593</td>
</tr>
<tr>
<td>OP</td>
<td>1.966</td>
<td>.321</td>
<td>.463</td>
<td>6.133</td>
</tr>
<tr>
<td>EP</td>
<td>.075</td>
<td>.068</td>
<td>.061</td>
<td>1.104</td>
</tr>
<tr>
<td>OC</td>
<td>1.002</td>
<td>.176</td>
<td>.508</td>
<td>5.700</td>
</tr>
<tr>
<td>SS</td>
<td>1.096</td>
<td>.439</td>
<td>.161</td>
<td>2.495</td>
</tr>
</tbody>
</table>

a. Dependent Variable: Productivity of Women Workers

Regression equation

Productivity of Women Workers = -14.502 + (1.966* Organizational Policy) + (0.075* Empathy) + (1.002* Organizational Cultural) + (1.096* Safety & Security)

The value of b coefficient from the above mentioned coefficient table indicates that, how many units of dependent variable increases or decreases for a single unit increase in each independent variable. Here, “1” point increase in Organizational Policy, corresponds to “1.966” unit increase in the level of Productivity of Women Workers. Similarly “1” point increase in Empathy, Organizational Culture, and Safety & Security will corresponds to “0.075”, “1.002” and “1.096” unit increase in the level of Productivity of Women Workers respectively. Here, all significant values are less than 0.05 except Empathy. Therefore, Organizational Policy, Organizational Culture, and Safety & Security have statistically significant effect.

According to this table, there is no Multicollinearity in this regression model as the values of VIF for all the independent variables fall within the range of 1 to 10. Therefore, it can be said that independent variables of the model are not similar and this regression model is a standard regression model.

Pearson Correlation:
Pearson correlation has also been conducted to check the correlation between the dependent and independent variables. Pearson correlation shows the degree of relationship between the dependent variable and the independent variable. Correlation output of this study illustrates that level of significance are less than 0.05 for all the independent variables. That means there is a significant relationship between all the independent variables (Organizational Policy, Empathy, Organizational Culture, Safety & Security) and the dependent variable (Productivity of Women Workers).

Organizational Policy and Organizational Culture are highly correlated with the level of productivity of women workers. On the other hand, Empathy and Safety & Security are moderately correlated with the level of productivity of women workers.

**Conclusions**

This paper is an attempt to identify the factors behind the existing level of women empowerment in the management level of RMG industry of Bangladesh and its impacts on the industry. From this study, it has been observed that current level of women empowerment in the management level of RMG industry is not satisfactory and some factors like Organizational Behavioral Influence, Social Structural Influence, Cultural Influence and Threats of Harassment are working as the catalysts behind this. Conversely, empowerment of women managers can stimulate the reformation of the working condition and environment of the factory by changing organizational policy and organizational culture, by being empathetic and by ensuring safety & security within the organization, which leads to enhance the productivity level of Blue Collar Women workers.
This research can be used as a way forward for further research. Future research can be conducted with larger sample size to obtain more generalized result. Furthermore, in-depth research might conduct to examine each of the factors that are identified to fetch by women managers and which can increase the level of productivity of Blue-collar women workers. Another concern has been come up from the prior researches that Labor Union can also play a vital role in empowering women by including more women in their leadership. Lastly, it can be concluded like this, that women empowerment in the management level of RMG is not only crucial for ensuring compliance but also for sustainable profit and growth of the RMG sector which will lead towards sustainable RMG industry in Bangladesh.

References
10. The Asian Foundation .

Biographies

Afrista Birjis is an academician working as the Assistant Professor of Department of Business Administration in Notre Dame University Bangladesh. In accordance with academic researches, she has also been involved in different industrial researches on marketing arena. Her areas of research interest are integrated Marketing Communication, Green Marketing, Brand Health Analysis, Consumer Behavior analysis, etc.

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Abstract

Occupational health and safety (OHS) in the industries of developing nations are overlooked in many aspects. Among them, textile industry, particularly in Southeast Asia where it plays the most important role in the economy, has been ironically the worst victim of safety and health issues according to various studies. Long working hours, lack of proper illumination and ventilation, unhealthy and polluted environment, scarcity of safety equipment, noise irritation, unsafe manufacturing units etc. have been found to be some of the major obstacles in the way of physical and mental wellness of the workers in many small and large garments factories in those countries. Governments are introducing zero tolerance policy toward any negligence and imposing higher standards of OHS on garments which are bound to face new challenges. Hence in this study an overall scenario of health and safety conditions of the workers, including women, in the textile industry in the developing countries has been summarized and a reconstruction of the safety system with newer technologies been recommended using the knowledge from recent research articles and reports.

Keywords

Occupational Health and Safety, Textile, Ergonomics, Work Environment, Productivity

1. Introduction

Textile industry involves long hours of work and high productivity because of its inherent nature of diverse procedures and stages which demands health and safety concerns for workers. As a predominantly private sector, the industry is unorganized and incorporates job possibilities for both men and women while the poor health conditions of the workers are affected by poverty, illiteracy, poor working conditions, long working hours and malnutrition (6). According to the statistics provided by International Labor Organization (ILO), about 2.3 million fall victim to occupational accidents and diseases annually which causes around 4% of the world’s total GDP loss, and different appalling incidents in recent times in several workplaces worldwide have given rise to initiatives to improve safety and health condition of the workers. This paper intends to draw attention of readers to these facts. The literature review section provides brief descriptions of different hazards and factors that relate to the overall health and safety needs of the garment industry workers, such as physical, mechanical, chemical, social and psychological factors. Also, ergonomic issues, engineering data and recent preventive strategies adopted by governments and international organizations have been discussed here. Lastly, a few remarks have been mentioned with a view to improving the conditions of the workers along with their workplaces.
2. Literature Review

The major scenarios of the garment industry as depicted in recent articles have been briefly highlighted in the following points.

2.1 Physical risk factors

Researchers found some serious problems in the places where workers work. Recent studies indicate that appearance of physical hazards are greater in small enterprises (10). The workplace is surrounded by some risk factors such as poor illumination, loud noise, poor ventilation, excess heat, cold, vibration and so on. In textile industries, weaving machines can produce more than 90 to 100 dB which can damage the eardrum and change pulse rate. Problems like fatigue, annoyance also occur for long time exposure to noise (5). Hearing may weaken gradually from chronic and repeated noise exposure and cause Noise-Induced Hearing Loss (NIHL). Excessive heat in the workplace can cause heat stroke, cramps, syncope and reduce efficiency. Vibration from drilling, hammer, sewing machine can cause musculoskeletal disorders (MSDs) (1). Many times, it has been seen that garments floor are not properly illuminated but randomly lighted. This cause the extra pressure in eyes and this impact to the production rate in the garments. Poor illumination level affects workers eyes and cause eye strain while working for a longer period (18).

2.2 Mechanical hazards

This type of hazards include tripping hazards, traumatic injuries, house-keeping injuries, steps and fault of moving equipment (5). They can also be in the form of incidents like caught-in, struck by machinery, confined space, slips and trips, compressed air or high pressure fluids (such as cutting fluid) and material handling in manual process (1). The workers who work with electrical current can be troubled at any time. The workers that are not aware of potential electrical hazards may fall victim to dangers, even death due to short circuit (20).

2.3 Chemical Risk Factors

High accident risks due to chemical hazards are larger in small industries and garments (10). Large amount of dusts, harmful gases in industries cause pneumoconiosis or ‘black lung’ and asthma when these are inhaled (1). Minimization of dust levels could include dilution, suppression, capture etc.(21). Crystalline silica causes silicosis and chronic obstructive pulmonary disease, diesel particulate exposure increases the risk of lung cancer, exposure to nickel compounds is responsible for nasal sinus cancer, different dangerous metals including lead, platinum, cobalt etc. cause different health hazards (9).

2.4 Psycho-social and Physical Risk Factors

Workplace stress include insufficient income, excessive pressure on work, poor standard of living, job insecurity, inequality, violence, etc.(1). Job dissatisfaction, psychological stresses, complex social issues, such as compensation laws and disability system (Frymoyer and Mooney, 1986), decision latitude, social support are the key measures of psychosocial factors at the workplace (13). Workers exposed to psycho-social hazards give low performance of work. High rates of accidents and absenteeism are the consequences of this (1). High exposure to psychosocial hazard is responsible to have impacts on the development of musculoskeletal disorders, cardiovascular diseases, hypertension, rapid aging etc.(13). Comparatively very few studies have been carried out of this factors (10).

2.5 Ergonomics and Engineering Measures

By using ergonomic workstation and equipment, a worker can keep himself safe from many work-related MSDs. Repetitive activities, prolonged standing often combined with a bent-over or awkward position and sitting for long hours result in MSDs. Cumulative-trauma-disorders (CTDs) are cumulatively received over time minor back injuries due to improper work postures (1). Cumulative trauma disorder prevalence rates among sewing machine operators to be 25% and 47.5%, respectively. High prevalence rates of problems in the upper body (the neck, shoulders, arms, hands, and back) have also been observed by others (Balder et al., 1991; Punnett et al., 1985; Nag et al, 1985; Anderson and Gaardboe, 1993 and, Chan et al., 2002) (11).

From several observations, many ergonomic issues were found, such as workspace was narrow and sitting postures were typically constrained and uncomfortable. Sitting cross-legged crouched or leaning forward made a
problem. Gripping and pinching with considerable forces are normal to their work. Seats were devoid of a backrest, which would have allowed intermittent micro breaks for resting the upper body after stressful sessions of bending the trunk and neck. Many seats were hard and wooden, without a cushion to prevent tissue compression at the area of the ischial tuberosities. Sharp bending of the neck was common, combined with sharp bending of the trunk (19). Ambient plant temperatures varied from 34-38 degree Celsius which was about 3 to 4 degree Celsius higher than the outside temperature because no air conditioning system was found (Sarder and Ali, 1996). The relative humidity was recorded varied between 50-70% (4).

Improper workstation design for workers, managing the tool procedure etc. cause MSDs. In a recent survey of 600 workers in Bangladesh textile, regarding nature of the job of workers, it was found that majority (37.2%) of the workers work as sewing operator, remaining workers worked as sewing operator helper (22.7%), cutting personnel (15.5%), finishing personnel (14.5%), supervisory and office personnel (10.2%). Majority (57.5%) of the respondents mentioned that they suffered from some kind of MSDs in different body parts. Amongst them 130 (37.7%) reported that they were suffering from pain in the back (lumbar region), 91 (26.4%) in the neck and shoulder region, 52 (15.1%) in the chest, 49 (14.2%) in the wrist and hand, 10 (3.9%) in the lower abdomen and 13 (3.77%) in the lower limb. Most (70.7%) of the respondents reported that their pain was intermittent type and occurred occasionally during heavy work load. Of the total respondents, 32 (5.3%) also mentioned that they felt numbness and tingling sensation on palmer surface of thumb and index finger and all of them worked in sewing and knitting sections. In addition to MSDs the respondents also mentioned about some injuries and other illnesses. Of the total respondents, only 30 (5.0%) mentioned some current accidental injuries during work, like needle prick (66.7%), iron press (20.0%) and cut injury (13.3%) (4, 17). For this purpose, there is a rough anthropometric measurement which may varies from country to country. According to the anthropometric measurements that were taken, the average sitting elbow height of workers was 639 mm while the workstation height was725mm for the straight machine work station which had the machine positioned at the same level as the table surface. This difference in height of about 86 mm, was above the recommended working height for a sitting elbow height of 639

- The overlock machine workstation was raised a further 110 mm above the existing 725 mm table surface, creating a working height of 835 mm, while the hemming machine was raised 160 mm above the existing table surface, yielding a working height of 885 mm. The result showed that the working height for both the over locking machine and hemming machine, which was supposed to be a maximum of 639 mm, were actually 196 mm and 246 mm, respectively, from the table surfaces (7, 16).

2.6 Availability of Medical Facilities

Proper treatment facilities and first-aid equipment are necessary to ensure the urgent needs of workers in every industry which many factories struggle to provide in the developing countries. Mehedi et al. (2014) (12) found in a survey that 90% of the industry has medical doctors only for primary aids while the other 10% does not have any. Nowhere in the industry was equipped with intensive medication facility. They also found that the average medical expense of a female worker is higher than her medical allowance. Moreover, the inability of the workers to pay for medical expenses has been found to be a variable related to the recent incidents of labor unrest in Bangladeshi ready-made garment industry caused mainly by long working hours and layoff (2).

3. Government Regulations and International Initiatives

Jobs in Garments sector are full of insecurities. Especially in the subcontinent where little safety is being insured by the owners of the big and small industries. However, some changes have been observed after many big occurrences. After the horrifying accident of Rana plaza, the Bangladesh government made some regulations to ease the difficulties faced by RMG entrepreneurs. Advance income tax was cut down to 0.3 percent of free on-board value from 0.8 percent. Nonetheless, this could not satisfy the requirements of global buyers. Therefore, a joint statement was signed between Government of Bangladesh (GoB), RMG workers, and RMG employers named National Tripartite Plan of Action (NTPA) on May, 2013 (3). In July 2013 an agreement was issued between GoB, EU, and International Labor Organization (ILO) based on NTPA of time-bound actions, “The Sustainability Compact: Compact for Continuous Improvements in Labor Rights and Factory Safety in the Ready-Made Garment and Knitwear Industry in Bangladesh” (international labour organization, 2019). There was a initiative by the GoB establishing two different factory inspection programs to make the work place safer in Bangladesh: the Bangladesh Accord on Fire and Building Safety in Bangladesh, and Alliance for Bangladesh. ILO was given the role of neutral chair here. Over 190 apparel companies from over 20 countries signed this 5-
year independent and legally binding agreement designed to build a safer and healthier Bangladeshi RMG Industry on May 15, 2013 (ACCORD, 2018) (15).

4. Concluding Remarks

There are different kinds of risk factor in the jobs in garments sector. Many researches are going on to prevent or eliminate those hazards from the work place. Government and many international organizations have taken necessary steps, several times to improve the overall condition of work place of some particular countries by forcing the owners of the garments industries which eventually may improve the condition of that particular sector or work place. However, hazards or risk factors cannot be permanently removed and therefore some steps should be taken to minimize the effect or number of incidents in the work place, for instance, one legislative measure that was made after the fire of Tazreen Fashion and another one after the destruction of Rana Plaza in Bangladesh. In order to prevent the fire hazard, fire extinguisher should be kept around the risky areas of the work place. To prevent physical risk factors garments floors have to be properly illuminated. Excessive heat, cold, noise needs to be eliminated from the work place. Proper masking needs to be assured if there is a possibility of inhaling dusts or harmful gases. An environment should be built so that workers do not feel the pressure of work or job insecurities and thus decrease of the psychological risk factors may be observed. The space for the workers has to be increased, housekeeping should be properly maintained and the factory should be established in well-planned premises. Provision of medical care and adequate first aid facilities for the workers should be mandatory (14). Use of personal protective equipment (PPE) and standard procedures should be encouraged to prevent injuries and casualties. In the light of the incidents at Tazreen Fashions and Rana plaza in Bangladesh, fire safety measures and standard building construction codes should be strictly maintained by the responsible authorities. South Asian countries have been benefited from their RMG sectors for a long time, particularly for their low-cost labor. For a South Asian developing country like Bangladesh, this sector provides 81% of total export income (8). It’s high time these countries improved the working condition and environment of the work place of the garments industry for the sake of a sustainable socio-economic development.

Acknowledgement

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**Biography**

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Risk Analysis of Ready-Made Garment Sector in Bangladesh

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Abstract

Managing industries effectively in the ready-made garment sector has emerged as a crucial issue in existing uncertainties and in order to attain the objectives in RMG sector, disruption risks has to be properly assessed so that the practitioners and academics can mitigate them accordingly. This study focuses on identifying and analyzing some common risks that occur in garment sector in respect of garment industries of Bangladesh. The proposed model evaluates twelve risk factors based on their order preference mathematically with the help of TOPSIS and fuzzy-TOPSIS method. The result of this study indicates major risks of the network and by the outcome of this research managers or practitioners in this sector can take actions to reduce the disruption risks. By changing the risk factors or the weightage of the criteria, this study can be used with any changing environment or even in other sectors.

Keywords

RMG, Risks, Risk ranking, Risk analysis in RMG, TOPSIS, Fuzzy TOPSIS

1. Introduction

Ready-made garment industry is the largest part of the economy of Bangladesh and it brings about 81% of the country’s export earnings (Source: www.bgmea.com.bd). As much as the industries have evolved in the past two decades, the risk management has been under burning question. Incidents like Rana plaza or Tazrin garments have bought the world limelight into this sector and affected it enormously. Like any other industry, it is very important to have a proper risk analysis and management strategy based on that analysis.

This study identifies and analyzes twelve common risks occurring in garment industries of Bangladesh. The factors are given weightage based on their probability, severity and quality of control. To evaluate those risks, a model is proposed using TOPSIS and Fuzzy TOPSIS to assess the risks. Risk management is unavoidable to overcome uncertainties evolving with the rapidly changing world.

Quantifying risks in various sectors was started in early 2000s but very few works are done on risk quantification based on the RMG sector. In 2000, a couple of researchers showed the gender imbalance in this sector. They showed the conditions in the work environment inside the garment industries (Paul-Majumder & Begum, 2000). Some operational disturbances were mentioned in a study in the RMG sector in Bangladesh which includes low salary, insufficient government policies, worker disputes etc. (Islam, Bagum, & Rashed, 2012). One of the studies identified the operational disturbances in this sector and found the root causes of those disturbances. (Islam et al., 2012). Safety issues in the garments industry have been analyzed and factual cases were presented in a study to support their claim (Uddin & Hossain, 2009). According to BKMEA (Bangladesh Knitwear Manufacturers and Exporters Association), potential problems in this sector occur because of the competition with China. Other than that, interrupted power supply, pollution, labor disputes are some key reason (Hoque, 2007). Currently approximately 4 million workers work in this sector. (Source: Export Promotion Bureau Compiled by BGMEA). An article discussed
some ways to improve the condition of the garment workers of this country (Bhuiyan, 2012). Labor unrest causes a huge financial loss almost every year and is a major risk in RMG. A survey based study claimed that considering Human Resource Management (HRM) practices can satisfy the workers and reduce protests (Sarker & Afroz, 2014).

A recent study identified criteria associated with productivity in garments. It used MCDM tools and Fuzzy AHP to evaluate the criteria (Halder, Karmaker, Kundu, & Daniel, 2018). Another one identified the risk causing factors and some risk controlling techniques are discussed (Hasan & Mahmud, 2017). Some papers did analysis on risks on some other industrial sectors in Bangladesh before (Zubayer, 2018) but it is new in the RMG sector. Also, using TOPSIS and fuzzy-TOPSIS is vastly used for decision making in any organization. Like in 2016, a paper showed how to select supplier in a supply chain risk management context for nine criteria. (Mavi, Goh, & Mavi, 2016).

Back in 2006, Hubbard made it clear that risk is measureable because it is a result of uncertainty that has the possibility of some unwanted loss (Hubbard, n.d., 2006). Fuzzy set theory is being used from before that, it has been used as one powerful tool that can handle imprecise data and helps decision makers dealing uncertainties (Chamzini et al., 2013).

Most of the research works that have been done on the risks of RMG sector either discuss a particular risk factor or identification of causes of those risks. But bringing the major risks together and doing an analysis on them to ensure where to focus first is hardly done. This study attempts to fill that gap.

Not focusing on a particular disturbance or only a few major risks, this study aims to cover all the major and even minor risks and proposes a way to analyze them by ranking them to know exactly where to start taking the mitigation strategies.

2. Methodology

The study consists of several steps mentioned below:

i. Identification of existing risk factors

ii. Selection of evaluating criteria: in this study three evaluation criteria are used to evaluate the risks factors.
   a. Probability (C1): the likelihood of occurrence of each risk
   b. Severity (C2): potential effect of each risk
   c. Quality of controls (C3): the quality of process, systems and cultural controls to mitigate these risks.

iii. Evaluation risks using TOPSIS and fuzzy-TOPSIS method

2.1 TOPSIS

Step 1: Construction of normalized decision matrix. This step transforms various attribute dimensions into non-dimensional attributes, which allows comparisons across criteria. The normalized value of $x_{ij}$:

$$
\tau_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}}, \quad i = 1, 2, \ldots, m; j = 1, 2, \ldots, n
$$

Step 2: Construction of the weighted normalized decision matrix. Assume a set of weights for each criteria $w_j$ such that $W = \{w_j | j = 1, 2, \ldots, n\}$.

Multiply each column of the normalized decision matrix by its associated weight gives the weighted normalized decision matrix. An element of the new matrix is:

$$
v_{ij} = w_j \tau_{ij}, \quad \text{for } i = 1, 2, \ldots, m; j = 1, 2, \ldots, n
$$

Step 3: Determination of the positive ideal ($A^+$) and negative ideal ($A^-$) solutions. The $A^+$ and $A^-$ are defined as positive ideal solution (PIS) and negative ideal solution (NIS) respectively.

Positive Ideal solution:

$$
A^+ = \{v1^*, \ldots, vn^*\}, \text{where } v_{ij}^* = \max (v_{ij})\text{ if } j \in J^b; \min (v_{ij})\text{ if } j \in J^c
$$

Negative ideal solution:

$$
A^- = \{v1^-, \ldots, vn^-\}, \text{where } v_{ij}^- = \min (v_{ij})\text{ if } j \in J^b; \max (v_{ij})\text{ if } j \in J^c
$$

Where $J^b$ is a set of benefit attributes (larger the better type) and $J^c$ is a set of cost attributes (smaller the better type).

Step 4: Calculation of the separation measures for each alternative.
The separation of each alternative from the positive ideal alternative is:

\[ S_i^+ = \sqrt{\sum (v_{ij} - v_{ij}^*)^2} \text{ for } i = 1, 2, 3, \ldots, m \]  

(5)

Similarly, the separation of each alternative from the negative ideal alternative is:

\[ S_i^- = \sqrt{\sum (v_{ij} - v_{ij}^-)^2} \text{ for } i = 1, 2, 3, \ldots, m \]  

(6)

**Step 5:** Calculation of the relative closeness to the ideal solution or similarities. Next, the relative closeness of alternative \( A_i \) with respect to the ideal solution \( A^* \) is defined as follows:

\[ C_i^* = \frac{S_i^-}{S_i^- + S_i^+} ; 0 \leq C_i^* \leq 1, \text{ for } i = 1, 2, 3, \ldots, m \]  

(7)

Evidently, \( C_i^* = 1 \) if and only if \( A_i = A^* \) and \( C_i^- = 0 \) only if \( A_i = A^- \).

**Step 6:** Ranking the preference order.

The best satisfied alternative can now be decided according to preference rank order of \( C_i^* \). Choose an alternative with maximum \( C_i^* \) or rank the alternatives according to \( C_i^* \) in decreasing order.

### 2.2 Fuzzy-TOPSIS

**Step 1:** Selection of the linguistic evaluations for criteria and alternatives regarding to criteria.

The significant weights of evaluation criteria and the alternatives’ ratings are considered as linguistic terms to calculate risk in fuzzy situation where \( p \) is the decision maker.

\[ \tilde{w}_j = \frac{1}{p} (\tilde{w}_j^1 + \tilde{w}_j^2 + \cdots + \tilde{w}_j^p) \]  

(8)

\[ \tilde{x}_{ij} = \frac{1}{p}(\tilde{x}_{ij}^1 + \tilde{x}_{ij}^2 + \cdots + \tilde{x}_{ij}^p) \]  

(9)

**Step 2:** Fuzzy decision matrix construction.

Fuzzy decision matrix of \( n \) criteria and \( m \) alternatives can be obtained with \( m \) rows and \( n \) columns as subsequent matrix:

\[
\begin{bmatrix}
C_1 & C_2 & \ldots & C_n \\
A_1 & \tilde{x}_{11} & \tilde{x}_{12} & \ldots & \tilde{x}_{1n} \\
A_2 & \tilde{x}_{21} & \tilde{x}_{22} & \ldots & \tilde{x}_{2n} \\
\vdots & \vdots & \vdots & \ddots & \vdots \\
A_m & \tilde{x}_{m1} & \tilde{x}_{m2} & \ldots & \tilde{x}_{mn}
\end{bmatrix}
\]

\[ \tilde{w} = (\tilde{w}_1, \tilde{w}_2, \ldots, \tilde{w}_n) \]

**Step 3:** Fuzzy decision matrix normalization.

Normalized matrix is obtained by dividing each element in the direct relation matrix by the largest row sum of the average matrix.

**Step 4:** Weighted normalized fuzzy decision matrix calculation.

Weighted normalized decision matrix, \( \tilde{P} \) is calculated by multiplying the weights of the criteria, \( \tilde{w}_j \), by the elements \( \tilde{k}_{ij} \) of the normalized fuzzy decision matrix

\[ \tilde{P} = \left[ \tilde{v}_{ij} \right]_{m \times n}, i = 1, 2, \ldots, m; j = 1, 2, \ldots, n \]  

(10)

Where \( \tilde{v}_{ij} = \tilde{k}_{ij} \times \tilde{w}_{ij} \)

**Step 5:** The fuzzy positive ideal solution (FPIS \( R^+ \)) and fuzzy negative-ideal solution (FNIS \( R^- \)) are determined as described in the following part.

\[ A^+ = \{ \tilde{v}_{i1}^+, \tilde{v}_{i2}^+, \ldots, \tilde{v}_{in}^+ \} \]  

(11)

\[ A^- = \{ \tilde{v}_{i1}^-, \tilde{v}_{i2}^-, \ldots, \tilde{v}_{in}^- \} \]  

(12)

**Step 6:** By using the following equations the distance of every alternative from \( R^+ \) and \( R^- \) are calculated.

\[ d_{i}^+ = \sum_{j=1}^{n} d(\tilde{v}_{ij}, \tilde{v}_{ij}^+) \text{ for } i = 1, 2, \ldots, m \]  

(13)

\[ d_{i}^- = \sum_{j=1}^{n} d(\tilde{v}_{ij}, \tilde{v}_{ij}^-) \text{ for } i = 1, 2, \ldots, m \]  

(14)

Where the distance between two fuzzy number \( \tilde{y} = (y_1, y_2, y_3) \) and \( \tilde{x} = (x_1, x_2, x_3) \) can be calculated as follows:
\[ d(y, z) = \sqrt{\frac{1}{3} [(y_1 - z_1)^2 + (y_2 - z_2)^2 + (y_3 - z_3)^2]} \]  \hspace{1cm} (15)

**Step 7:** Closeness coefficient calculation.

The closeness coefficient \((CC_i)\) considers the distance of the FPIS, \(d_i^+\), and the FNIS, \(d_i^-\), instantaneously.

\[
CC_i = \frac{d_i^-}{d_i^- + d_i^+} \hspace{1cm} (16)
\]

**Step 8:** Preference order ranking.

Based on the closeness coefficient, \(CC_i\), the ranking order of all alternatives can be determined and the best one from a set of alternatives can be selected. The best alternatives are closest to the FPIS and farthest to the FNIS.

### 3. Numerical Analysis

The discussed methodology has been applied to a case study and used to rank the risks in ready-made garment sector in Bangladesh. The case study requires the identification of major risks and the ranking of those risks to take necessary proactive measures. In last few decades, it has been seen that industries growing rapidly do not maintain the safety codes and develop unplanned and clustered workplaces. A simple fire incident can cause huge loss of human lives because of this. Building collapse is one of the disastrous risks that happen due to taking more load on the floors than it can possibly take, weak foundations. It has happened only once in the history of garments in Bangladesh but the consequences shook the world. In recent times, laborers are seen to come down on streets to insurge their demands. They come down even with disputes that could be handled inside the workplace. It hampers the image of the country. Political unrest in 2014 caused problems as well. Every risk factor cause hamper in the business and some take a toll on the lives of the people working in it. Twelve possible risks were identified for RMG sector in Bangladesh and presented in Table 1.

<table>
<thead>
<tr>
<th>Table 1. Factors causing risk/hazard in RMG sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finance/capital risk (R1)</td>
</tr>
<tr>
<td>Employee turnover risks (R2)</td>
</tr>
<tr>
<td>Building collapse risks (R3)</td>
</tr>
<tr>
<td>Fire incident risks (R4)</td>
</tr>
<tr>
<td>Labor unrest risks (R5)</td>
</tr>
<tr>
<td>Political unrest risks (R6)</td>
</tr>
<tr>
<td>Health safety risks (R7)</td>
</tr>
<tr>
<td>Electricity and gas risks (R8)</td>
</tr>
<tr>
<td>Local politics risks (R9)</td>
</tr>
<tr>
<td>Sexual harassment risks (R10)</td>
</tr>
<tr>
<td>Administration risks (Police/RAB etc.) (R11)</td>
</tr>
<tr>
<td>Environmental risks (R12)</td>
</tr>
</tbody>
</table>

#### 3.1 TOPSIS

Table 2 represents the decision matrix constructed based on the performance ratings (1-10 scale where 10 indicate very risky) given by the decision makers.

<table>
<thead>
<tr>
<th>Table 2. Decision matrix</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Risks</strong></td>
</tr>
<tr>
<td>Finance/capital risk (R1)</td>
</tr>
<tr>
<td>Employee turnover risks (R2)</td>
</tr>
<tr>
<td>Building collapse risks (R3)</td>
</tr>
<tr>
<td>Fire incident risks (R4)</td>
</tr>
<tr>
<td>Labor unrest risks (R5)</td>
</tr>
<tr>
<td>Political unrest risks (R6)</td>
</tr>
<tr>
<td>Health safety risks (R7)</td>
</tr>
<tr>
<td>Electricity and gas risks (R8)</td>
</tr>
</tbody>
</table>
To calculate the weighted normalized matrix the attribute weight information is required. The relative weight of each criterion has been estimated. The linguistic definitions for the importance ratios are shown in Table 3.

Table 3. Degree of importance scale

<table>
<thead>
<tr>
<th>Degree of Importance</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Equal importance</td>
</tr>
<tr>
<td>3</td>
<td>Weak importance of one over other</td>
</tr>
<tr>
<td>5</td>
<td>Essential or strong importance</td>
</tr>
<tr>
<td>7</td>
<td>Demonstrated importance</td>
</tr>
<tr>
<td>9</td>
<td>Absolute importance</td>
</tr>
<tr>
<td>2, 4, 6, 8</td>
<td>Immediate values between two adjacent judgments</td>
</tr>
</tbody>
</table>

Table 4. The pairwise comparison table of the relative importance

<table>
<thead>
<tr>
<th></th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
<th>Weights</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probability (C1)</td>
<td>1</td>
<td>3</td>
<td>5</td>
<td>0.106</td>
</tr>
<tr>
<td>Severity (C2)</td>
<td>0.333</td>
<td>1</td>
<td>3</td>
<td>0.260</td>
</tr>
<tr>
<td>Quality of Control (C3)</td>
<td>5</td>
<td>3</td>
<td>1</td>
<td>0.633</td>
</tr>
</tbody>
</table>

The weighted normalized decision matrix is shown in Table 5. The positive ideal solution, PIS and the negative ideal solution, NIS are also shown in the table 5. Lastly, the separation measures, relative closeness coefficient and the ranking order of different risks are shown in Table 6.

Table 5. Weighted normalized decision matrix

<table>
<thead>
<tr>
<th>Risks</th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>0.338971</td>
<td>0.304348</td>
<td>0.373062</td>
</tr>
<tr>
<td>R2</td>
<td>0.423714</td>
<td>0.391304</td>
<td>0.373062</td>
</tr>
<tr>
<td>R3</td>
<td>0.169485</td>
<td>0.173913</td>
<td>0.124354</td>
</tr>
<tr>
<td>R4</td>
<td>0.254228</td>
<td>0.347826</td>
<td>0.331611</td>
</tr>
<tr>
<td>R5</td>
<td>0.381342</td>
<td>0.391304</td>
<td>0.414513</td>
</tr>
<tr>
<td>R6</td>
<td>0.254228</td>
<td>0.173913</td>
<td>0.248708</td>
</tr>
<tr>
<td>R7</td>
<td>0.381342</td>
<td>0.347826</td>
<td>0.331611</td>
</tr>
<tr>
<td>R8</td>
<td>0.2966</td>
<td>0.304348</td>
<td>0.290159</td>
</tr>
<tr>
<td>R9</td>
<td>0.211857</td>
<td>0.217391</td>
<td>0.124354</td>
</tr>
<tr>
<td>R10</td>
<td>0.084743</td>
<td>0.086957</td>
<td>0.124354</td>
</tr>
<tr>
<td>R11</td>
<td>0.169485</td>
<td>0.173913</td>
<td>0.165805</td>
</tr>
<tr>
<td>R12</td>
<td>0.2966</td>
<td>0.347826</td>
<td>0.331611</td>
</tr>
<tr>
<td><strong>PIS, R</strong></td>
<td>0.084743</td>
<td>0.086957</td>
<td>0.414513</td>
</tr>
<tr>
<td><strong>NIS, R</strong></td>
<td>0.423714</td>
<td>0.391304</td>
<td>0.124354</td>
</tr>
</tbody>
</table>

Table 6. TOPSIS analysis result

<table>
<thead>
<tr>
<th>Risks</th>
<th>$S^*$</th>
<th>$S^-$</th>
<th>$C_i^*$</th>
<th>Rank</th>
</tr>
</thead>
</table>
The final result obtained using TOPSIS method is the ranking order of the risks as follows R5 > R1 > R2 > R4 > R12 > R7 > R8 > R6 > R11 > R10 > R3 > R9.

3.2 Fuzzy-TOPSIS

Three decision makers are assumed to evaluate the weight of criteria and the ratings of risk factors according to the linguistic terms for which triangular fuzzy numbers (TFN) were used, presented in Table 7. The weight of the criteria’s given by three decision makers is demonstrated in Table 8. The linguistic variables displayed in Table 9 are then transformed into TFN, triangular fuzzy numbers.

Table 7. Definitions of linguistic variables for expert judgment

<table>
<thead>
<tr>
<th>Linguistic variable to evaluate the weight of the criteria</th>
<th>Linguistic variable to evaluate the ratings of the risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terms</td>
<td>Notation</td>
</tr>
<tr>
<td>Very low</td>
<td>VL</td>
</tr>
<tr>
<td>Low</td>
<td>L</td>
</tr>
<tr>
<td>Moderately low</td>
<td>ML</td>
</tr>
<tr>
<td>Moderate</td>
<td>M</td>
</tr>
<tr>
<td>Moderately high</td>
<td>MH</td>
</tr>
<tr>
<td>High</td>
<td>H</td>
</tr>
<tr>
<td>Very high</td>
<td>VH</td>
</tr>
</tbody>
</table>

Table 8. Linguistic assessments for the 3 criteria

<table>
<thead>
<tr>
<th></th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM1</td>
<td>ML</td>
<td>H</td>
<td>VH</td>
</tr>
<tr>
<td>DM2</td>
<td>H</td>
<td>MH</td>
<td>H</td>
</tr>
<tr>
<td>DM3</td>
<td>M</td>
<td>VH</td>
<td>VH</td>
</tr>
</tbody>
</table>

Table 9. Linguistic assessments for the twenty risks factors

<table>
<thead>
<tr>
<th>Risks</th>
<th>DM</th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM1</td>
<td>VR</td>
<td>R</td>
<td>R</td>
<td></td>
</tr>
</tbody>
</table>
Table 10 represents the TFN of the fuzzy decision matrix from aggregation of the decision makers point of view presented in Table 9.

<table>
<thead>
<tr>
<th>Risks</th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>7.667</td>
<td>9.333</td>
<td>10</td>
</tr>
<tr>
<td>R2</td>
<td>8.333</td>
<td>9.667</td>
<td>10</td>
</tr>
<tr>
<td>R3</td>
<td>4.333</td>
<td>5.333</td>
<td>7</td>
</tr>
<tr>
<td>R4</td>
<td>6.333</td>
<td>7.667</td>
<td>9.667</td>
</tr>
<tr>
<td>R5</td>
<td>7.667</td>
<td>6.667</td>
<td>5.667</td>
</tr>
<tr>
<td>R6</td>
<td>9.333</td>
<td>2.333</td>
<td>1.667</td>
</tr>
<tr>
<td>R7</td>
<td>8.333</td>
<td>5.333</td>
<td>3.333</td>
</tr>
<tr>
<td>R8</td>
<td>9.333</td>
<td>4.333</td>
<td>8.333</td>
</tr>
<tr>
<td>R9</td>
<td>5.333</td>
<td>3.333</td>
<td>7.333</td>
</tr>
<tr>
<td>R10</td>
<td>2.333</td>
<td>1.667</td>
<td>1.667</td>
</tr>
</tbody>
</table>

Table 10. Aggregated Fuzzy decision matrix
Tables 11 demonstrates the weighted normalized fuzzy decision matrix.

Table 11. Weighted normalized Fuzzy decision matrix

<table>
<thead>
<tr>
<th>Risks</th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
<th>Total di*</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>0.034</td>
<td>0.064</td>
<td>0.089</td>
<td>0.065</td>
</tr>
<tr>
<td>R2</td>
<td>0.037</td>
<td>0.066</td>
<td>0.089</td>
<td>0.065</td>
</tr>
<tr>
<td>R3</td>
<td>0.003</td>
<td>0.016</td>
<td>0.038</td>
<td>0.017</td>
</tr>
<tr>
<td>R4</td>
<td>0.012</td>
<td>0.039</td>
<td>0.068</td>
<td>0.053</td>
</tr>
<tr>
<td>R5</td>
<td>0.034</td>
<td>0.064</td>
<td>0.089</td>
<td>0.076</td>
</tr>
<tr>
<td>R6</td>
<td>0.034</td>
<td>0.039</td>
<td>0.068</td>
<td>0.014</td>
</tr>
<tr>
<td>R7</td>
<td>0.028</td>
<td>0.057</td>
<td>0.086</td>
<td>0.059</td>
</tr>
<tr>
<td>R8</td>
<td>0.016</td>
<td>0.039</td>
<td>0.068</td>
<td>0.036</td>
</tr>
<tr>
<td>R9</td>
<td>0.016</td>
<td>0.039</td>
<td>0.068</td>
<td>0.025</td>
</tr>
<tr>
<td>R10</td>
<td>0.000</td>
<td>0.004</td>
<td>0.020</td>
<td>0.003</td>
</tr>
<tr>
<td>R11</td>
<td>0.000</td>
<td>0.004</td>
<td>0.020</td>
<td>0.010</td>
</tr>
<tr>
<td>R12</td>
<td>0.028</td>
<td>0.057</td>
<td>0.086</td>
<td>0.059</td>
</tr>
</tbody>
</table>

The distances of $d_{i+}$ and $d_{i-}$ from $R^+$ and $R^-$ are presented in Tables 12 and 13 respectively using equation (11) and (12).

Table 12. Distances of the ratings of each risk type from $A^+$ with respect to each criterion

<table>
<thead>
<tr>
<th>Risks</th>
<th>FPIS</th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
<th>Total di*</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>d(R1, $R^+$)</td>
<td>0.002169</td>
<td>0.00685</td>
<td>0</td>
<td>0.009018</td>
</tr>
<tr>
<td>R2</td>
<td>d(R2, $R^+$)</td>
<td>0.00685</td>
<td>0.004501</td>
<td>0.011351</td>
<td></td>
</tr>
<tr>
<td>R3</td>
<td>d(R3, $R^+$)</td>
<td>0.045695</td>
<td>0.064353</td>
<td>0.068129</td>
<td>0.178176</td>
</tr>
<tr>
<td>R4</td>
<td>d(R4, $R^+$)</td>
<td>0.024686</td>
<td>0.019434</td>
<td>0.021173</td>
<td>0.065292</td>
</tr>
<tr>
<td>R5</td>
<td>d(R5, $R^+$)</td>
<td>0.002169</td>
<td>0</td>
<td>0.009005</td>
<td>0.011351</td>
</tr>
<tr>
<td>R6</td>
<td>d(R6, $R^+$)</td>
<td>0.019992</td>
<td>0.060343</td>
<td>0.049137</td>
<td>0.129473</td>
</tr>
<tr>
<td>R7</td>
<td>d(R7, $R^+$)</td>
<td>0.007587</td>
<td>0.011547</td>
<td>0.016323</td>
<td>0.035456</td>
</tr>
<tr>
<td>R8</td>
<td>d(R8, $R^+$)</td>
<td>0.023258</td>
<td>0.03906</td>
<td>0.041787</td>
<td>0.098952</td>
</tr>
<tr>
<td>R9</td>
<td>d(R9, $R^+$)</td>
<td>0.023258</td>
<td>0.046961</td>
<td>0.056549</td>
<td>0.126768</td>
</tr>
<tr>
<td>R10</td>
<td>d(R10, $R^+$)</td>
<td>0.057587</td>
<td>0.011547</td>
<td>0.014959</td>
<td>0.034092</td>
</tr>
</tbody>
</table>

Table 13. Distances of the ratings of each risk type from $A^-$ with respect to each criterion

<table>
<thead>
<tr>
<th>Risks</th>
<th>FNIS</th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
<th>Total di-</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>d(R1, $R^-$)</td>
<td>0.055942</td>
<td>0.080286</td>
<td>0.081732</td>
<td>0.217961</td>
</tr>
<tr>
<td>R2</td>
<td>d(R2, $R^-$)</td>
<td>0.06767</td>
<td>0.080286</td>
<td>0.078209</td>
<td>0.226164</td>
</tr>
<tr>
<td>R3</td>
<td>d(R3, $R^-$)</td>
<td>0.024187</td>
<td>0.020692</td>
<td>0.013928</td>
<td>0.058807</td>
</tr>
</tbody>
</table>
The ranking of each risk factor is calculated by closeness coefficient, CCI, by using equation (16) and presented in Table 14. The closeness coefficient is the ultimate value which is used to rank the risks.

### Table 14. Closeness coefficients (CCI) of the risks factors

<table>
<thead>
<tr>
<th>Risks</th>
<th>Total di*</th>
<th>Total di-</th>
<th>CCI</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>0.009018</td>
<td>0.217961</td>
<td>0.960267</td>
<td>1</td>
</tr>
<tr>
<td>R2</td>
<td>0.011351</td>
<td>0.226164</td>
<td>0.952209</td>
<td>3</td>
</tr>
<tr>
<td>R3</td>
<td>0.178176</td>
<td>0.058807</td>
<td>0.248148</td>
<td>10</td>
</tr>
<tr>
<td>R4</td>
<td>0.065292</td>
<td>0.17664</td>
<td>0.730121</td>
<td>6</td>
</tr>
<tr>
<td>R5</td>
<td>0.011173</td>
<td>0.22603</td>
<td>0.952895</td>
<td>2</td>
</tr>
<tr>
<td>R6</td>
<td>0.129473</td>
<td>0.108977</td>
<td>0.457024</td>
<td>9</td>
</tr>
<tr>
<td>R7</td>
<td>0.035456</td>
<td>0.204569</td>
<td>0.852281</td>
<td>5</td>
</tr>
<tr>
<td>R8</td>
<td>0.098952</td>
<td>0.140765</td>
<td>0.587214</td>
<td>7</td>
</tr>
<tr>
<td>R9</td>
<td>0.126768</td>
<td>0.11201</td>
<td>0.469098</td>
<td>8</td>
</tr>
<tr>
<td>R10</td>
<td>0.214107</td>
<td>0.041124</td>
<td>0.161125</td>
<td>11</td>
</tr>
<tr>
<td>R11</td>
<td>0.223966</td>
<td>0.012281</td>
<td>0.051985</td>
<td>12</td>
</tr>
<tr>
<td>R12</td>
<td>0.034092</td>
<td>0.206686</td>
<td>0.858408</td>
<td>4</td>
</tr>
</tbody>
</table>

### 4. Result and Conclusion

The ranking of risks is summarized in Table 15. It shows where the garment industries have to give the most effort in order to maintain a smooth production.

### Table 15. The ranking of risk factors for different method

<table>
<thead>
<tr>
<th>Risks</th>
<th>TOPSIS</th>
<th>Fuzzy-TOPSIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finance/capital risk (R1)</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Employee turnover risks (R2)</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Building collapse risks (R3)</td>
<td>11</td>
<td>10</td>
</tr>
<tr>
<td>Fire incident risks (R4)</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Labor unrest risks (R5)</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Political unrest risks (R6)</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>Health safety risks (R7)</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Electricity and gas risks (R8)</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Local politics risks (R9)</td>
<td>12</td>
<td>8</td>
</tr>
<tr>
<td>Sexual harassment risks (R10)</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>Administration risks (Police/ RAB etc.) (R11)</td>
<td>9</td>
<td>12</td>
</tr>
<tr>
<td>Environmental risks (R12)</td>
<td>5</td>
<td>4</td>
</tr>
</tbody>
</table>
From the order of preference shown in the table, it is clear that both methods identified similar factors to be more risky. Labor unrest, finance risk and employee turnover risk are identified to be the biggest obstacles in this industry. This study aimed to recommend a systematic evaluation process to rank the risks that occur in garment industry as well as the TOPSIS and fuzzy-TOPSIS comparison. Fuzzy-TOPSIS is more preferred than TOPSIS when the data are not precise and the criteria are vague (Ataei, 2013). An approach to slandering the risks types and to facilitate the decision making process is prescribed by the proposed method.

Based on the results of this study, managerial implications on risk mitigation strategies can be taken immediately to avoid occurrence of these risks in future. This sector of vast opportunities should be utilized accordingly so that in can bring more monetary value in the economics of this country. Risk analysis and management based on the analysis can bring betterment for not only the workers and the economy, but the industries and the entire sector itself.

5. References


17. Biography

Farnaz Faruk and Shafikul Alam Nabil are Research Students at Ahsanullah University of Science and Technology (AUST) and continuing B.Sc. in Industrial and Production Engineering (IPE) at AUST.

Sayem Ahmed is currently an Assistant Professor in the Department of Mechanical and Production Engineering at Ahsanullah University of Science and Technology (AUST), Dhaka, Bangladesh. Mr. Sayem received his B.Sc. degree in Industrial and Production Engineering from Ahsanullah University of Science and Technology (AUST) in
2014 securing 1st class 1st position in order of merit. He has received M.Sc. degree in Industrial and Production Engineering from Bangladesh University of Engineering and Technology (BUET) in 2017.

Professor Dr. Sarwar Morshed is currently a Professor in the Department of Mechanical and Production Engineering at Ahsanullah University of Science and Technology (AUST), Dhaka, Bangladesh. He has a teaching experience of over 27 years and has been associated with many researches in the field of Industrial and Production Engineering.
Raw Material Inventory Control Model for RMG with Shortage Prediction using Nature Inspired Algorithm

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Abstract
Inventory control management is one of the most important tasks in RMG industry for optimizing lead time, production time, total inventory cost and storage space and buyer-supplier relationship. This research is about optimizing the total inventory cost and inventory layout management by controlling the inventory model and determining the economic order quantity (EOQ). Assuming deterministic demand, the raw material inventory control model is designed. In order to solve the nonlinear inventory control model, a metaheuristic nature inspired algorithm named multi-objective particle swarm optimization (MOPSO) algorithm is proposed. Raw material shortage is predicted using support vector regression (SVR), in order to meet the production demand before deadline.

Keywords

1. Introduction
The readymade garments (RMG) industry of Bangladesh contributes almost 84% of total export of $36.66 billion to date. Feature wise the export oriented RMG industry of Bangladesh is quite different from other industries (Hasan, 2017). Wage, Supply chain, Time-frame, Procurement and Compliances are among the most important features of this business. All these five features are correlated to each other in many aspects. To meet the short delivery time and to minimize stock level and wastage, to reduce an extra load on finance and to gain customer satisfaction there is no alternative than an effective supply chain management (SCM) system in place. Inventory management plays a big role in apparel manufacturing organization in order to meet deadline and reduce extra inventory cost that comes with excessive tardiness.

Effectiveness of inventory management is generally evaluated by trading off two conflicting objectives – maximizing responsiveness and minimizing cost. Controlling both comes handy with respect to RMG factory especially for a fast growing market comprising large number of competitors like Bangladesh. Most of these RMG
factories handle multiple orders at a time. For each style various items have to be procured simultaneously from different buyers. So classical single buyer - single supplier inventory control doesn’t hold much importance here. Inventory control management in real practice is quite different from its theoretical aspect. In this regard a multi-criteria approach makes more sense especially when the number of items is very large.

Economic order quantity (EOQ) is an important element of pre costing before starting bulk production. Procurement of each raw material and accessories require perfect estimation in order to achieve the desired profit margin. It comes with the possibility of unwanted shortage and delay in production. So to incorporate proper costing allowance not only respective manager’s experience but also a quantitative model is much needed. In this paper an inventory control model for raw material inventory is proposed considering multiple conflicting objective with shortage prediction.

2. Literature Review

Cost reduction and profit maximization of raw material inventory can be ensured with the help of effective planning and efficient management. Modeling of this inventory control management had been a research interest among industrial engineers for a long time. Agrell (1995) proposed a multi-criteria framework for inventory control problem, in which the solution procedure was IDEM to determine batch size and security stock. To determine the average holding cost and stock out probabilities with lead time uncertainties, a dynamic single stage multi-item inventory control model was proposed by Ould-Louly and Dolgui (2001). A multi item single source ordering problem was solved by Ertogral (2008) including transportation cost based on Lagrangian method. Lee & Kang (2008) developed a model for managing inventory of a product in multiple periods. Their model was first derived for one item and then was extended for several products. Similar to the evaluation of multiple item model, multi-objective models got the interest of researchers. Roy & Maiti (1998) presented multi-item inventory models of deteriorating items with the objectives of maximizing the profit and minimizing the wastage cost in a fuzzy environment. But they didn’t consider any shortage. (Pasandideh et al. (2013) investigated a bi-objective economic production quantity problem for defective items formulated as a multi-objective nonlinear programming model, where the goal was to find the order quantities of the product so that both the total inventory cost and the required warehouse space are minimized. With the same objectives, Mousavi et al. (2014) developed a multi-item multi-period inventory control model for known-deterministic demand under budget limitation.

For any apparel manufacturer determination of economic order quantity (EOQ) and optimum stock levels is important in raw material management. The basic model of EOQ was first conceptualized by Harris (1990) which paved the way for further researches. The popular square root formula of EOQ was developed in 1915 and a lot of inventory models were developed applying this. Considering time varying demand instead of constant demand, Silver & Meal (1969) modified the classical square root formula. Goyal (1988) introduced the inventory replenishment policy for an item having a deterministic demand pattern with a linear (positive) trend and shortages. After that lots of researches had been done economic ordering policy for perishable goods. Like, Xu and Wang (1990) developed a deterministic inventory model for deteriorating items with time proportional demand along with a numerical example. Hayek and Salameh (2001) measured EOQ taking imperfect items in consideration with backorder and shortage. Taleizadeh et al. (2008) extended the EOQ model in a joint replenishment policy considering holding cost, fixed order cost, insurance cost, transportation cost and capital cost. In this research a deterministic total inventory cost model has been formulated considering holding, ordering and shortage costs and from that model EOQ had been determined using differential approach.

To optimize solution by searching in large search space a number of nature inspired metaheuristic algorithms have been proposed. Particle swarm optimization (PSO) is one of the metaheuristic algorithms for solving global optimization problem. Kennedy and Eberhart (1997) developed this algorithm by analyzing social behavior of flock
of birds or fishes. Since then many researchers worked with this algorithm to solve inventory related optimization problems. Like Taleizadeh et al. (2009) solved a single buyer- single vendor problem using a PSO approach in which the demand is stochastic and the lead time is assumed to vary linearly with respect to the lot size. PSO is enough for solving single objective optimization problem but to solve a problem consisting multiple conflicting objective a modification is required. In early 2000, Coello Coello & Lechuga (2002) proposed a new approach named multi-objective particle swarm optimization (MOPSO) which was a constrained multi-objective formulation of PSO.

To meet the desirable demand of customer with minimum cost or budget most of the real life inventory problem could be recast in to a multi-objective optimization problem. Tsou (2008) developed such a model and applied MOPSO to build the Pareto front of non-dominated solutions and sorted them using technique for order preference by similarity to ideal solution (TOPSIS) by the preference of decision makers. Mousavi et al. (2014) used MOPSO to solve a multi-item multi-period inventory planning model with known deterministic demand under limited budget. Storage space is another important decision comes with inventory management as the decision to keep more inventory and storage space requirement have contradictory objective with respect to cost. Tavana (2016) evaluated an inventory optimization problem with the objective to find Pareto optimal solution in different periods and minimize total inventory cost as well as total storage space, simultaneously. As all these proposed algorithms are very much parameter sensitive, Taguchi method was used in this model to tune the level of parameter and model response variable. This method also has the advantage of giving near optimum solution.

Shortage forecasting in RMG has been a challenging issue for decades. With continuously changing order, style, fashion and limitation of historical data make it more difficult to predict; mostly for small size apparel manufacturers. Traditional forecasting methods have many limitations and also reduces competitive advantages. An unconventional approach like support vector machine theory based on structural risk minimization (SRM) can be a better solution to this problem. The theory has originally been developed by Vapnik and his co-workers on a basis of a separable bipartition problem at the AT and T Bell Laboratories (Vapnik 1963). A version of a SVM for regression has been proposed in 1997 by Vapnik et al. (1997). This method is called support vector regression (SVR). An overview of the basic ideas underlying support vector (SV) machines for regression and function estimation has been given by Smola & Schölkopf (2004) saying that the model produced by support vector classification only depends on a subset of the training data. SVM can be used in circumstance with few observations in a forecasting process, and construct nonlinear mapping relationship between the factors and demand series. Thus, it is convenient to overcome the limitations of traditional methods. The proposed multi-objective inventory model can be useful in situation when procurement department in any garments manufacturer decides to purchase raw materials which require extra storage space but the budget is fixed. To perfectly model this type of inventory controlling scenario shortage cost, truck capacity and other realistic limitations must be considered.

The rest of this paper is structured as follows: In Section 3, the problem is explained along with the necessary notations and assumptions. In Section 4, the problem is formulated. The solution algorithm is demonstrated in Section 5. Section 6 provides results and analysis with shortage prediction method. At last, conclusion and recommendations for future works are given in Section 7.

3. Problem Definition, Assumptions and Notations

Inventory control management is one of the most important and challenging tasks in RMG industry. Considering a RMG industry, where deterministic demand is followed and raw material is supplied from different buyer demand. The costs associated with the inventory control system are mainly holding and ordering costs. Shortage cost is considered where economic quantity is not maintained during order. Several items are considered here with real life
constraints like warehouse space, order capacity and budget constraints. Here zero lead-time is assumed, as raw material is always purchased from a fixed supplier in a continual basis. The assumptions of this study are inspired from the work of Roozbeh Nia (2015) and the decision variables are integer digits. The goal is to identify the optimum level of inventory and required warehouse space, where total inventory cost is minimized as a whole.

3.1 Assumptions
Deterministic demand of the garments.
Multiple production demands are considered.
Production process run by batches or in lot.
No volume discount is considered.
Holding, Ordering and Shortage costs are considered.

3.2 Notations
The following parameters are decision variables used for items $i = 1, 2, \ldots, n$.

- $n$: number of items to be purchased annually
- $Q_i$: order quantity of the $i$th items (decision variable)
- $D_i$: annual demand of the $i$th items
- $S_i$: ordering cost per ordering an item
- $H_i$: unit inventory holding cost for item $i$
- $I_i$: shortage level of the $i$th item
- $C_p$: order capacity
- $A_i$: required storage space per unit of the $i$th item
- $F$: total available warehouse space
- $L_i$: annual per-unit cost of shortages of the $i$th item
- $B_i$: purchasing cost per unit of item
- $M$: total budget

Based on the above assumptions and notations, the mathematical model of the problem is derived in the next section.

& Mathematical Model Formulation

1 Objective Functions
Total inventory cost is the 1st objective function of this model which can be obtained as

$$Z_1 = \text{Total Inventory Cost}$$

$$Z_1 = \text{Total Ordering Cost} + \text{Total Holding Cost} + \text{Total Shortage Cost}$$

where each part is derived as follows.

$$\text{Total Ordering Cost} = \sum_{i=1}^{n} \frac{D_i}{Q_i} S_i$$

$$\text{Total Holding Cost} = \sum_{i=1}^{n} \frac{H_i}{2Q_i} (Q_i - I_i)^2$$

$$\text{Total Shortage Cost} = \sum_{i=1}^{n} \frac{L_i}{2Q_i} I_i^2$$

Thus, $Z_1 = \sum_{i=1}^{n} \frac{D_i}{Q_i} S_i + \frac{H_i}{2Q_i} (Q_i - I_i)^2 + \frac{L_i}{2Q_i} I_i^2$ (5)

2nd objective function has been derived to minimize warehouse space requirement, which is:

$$Z_2 = \sum_{i=1}^{n} (Q_i - I_i) A_i$$
4.2 The Constraints
There are three non-equality constraints and two non-negativity constraints. Total budget has some constraint which should be considered. (Mousavi, Niaki, Bahreininejad, & Musa, 2014):
\[ \sum_{i=1}^{n} B_i Q_i \leq M \]  
(7)

There are some limitations in the order capacity:
\[ \frac{D_i}{Q_i} \leq C_p \]  
(8)

Storage space constraint:
\[ \sum_{i=1}^{n} A_i Q_i \leq F \]  
(9)

Non-negativity constraints are:
\[ Q_i I_i > 0 \]  
(10)

Where, \( i = 1, 2, \ldots, n \); where \( n \) is the number of items and decision variables are \( Q_i \) and \( I_i \).

4.3 Final Model
Final mathematical model of the total inventory control is to

Minimize,
\[ TOF = \omega Z_1 + (1 - \omega) Z_2 \]

Where,
\[ Z_1 = \sum_{i=1}^{n} \frac{D_i}{Q_i} S_i + \frac{H_i}{2Q_i} (Q_i - I_i)^2 + \frac{L_i}{2Q_i} I_i^2 \]
\[ Z_2 = \sum_{i=1}^{n} (Q_i - I_i) A_i \]

Subject to,
\[ \sum_{i=1}^{n} B_i Q_i \leq M \]
\[ \frac{D_i}{Q_i} \leq C_p \]
\[ \sum_{i=1}^{n} A_i Q_i \leq F \]
\[ Q_i I_i > 0 \]

Where, \( i = 1, 2, \ldots, n \); where \( n \) is the number of items.

5. The Proposed Algorithm
In this research a modified version of PSO algorithm named multi-objective particle swarm optimization (MOPSO) is used. The purpose of using this algorithm is its simplicity. It is easy to implement and has the ability to deal with multiple conflicting objectives.
5.1 Multi Objective Particle Swarm Optimization (MOPSO)

Two modifications are required to use PSO for solving multi objective optimization problems. The main target is not to find one “global best” solution, but a set of solutions comprising the Pareto Front. After archiving all the solutions, they can be found at each iteration are stored. Inspired by the work of Coello Coello & Lechuga (2002), the detailed formulation is as follows.

Initial position of the particle $i$ is $x_i(t)$. In the search space particles interact with each other and after learning their position, particles increase their velocity, $v_i(t)$ to find the best solution for the problem. Local best solution or $p_i(t)$ is the personal best position for each article which is obtained by updating the position by $x_i(t + 1)$ and end vector has an velocity of $v_i(t + 1)$.

There is a common best experience among the members of the swarm denoted by $g(t)$ called the global best solution. So the equation for the position is-

$$x_i(t + 1) = x_i(t) + v_i(t + 1)$$ (12)

where,

$$v_i(t + 1) = wv_i(t) + C_1(p_i(t) - x_i(t)) + C_2(g(t) - x_i(t))$$ (13)

A simplified approach is used to standardize the PSO equation and that is-

$$v_i(t + 1) = wv_i(t) + C_1r_1(x_{pbest} - x_i(t)) + C_2r_2(x_{gbest} - x_i(t))$$ (14)

where,

$w =$ inertia coefficient; $C_1, C_2 =$ acceleration coefficients; $r_1, r_2 \in (0,1)$

Pseudocode of MOPSO (Mousavi et al., 2014) algorithm is as follows.

```
for i = 1 to Pop
    initialize position (i)
    initialize velocity (i)
    if position (i) and velocity (i) be a feasible candidate solution
        penalty = 0
    else penalty = a positive number
    end if
end for

w = [0.4, 0.9]
do while Iter <= Gen
    for j = 1 to Pop
        Calculate new velocity of the particle
        Calculate new position of the particle
        $p_{best}$ (iter) = min ($p_{best}(i)$)
    end for
    $g$best (iter) = min ($g$best)
    $w = W_{max} - ((W_{max} - W_{min}) / iter\_max) \times iter$
    modifying the velocity and position of the particle
end while
```

Pseudocode 1. Pseudocode of MOPSO algorithm

6. Results and Analysis

MOPSO algorithm is coded in MATLAB 15a in order to fine the near optimal solution. The obtained Pareto front is presented in Figure 1. The parameter values are presented in Table 1. The outcomes of this solution process are Pareto front of all local optimum solutions, optimum solution for both objectives and related parameter values, total elapsed time to reach solution and mathematical formulation of EOQ for raw material inventory control.
From equation (7),

\[ TC = \frac{D_i}{Q_i} S_i + \frac{H_i}{2Q_i} (Q_i - L_i)^2 + \frac{L_i}{2Q_i} L_i^2 \]

Differentiating by \( Q \), we get the equation of economic quantity to order for keeping raw material inventory. Thus,

\[ EOQ = \sqrt{\frac{2DS}{H} + \frac{LI^2}{H} + T^2} \]  

(15)

In order to tune the parameters used to solve the problem, Taguchi L\( _9 \) design is used. For implementing Taguchi L\( _9 \) design, at first four factors for the algorithm is chosen and then three level of value is selected for each factor based on parameter values of the algorithm from Table 1. These factors and their levels are shown in Table 2. As a result, nine different combinations of parameter value shown in Table 3 and S/N ratio for parameter levels are obtained using Minitab 18. At last, from the mean S/N ratio plot shown in Figure 2 the optimal level of parameters’ value is chosen along with their optimal values of the algorithm which are shown in Table 4.
Table 3. Taguchi L9 design along with their objective values

<table>
<thead>
<tr>
<th>Run No.</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>MOPSO</th>
</tr>
</thead>
<tbody>
<tr>
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<td>1</td>
<td>1</td>
<td>1</td>
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<td>2</td>
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<td>3</td>
<td>2</td>
<td>1</td>
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Table 4. The optimal levels of the algorithms’ parameters

<table>
<thead>
<tr>
<th>Algorithms</th>
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<th>Optimal Levels</th>
<th>Optimal Values</th>
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</thead>
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<td></td>
<td>C2</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Rep</td>
<td>20</td>
<td></td>
</tr>
</tbody>
</table>

Figure 2. The mean S/N ratio plot for parameter levels of MOPSO

The results obtained with the optimal level of parameters and the one with Pareto front of MATLAB formulation show no difference. It means that MOPSO is capable of finding best result for the proposed inventory control model. In order to predict the shortage in raw material inventory, support vector regression is used. Using Regression learner app in MATLAB 18, shortage is predicted and the graph is shown in figure 3.

6.1 Shortage prediction using SVR

MATLAB 2018b is used to import a large number of pre-costing data to predict shortage quantity for raw material inventory. All these data are taken from Fiat Fashion Limited located in Gazipur, Bangladesh. The minimization problem is expressed in standard quadratic programming form and solved using quadratic SVM technique (Scholkopf et al. 1997). MATLAB Regression Learner App is used in this regard to select predictor variables,
response variables and validation. In this study, response variable is shortage level. 5-fold cross-validation is applied to increase model performance on new data and choose best model. The model is trained into all six SVM regression model type and among them quadratic model gives the lowest root mean square error (RMSE) value. Again, efficiency of prediction is quite good for both model as it is seen from the predicted response vs true response plotting shown in Figure 4.

![Figure 3. Shortage prediction plot using Quadratic SVR (Yellow dot- record number and blue dot- response)](image1)

![Figure 4. Efficiency of prediction: Predicted response vs true response for raw material inventory](image2)

8. Conclusion and recommendation for future work

In this research a multi-item raw material inventory control model was designed with the goals of minimizing both the total inventory cost and total required storage space. Independent demand rates of items with shortage considering no volume discount where budget was limited. The aim was to determine optimal order quantity such that objective function is minimized and constraints hold. The developed nonlinear programming model was solved by Pareto based multi-objective particle swarm optimization algorithm. Taguchi L9 design was applied to calibrate the parameters of the algorithm and the combination that best suited to the objective was chosen. At last shortage in raw material inventory was predicted using support vector regression.

Some recommendations for future work are to develop a probabilistic model using fluctuating demand, to consider green manufacturing, volume discount, lead time uncertainty, multiple supplier selection, defective items, inflation and time value of money and other performance metrics and to apply recently developed meta-heuristic nature inspired algorithms to solve the problem.

9. References


9. Biography

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An Integrated Support Vector Classification Approach for Performance Evaluation and Selection of Multi-Attribute Suppliers Using Canonical Correlation Analysis (CCA) and Principal Component Analysis (PCA)

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Abstract
Supplier selection is an important and widely studied concern since it has significant impact on purchasing management in supply chain. Multi-attribute supplier classification and selecting the optimum supplier is a popular multi-criteria decision-making problem dealt in most of the manufacturing companies. In order to select the best supplier, it is necessary to make a trade off among the attributes suppliers secure individually. An AI classification technique (SVM) integrated with PCA and CCA is being chosen in this research to correlate and classify multi-attribute suppliers considering both the qualitative and quantitative attributes as well as to find the best among them. A numerical model for grading suppliers is shown to illustrate the evaluation and grading processes. Support vector machines (SVMs) capable of operating on non-uniform, “partial” or otherwise limited data to classify potential transaction, assess transaction risk, and provide degree of confidence values for classifications. SVMs are being used recently in where individual supplier transactions might differ or remain similar under specific statistical considerations, high-tech markets, speaker verifications evaluating very precise high-level features and solving many more classification problems. The outcome of this thesis truly ensures to be implemented for solving similar practical and realistic classification problems.

Keywords
Supplier Selection, Support Vector Machines (SVMs), Canonical Correlation Analysis (CCA) And Principal Component Analysis (PCA)

1. Introduction
In the current competitive scenario supply chain management (SCM) has significant importance for major research attention, as industries are evocated with finding measures to satisfy ever-rising customer expectations at a manageable cost. So, businesses must search out which parts of their supply-chain process which are not competitive are searched. In the field of supply chain management, it is necessary to choose the appropriate strategy of the best supplier. Multi-attribute supplier classification and selection issues are being solved considering the supply demand relationships, complex interactions and insufficient information of vendors. With AI approaches, even though the relationship between inputs and outputs are not identified, predicted result may still be assessed
with an acceptably high degree of accuracy than any other mathematical programming model. Moreover, multi-attribute decision making models depend on human judgment for evaluating different weights for different qualitative features creates severe impact in the enterprise’s production and quality directly. This research results indicate that the supplier selection process exhibits to be the most fundamental variable by contributing to achieve customer satisfaction and high quality products.

This thesis proposes an efficient integrated solving approach for the supplier selection problem. The support vector machine, support vector classification, principal component analysis and canonical correlation analysis is applied to solve the problem of selecting potential suppliers in the procedure of the integrated solving approach.

2. Literature Review

AI-based models estimate the relationships between the input(s) and output(s) without the need for prior knowledge about the extra data file that produced the collected data Gandomi & Alavi, (2011). These models are able to provide excellent results with minimal attempts (Metenidis, Witczak, & Korbicz, 2004). Again, AI-based approach is one of the best-known techniques in modeling the suppliers’ performance (Vahdani, Iranmanesh, Mousavi, & Abdollahzade, 2012). Using purchasing experts and historical data, this technique is able to be designed based on computer aided systems. Numerous pure AI models have been applied for forecasting suppliers' performance.

Li, (2009) proposed an ANN-based model to help managers describe and refresh their specific supplier selection attributes based on changing situations. The approach establishes the supplier selection attributes for different enterprises on the basis of their own circumstances and once business environment changes, with new data being generated, the set can be refreshed appropriately.


Vahdani et al., (2012) proposed a predictive AI-based structure where a linear neuro-fuzzy model was used to review the suppliers’ performance with the help of the defined attributes. After collecting the historical dataset (about the attributes and the performance), the dataset was divided into two parts for training the neuro fuzzy system and testing the predictive ability of the proposed model. To validate the accuracy of the model in the training process and the testing process, the results obtained by the proposed model were compared with the results obtained by Radial Basis Function (RBF) neural network, Multi-Layer Perceptron (MLP) neural network and Least Square-Support Vector Machine (LS-SVM).

Support Vector Machine (SVM) is a learning theory recommended by C.-Cortes, C.-Cortes, V.-Vapnik, & V.-Vapnik, (1995) and has been widely using for its classification and regression ability. Several authors compared SVM with traditional statistical learning methods, such as logit, neural networks or discriminant analysis, and lastly the most efficient outcomes are gained by SVM among these methodologies.

Moreover, traditional statistical learning processes are lagging in efficiency than machine learning algorithms. Again, neural networks also lag in efficiency than machine learning algorithms because of their severe drawbacks like unrestrained convergence, principle lacking and local optimization solution, presented by (Guosheng & Guohong, 2008). In this research, a relatively new machine learning technique, support vector machine (SVM) is introduced to provide a model with better explanatory power which overcomes the drawbacks of neural networks to fix the optimal supplier. The actual examples illustrate that SVM methods are superior to BPNN.

Many authors tried to collaborate SVM with SCM through supplier selection, regression, classification and so on. Support vector machine algorithms (SVM) are flexible enough to manage with small samples’ training and testing. (Sun, Xie, & Xue, 2005) proposed a model for selecting suppliers based on SVM for classification genre and showed the supplier selection attributes and quantitative measuring processes through fuzzy and pairwise comparison. Constructing the supplier evaluation classifier through SVM, Hsu, Chang, & Hung, (2007) found better outcome rather than measuring in fuzzy and Likert scale.

Jiang, Chen, Zhang, & Pan, (2013) combined DEA with SVM in order to reduce the risk of associations and to search the compatible suppliers. Two steps are included in the presented model. In the first step the suppliers are
classified within efficient and inefficient which is computed through DEA. Thereafter in the second step, efficiency scores are applied as a recent data set to categorize SVM model and for estimating new suppliers’ classification and efficiency.

An integrated DEA-SVM method was also proposed by Abumalloh, Al-Sarhan, Ibrahim, & Abu-Ulbeh, (2016) for evaluating suppliers’ efficiency. In the first step of the model, proper criteria were measured as the inputs and outputs. Then applying DEA, the efficiency estimation of each supplier was assessed. Thereafter, for predicting the efficiency estimation an appropriate SVM-based formation was generated by gathering the data set involved with the efficiency. Deriving from the mentioned model, the results were weighed along with the attained results from DEA-ANN model for exhibiting the accuracy of the model. The DEA-SVM model is more appropriate and precise than the DEA-ANN model that was signified by the findings.

**Theoretical Background**

**3.1 Support Vector Machine (SVM)**

The support vector machine (SVM) is regarded as a supervised learning method for generating input-output mapping functions from a set of labeled training data. The mapping function can perform either as a classification function or as a regression function. For transforming input data to a high-dimensional feature space nonlinear kernel functions are often used with regard to classification which creates maximum-margin hyper-plane. The produced model thus depends on only a subset of the training data around the class boundaries. Similarly, any training data that is sufficiently near the model prediction is ignored by the model generated by Support Vector Regression.

Suppose that particular a set A of points \( x_i \in \mathbb{R}^n \) with \( i = 1, 2, \ldots, N \). Each point \( x_i \) consists of two classes and thus a label is given, \( y_i \in \{-1, 1\} \). The objective is to ascertain the equation of a hyper-plane that allocate A separated all the points within the same class on the same margin. SVM implements classification by structuring an \( N \)-dimensional hyper-plane by which the data are separated optimally into two categories. Let’s discuss the objects illustrated on the left (Figure-1(a)). Here the objects consist of two different classes. On the second picture (Figure-1(b)), the separating line (2-dimensional hyper-plane) is a decision plane through which the objects are divided into two subsets where all elements are coincidental in each subset.

Learning can be considered as getting the maximum margin separating hyper-plane between two classes of points.

Assume that a pair \( (w, b) \) defines a hyper-plane which has the following equation:

\[
wx + b = 0
\]  

(1)

Let \( \{X_1, \ldots, X_m\} \) be the data set and let \( y_i \in \{-1, 1\} \) be the class label of \( x_i \).
All the points should be classified correctly by the decision boundary i.e. the following equations have to be satisfied:

\[ w \cdot x_i + b \geq 1 \quad \text{if} \quad y_i = 1 \]
\[ w \cdot x_i + b \leq -1 \quad \text{if} \quad y_i = -1 \]
\[ \Rightarrow y_i (w \cdot x_i + b) \geq 1 \]

A unique one exists among all hyper-planes separating the data which outcomes the maximum margin of separation between the classes that can be determined in the following way:

\[
\max_{w,b} \min_{i} \left\{ \|x - x_i\| : x \in \mathbb{R}^N, (w \cdot x) + b = 0, i = 1, \ldots, m \right\}
\]

3.2 Principle Component Analysis (PCA)
The PCA is applied for finding the so called principal components of accomplished data introduced by a large random vector, i.e. of components of a smaller vector which conserves principal features of accomplished data. In particular, this points out that the original vector can be reformed from the smaller one with the least possible error. In case of dimension reduction, PCA is often used as a process.

3.3 Canonical Correlation Analysis (CCA)
For measuring the linear relationship between two multidimensional variables, Canonical Correlation Analysis (CCA) is an important way of measure. Two bases are found, one for each variable, which are optimal regarding to correlations and it results the corresponding correlations at the same time. In other words, the two bases are found where the correlation matrix between the variables is diagonal and at the same time the correlations on the diagonal are maximized. It results that the dimensionality of these bases is equal to or less than the smallest dimensionality of the two variables. A significant feature of canonical correlations is that they are invariant regarding to affine transformations of the variables. This is the most fundamental distinction between CCA and ordinary correlation analysis.

4. Model Formulation
4.1 Problem Statement
In this thesis we assume, the products in lot are considered for supplier selection and order allocation. In this problem, a manufacturer has alternative suppliers and makes decisions over periods based on the suppliers’ criteria. In this problem, best suppliers are classified and then ranked among 30 suppliers based on 10 criteria such as price (P), quality (Q), quantity discount (Q.D), delivery accuracy rate (D.A.R), rejection rate (R.R), product reliability (P.R), research and development (R&D), past performance (P.P), supplier capacity (S.C), and warranty period (W.P).

Here AI techniques are developed to deal with the problem where Support Vector Machine (SVM) & Support Vector Classification (SVC) are applied to classify the suppliers into two classes. As supplier selection problems are multi-objective problems, no single methodology can address all the issues of the problem and provide the optimal solution. Therefore with the SVM & SVC, Principal Component Analysis (PCA) & Canonical Correlation Analysis (CCA) are applied for in reducing the number of variables under study and thus ranking and analysis of decision-making units. Thus, this combination of methods would definitely prove to be a good methodology to tackle the multiple criteria of the supplier selection problem. In this study various criteria are considered and different multi-criteria methodologies are studied to find a suitable solution.
5. Model Implementation

5.1 The proposed SVM model

This section will introduce the detailed procedure of implementing our SVM based model. The employed model could be divided into five steps described as below:

Step 1: Loading the specific desired libraries from PYTHON
Step 2: Data preprocessing
Step 3: Feature selection
  Step 3.1: Implement correlation analysis (CCA)
  Step 3.2: Reducing the dimensions (PCA)
Step 4: Construct SVM classifier
  Step 4.1: Select kernel function (linear)
  Step 4.2: Find optimal parameter settings
  Step 4.3: Train SVM classifier
Step 5: Performance evaluation (sorting and ranking)

Step 1: Loading the specific desired libraries from PYTHON
The ‘numpy’ library function has been implemented to compute numerical calculations and the ‘matplotlib’ function to plot or draw graphs. The ‘Rankdata’ API is imported for ranking the final suppliers as well as ‘onevsrestclassifier’ classifier function is also imported from the Multilabel classification packages of sklearn.

Step 2: Data preprocessing
The dataset is prepared beforehand. Considering ten criteria for thirty suppliers are regarded as shown below:

Table 1. Normalized values of 30 suppliers for 10 criteria

<table>
<thead>
<tr>
<th>Suppliers</th>
<th>P</th>
<th>Q</th>
<th>D.A.R</th>
<th>R.R</th>
<th>Q.D</th>
<th>P.R</th>
<th>R&amp; D</th>
<th>P.P</th>
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</table>
Step 3: Feature selection
Support vector classifier is implemented for classification purposes, Principle Component Analysis and Canonical Component Analysis is imported for reduction of dimensionality. The documents that are assigned to both classes are plotted surrounded by two colored circles. The classification is performed by projecting the first two principal components found by PCA and CCA for visualization purposes, followed by using the class: ‘sklearn multiclass. One vs Rest Classifier’ meta-classifier using two SVCs with linear kernels to learn a discriminative model for each class. Note that PCA is used to perform an unsupervised dimensionality reduction, while CCA is used to perform a supervised one. Note: in the plot, "unlabeled samples" does not mean that we don't know the labels (as in semi-supervised learning) but that the samples simply do not have a label.

Step 4: Construct SVM classifier
One Vs Rest classifier with an input parameter of linear SVC kernel is utilized to classify the dataset. The dataset (the suppliers) is classified based on the formulation of Support Vector Machine (SVM). A hyperplane is drawn visually to show the classification. Two subplots were drawn (one based on PCA, another for CCA). Principal Component Analysis (PCA) is used to reduce the dimensionality of the data. The 10 supplier attributes which are transformed into two axes (number of components is equal to 2). Then, the data is fitted for X data.

There are four classes in the dataset. The gray circle is class -1, the edge color of blue for another class, edge color of orange for another class, both color for 4th class.

Step 5: Performance evaluation (Sorting)
A ranking algorithm from the Scientific Python packages is used to rank the suppliers from the first class. An excel file is created to store the final rank of the suppliers. Supplier number in python = the supplier in the dataset + 1.
Figure 3. Four different classes of suppliers are being separated by two hyper-planes after doing PCA

Figure 4. Four different classes of suppliers are being separated by two hyper-planes after doing CCA

6. Result

The ultimate goal of ranking the selected suppliers is done by a sorting algorithm from Scientific Python packages. Thus, the first 5 optimum suppliers can be declared gradually from the output generated by the code are 3rd, 19th, 9th, 27th and 20th supplier shown in the table-2.

Table 2. Final Ranking of the suppliers

<table>
<thead>
<tr>
<th>Rank of the supplier</th>
<th>Supplier no. in the raw dataset</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>19</td>
</tr>
<tr>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>4</td>
<td>27</td>
</tr>
<tr>
<td>5</td>
<td>20</td>
</tr>
</tbody>
</table>
7. Conclusion

All the defined objectives of this research study have been achieved. This research includes four objectives. The first objective is to implement Support Vector classifier to classify 30 suppliers based on 10 criteria. As stated in the previous chapters, although the predictive AI techniques like SVM, SVC have been successfully applied for supplier selection. The second objective is to develop PCA & CCA for the reduction of dimensionality of the data for overcoming the shortcoming of the previous AI techniques in performance evaluation and ranking. The third objective is to investigate the performance of the proposed algorithm to classify supplier. By conducting these different methods, the robustness of the proposed algorithm is demonstrated in terms of performance estimation and ranking power. The forth objective has been achieved by ranking the classified suppliers that meet the optimal requirements and finally select the best supplier among the available ranked alternatives.

Appropriate suppliers directly improve the SCM performance. Therefore, many manufacturers have concentrated on this issue to increase the efficiency of the supply chain of their industries. This study conducted a research in the field of supplier selection to help the manufacturers for facing the problems in this area. The main conclusions of this study are as below:

1. A comprehensive list of criteria for evaluating the suppliers’ performance as well as establishing their importance and applicability in industries.
2. An intelligent approach known as SVM has been introduced to the literature of supplier selection.
3. An SVM-based algorithm is proposed with respect to the determined criteria for performance evaluation and ranking.
4. The presented algorithm can be applied for those companies having problems in selecting appropriate suppliers for long-term cooperation.
5. PCA has proved to be capable of handling multiple conflicting attributes maintaining the variance of the multiple features inherent in supplier selection while simultaneously trading-off key for supplier selection criteria.

8. References


9. Biography

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