

Time Befitting Supply Chain for the Future of Bangladesh Apparel Industry by Aligning Industry 4.0

Md. Rafiul Islam Fahim¹, Fuad Ahmed Chyon¹, Md. Nazmul Hasan Suman^{1}, Md. Zahidul Islam²*

¹Department of Industrial and Production Engineering, Rajshahi University of Engineering & Technology (RUET), Rajshahi-6204, BANGLADESH

²Lecturer, Department of Industrial and Production Engineering, Rajshahi University of Engineering & Technology (RUET), Rajshahi-6204, BANGLADESH

ABSTRACT

The ready-made garment is the largest industry in Bangladesh, where the economy is growing depending on it. However, the supply chain structure of this industry is volatile in many cases. The traditional supply chain strategies may fall concerning the competitors and are facing alarming challenges. High lead time, low responsiveness, the ambiguity of information, high cost, uncertain demand forecasting, and lack of a proper industrial ecosystem are the barriers to Bangladesh's RMG supply chain structure. These problems are impeding the continuous growth of the industry. However, the fourth industrial revolution or Industry 4.0 is the latest modern industries' transformation with smart technologies. Integration of Industry 4.0 in traditional supply chain management provides additional benefits like high responsiveness, real-time data monitoring, forecasting, cost-effectiveness, reduction of the bullwhip effect, and making a good ecosystem worldwide. Nevertheless, the digitalized supply chain and Industry 4.0 can collaborate all the players and stakeholders in one platform to increase responsiveness with optimum cost. In this study, we considered three approaches to collaborate Industry 4.0 with the traditional supply chain of Bangladesh's ready-made garments industry to increase the responsiveness to cost efficiency. The strategies were based on the leagile supply chain, aggregate demand forecasting, and industrial ecosystem.

Keywords: Industry 4.0, Digitalized supply chain, Responsiveness, Leagile Supply Chain strategy, Aggregated Demand Forecasting, Industrial Ecosystem.

1. Introduction

The ready-made garments (RMG) industry acts as the cornerstone of Bangladesh's economy. The apparel sector takes pride by fetching billions of dollars through export earnings and creating jobs for millions of people. Rakib and Adnan (2015) noted that 4 million people worked in around 5000 garment factories in Bangladesh, and around 80 percent were female [1]. The first chapter of the RMG sector's story was written in the 1970s, heavily expanded in the 1990s, and now in 2020, following China to become the world's largest RMG industry. [2]. Though Bangladesh was the last mover, it moved faster than its competitors having a blessing of cheap and simply operated swing machine and a comparatively more inexpensive female workforce. The competitiveness in the market place depends mainly on an organization's ability to handle the challenges of reducing manufacturing cycle time, reducing delivery lead time, reducing total supply chain cost, right customer service level, and improving product quality. To remain competitive and hold on in the market, organizations need to handle the variation of the trends and fashions effectively in an ever-changing market better than their competitors. Consumers tend to demand a product from various alternatives, and they often want it in hand overnight at a comparatively low price. These constraints are making the situation more challenging and more complex. Nevertheless, the companies are bound to the traditional, linear supply chain processes because of

being deficient in digital transformation. It severely limits their ability to fulfill market demand.

However, the RMG sector moves towards a challenging position with Vietnam and other countries as buyers want more high-end diversified products within a short lead time at low cost. The recent United States-China trade war in 2020 has made the sector more concerned about this competition. In 2019, the export of RMG products fell by 7.59% and 15.77 dollars due to the worldwide demand's downfall, consequent of the Export Promotion Bureau (EPB) [3]. Lead time is also an essential factor in the RMG sector, and day by day, Bangladesh is backpedaling in this factor as its lead time is 80 to 90 days though many buyers want it within 35 to 40 days [2]. The level of practice of supply chain management in Bangladesh's RMG sector is not very satisfactory in many instances. Since Bangladesh has low labor costs, it helped to build up the RMG sector quickly. Even so, the labor cost is increasing now. To sustain in the world market with only minimum labor costs will not going to help in the upcoming years.

The world is already shifting in Industry 4.0. So, Bangladesh also needs to build the structure and adopt technologies as early as possible. Bangladesh's apparel industry has enormous pressure on the lead time. Without implementing Industry 4.0 in the supply chain, only wage competitiveness cannot ensure to hold this position for a long time.

'Industry 4.0', also known as the fourth industrial revolution introduced by the Internet of Things (IoT), has already changed the production and manufacturing environment. The advantages of the Internet of Things (IoT), cloud services, big data analysis, 3D printing, and augmented reality made this possible, creating the cyber-physical system concept of Industry 4.0. This system is capable of transforming the smart factory to operate autonomously. It is a game-changing opportunity for the Bangladesh garments sector. It is high time to develop the supply chain more robust with Industry 4.0 and build an ecosystem with the government's support. In this study, we proposed some useful supply chain model with the integration of industry 4.0 for Bangladesh's apparel sector's supply chain. These models described the integration of trade-off between agile supply chain and lean supply chain model, aggregate demand forecasting approach to increase responsiveness aligning real-time monitoring system, and implement smart items in the supply chain.

2. Literature Review

"Industry 4.0" or the fourth industrial revolution is more capable of accomplishing individual customer needs. This industry 4.0 is implemented from customer orders generated through the product's development and manufacturing and finally delivered to the customer [4]. It is a part of digital technologies that gather real-time data, analyze it, and provide useful information to the manufacturing system [5]. The global garments sector has already started to move its supply chain towards the IoT. Industry 4.0, with the IoT system's help, shifts the manufactures production floor's current operation. Marufuzzaman et al. (2020) showed that biofuel industries used a two-stage stochastic model to significantly impact the supply chain [6]. Moreover, this model was also used to design and manage logistics in the supply chain [6]. Alfaqiri et al. (2019) explored the supply chain in the oil and gas industries and found some risk that disrupted the supply chain. These risks were associated with some complicated system of the supply chain [7]. Moreover, Tjahjono et al. (2017) expected the industries would bridge a connection between machines and human-beings in Cyber-Physical-System (CPSs) near future [8].

A responsive supply chain is the ability to react and flexibility of customer demand. Konecka (2010) described that the fast response-ability in a supply chain reaction to customer demand changes depended on the cooperation and integration within this [9]. Few factors also decrease the supply chain performance associated with the problems of port disruption. Hossain et al. (2020) used the Bayesian network for the visualization of the interdependency of these factors [10]. The Bayesian network was also used to find the relationship between the qualitative and quantitative variables and find out which variable is affected the others in the oil and gas supply chain [11].

On the other hand, the supply chain's success or failure is determined by the consumer's satisfaction. At the right price, getting the right product at the right time to the consumer is the leading competitive success of responsiveness [12]. Only a good supply chain can result in shorter lead time, avoid over or under inventory, minimize wastage of money, and ensure the sustainable and efficient growth of an industry or a company [13]. You and Grossmann (2008) suggested that the information delay of a supply chain known as the "bullwhip effect" is positively related to lead time or responsiveness [14].

The ready-made garments (RMG) industries are the most important sector of Bangladesh and its economies. It works as a catalyst for the country's development. However, in Bangladesh, the RMG sector has been facing some problems due to faulty infrastructure and lack of good port management, resulting in low responsiveness to the market [15]. Responsive operational systems include good information management, reliable partnerships, supply chain stakeholders, flexible manufacturing systems, sufficient inventory, and robust logistic systems [16]. Bangladesh's RMG sector has the same shortage of responsiveness due to a shortage of oil and gas, a dependency on imported raw material, suppliers' insufficiency, low labor productivity rate, high-interest rate, and political unrest [1].

Gradually the new technology like IoT is entering in global RMG sector. Lawrence (2019) evaluated the simulation and cloud-based impact of the global supply chain on students' ability to think in specific terms [17]. Gökalp et al. (2015) suggested a cost-benefit analysis for the producer and customer's benefit in innovative approaches [18]. Jayatilake and Rupasinghe (2016) suggested implementing their framework in real apparel industries rather than simulation software [19]. The world is moving faster than before. To satisfy the customer, the increase of responsiveness of the supply chain will be a time worthy solution which should be guided by Industry 4.0.

3. Model Background

3.1 Agile Supply Chain

Agility is defined as the ability to understand the demand in a volatile market place [20]. The agile supply chain is mainly relied on strategic alliances or partnerships to gain speed, flexibility, and responsiveness. It also concerns the fulfillment of customers' diversified choices. However, this strategy is not much concerned about cost and the collaboration of suppliers and customers. However, today's customers want their product within a short time and at a low cost.

3.2 Lean Supply Chain

Leanness is an uplift of a value stream to remove all waste, including time, human resources, machine use, raw material, and so on [21]. The agile and lean supply chain idea is demonstrated by three critical

dimensions: variety, variability (or predictability), and volume. The lean supply chain is mainly concerned about the elimination of every waste. Nevertheless, now a day's customers want more variation and customization. To mitigate the gap lean supply chain method can be very handy. Furthermore, a lean supply chain is unable to fulfill this need.

3.3 Leagile supply chain

The combination of lean and agile supply chain management is widespread and relatively widely discussed, where both the lean and agile strategy is merged to eliminate each other's drawbacks. The lean supply chain is applied before receiving the customer order, where diversification is less, and the agile supply chain is applied after receiving the customer order where diversification is high. So, the leagile supply chain is a more efficient strategy to fulfill customer's diversified demand within less lead time at low cost.

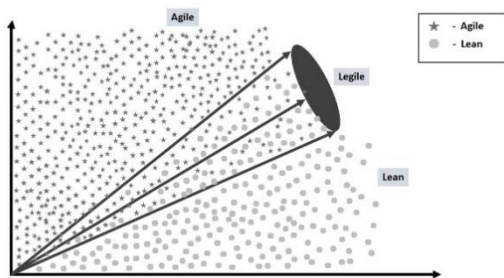


Fig.1 Graph of Leagile new concept

Figure 1 showed that the agile supply chain was marked in the star symbol, and the lean supply chain was marked in the circular symbol. The leagile supply chain in the middle of these two was shaped like a funnel.

3.4 Customer Order Decoupling Point

The idea of the de-coupling point is to hold inventory in some generic or modular form. It only completes the final assembly or configuration after the real customer requirement is known. The customer order de-coupling point in a supply chain is the point that divides the supply chain into a lean supply chain and an agile supply chain [22]. A lean supply chain is used before the de-coupling point, and the agile supply chain is used after the de-coupling point.

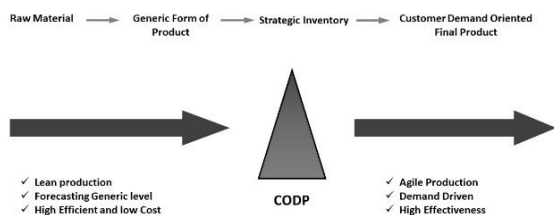


Fig. 2 De-coupling point

Figure 2 showed the comparison of the lean supply chain and the agile supply chain strategy. The lean supply chain is highly efficient, and the forecasting is a generic level. On the other hand, the agile supply chain is demand-driven and has high effectiveness.

3.5 Responsive Supply Chain

A single entity may not lead to today's competition in the market place, yet the top fact is the supply chain. The supply chain, which is more flexible with diversified choice, more adaptable to demand, and more efficient, will lead the market. For better customer impregnation and understanding the market demand, every company is trying to acquire its best performance and forecast market demand accurately with a responsive supply chain [23]. A responsive supply chain is the supply chain that can respond quickly to customer demand changes, both in terms of volume and variation [24]. The RMG sector's supply chain of Bangladesh needs to be more responsive to compete globally. A few necessary steps should be taken to achieve responsiveness. In figure 3, we saw the fishbone diagram of the responsiveness supply chain. The figure indicated the main factors needed to be considered to make a responsive supply chain. The customer demand-driven supply chain can be obtained by real-time data monitoring and demand integration. Flexible production and high production rate can be achieved by part variation and lean production systems, respectively. In Bangladesh, short lead time can be acquired by fast management in port. Transparency is an essential facet of the responsiveness supply chain. By applying IoT, we can gain it. Interconnection between the supply chain can be achieved by eliminating over the wall process and cloud communication.

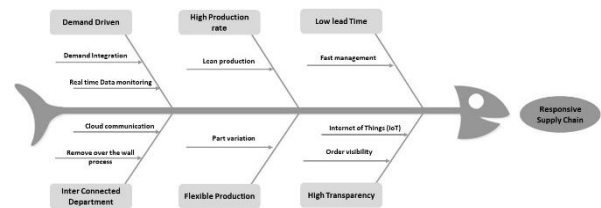


Fig.3 Fishbone Diagram of Responsive supply chain

3.6 Digital Supply Chain

The rebellion of the twenty-first century is named on computer science and telecommunication. It marked its impression in all sectors. So, in the competitive world, the whole supply chain management is integrated by the digital supply chain. It reduces cost and increases responsiveness. Researchers predicted that the digital supply chain would have a high demand in the next decade. It has the power of collaborating with all the stakeholders and communicate faster. It also has several advantages: it increases transparency rate, reduces lead time, understands customer demand better, reduces risk and cost, and so on [25].

In figure 4, we observed the framework of the digital supply chain. It connected suppliers, distributors, producers, and customers in a circular supply chain rather than a traditional vertical or horizontal supply chain framework [26].

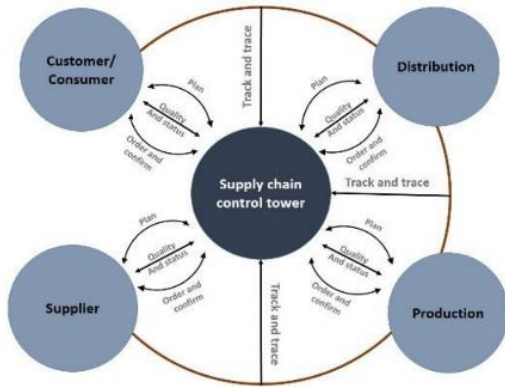


Fig.4 Digital Supply Chain Model

4. Proposed Model

4.1 Postponement and Leagile Supply Chain Strategy Model

In this model, the agile supply chain strategy and lean supply chain strategy were integrated for increasing responsiveness by postponement with incorporating industry 4.0 in Bangladesh's apparel sector. Together these two are called Leagile Supply Chain Strategy. Here, a customer order de-coupling point (CODP) was found between agile and lean supply chain strategies. Where the lean supply chain strategy needed to be applied before the CODP and agile supply after CODP [27].

In this model (Figure 5), supplier, warehouse, manufacturer, inventory, shipment, retailer, and customer or in one-word full supply chain management were interconnected through the internet of things (IoT). So, every player of the supply chain could monitor and analyze data quickly. It reduced lead time and increased responsiveness. The leagile supply chain strategy

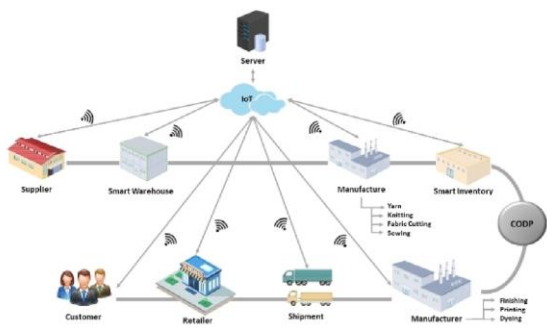


Fig.5 Postponement and Leagile Supply Chain Strategy Model

benefited both make to stock and make to order strategy. Yarn, knitting, fabric cutting, and sewing took most of the working hours to produce RMG. These sections had fewer variations yet large volumes. The manufacturer could finish these steps before the order was received and stocked them in inventory for the future. When the order was received, the manufacturer could do less variation work like dyeing, printing, and finishing. This model is already using in various apparel industries around the world. One of them is Italian fashion brand 'Benetton' and another one is very familiar that is 'Zara Fashion' [28]. So, it is High time to introduce and make familiar this model in this country.

4.2 Aggregated Demand Forecasting with High Risk and Low-Risk Product Model

Demand forecasting is always a challenge for any industry for its high opacity. Aggregated demand forecasting has fewer errors than the traditional one. RMG products have variations as it contains diversified customer trends. Industry 4.0 opened the door for real-time data analysis and demand forecasting. Aggregated demand forecasting is more beneficial and effective than the traditional one as it has high accuracy in uncertain conditions [29]. In figure 6, we considered two manufacturing products and let them call 'A' and 'B'. 'A' had a saturated demand in the market, low risk, and a traditional product. However, 'B' had a high demand, high risk, and a seasonal product. So, the manufacturer could supply 'A' as demanded. In the case of 'B', the manufacturer stocked the raw materials as much as possible.

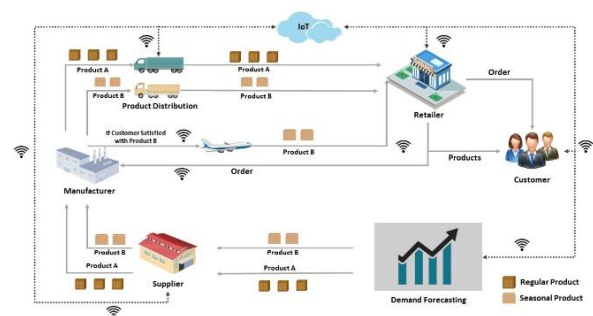


Fig. 6 Aggregated Demand Forecasting Model

But he would produce a portion of the actual demand. Here, the internet of things (IoT) played a critical role. The manufacturer had the opportunity to have real-time market data through monitoring and analyzing the retailers and customers. If 'B' ran well in the market, he could have the window to supply the customer as early as possible. Demand forecasting is the prime activity to build a strong customer relationship management. And aggregated demand forecasting is very popular in apparel industries. Low risk and risk product strategy is very useful to fulfill customer's demand within a very short time [30].

4.3 Industrial Ecosystem Approach

A consequential reason for the low responsiveness supply chain in Bangladesh's RMG sector is the shipment delay [27]. Furthermore, most of the time, a delay is occurred in the ports due to a lack of proper handling. Most of the investors focus on investing in RMG rather than cotton industries. So, the local cotton industries can hardly fulfill the massive demand, and that is why Bangladesh imports most of the raw materials from China. It takes at least one month to order and receive the materials. However, the customers are not ready to provide such an extended period. The consequence of this is that the buyers are now focusing on their closest countries. Therefore, Bangladesh Garment Manufacturers and Exporters Association (BGMEA) should develop the garment industry's ecosystem. China, India, and Pakistan are the world's top cotton-producing countries.

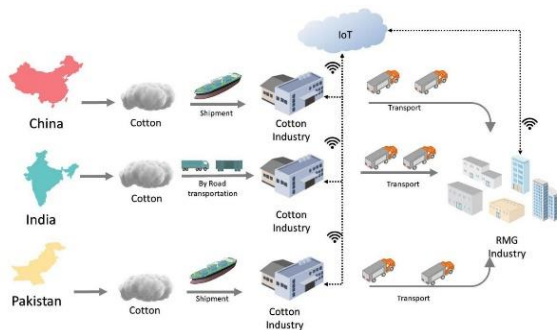


Fig. 7 Industrial Ecosystem Model

India is Bangladesh's neighbor country and has 23 land customs stations between these two countries. BGMEA should encourage the investors to make cotton industries in Bangladesh, where the supply chain players will be interconnected through the internet of things (IoT). Figure 7 represented the industrial ecosystem approach graphically. This ecosystem reduced lead time and increased responsiveness and would have reduced cost and created more job opportunities. As cotton industry is an upcoming opportunity for Bangladesh by reducing lead time and opening a new job sector [31].

5. Discussion

Industry 4.0 has opened an enormous scope to improve the supply chain to satisfy customer's diversified demand at minimum cost. Industry 4.0 is a crucial factor in becoming the market winner by improving the supply chain. Industry 4.0 makes the supply chain more transparent with the internet of things (IoT) and gives accurate demand forecasting. Industry 4.0 also decreases the bullwhip effect as more transparent and accurate demand flow is achieved. It will give order visibility to customers for their greater satisfaction. This study introduced three approaches to integrating industry 4.0 with the traditional RMG supply chain for achieving a more responsive supply chain. We expect these three approaches will reduce

the cost of product flow with accurate demand forecasting.

The first model will assure the customer's choice option with the best quality product. In the lean supply chain (before CODP), it will decrease cost. The agile supply chain (after CODP) will decrease lead time and make it more responsive [29]. So, the overall supply chain will be more productive with less lead time and minimum cost [27]. This supply chain model will beat its competition with an excellent service level.

The second approach is more acceptable in the RMG sector as it has an uncertain high demand. It will collect real-time data for accurate forecasting. The accuracy will be increased with the help of the aggregation of various stakeholders of the supply chain. It will assure product availability in miscellaneous retailers as its unique strategy is to predict and observe customers' behavior at a time. It will not increase the cost yet will be delivered with customer satisfaction. It also offers rapid delivery and a high-volume delivery system. These Models can also be used to be competitive in the global competition of RMG.

A third approach is a possible option for the industry to improve the supply chain from every perspective. It will dramatically reduce the lead time as the raw materials will be produced inside the country, open a new window for the job market, and reduce the unemployment problem. Bangladesh's government and BGMEA should take joint actions to give a reality to these models and strategies. It will make the industry more robust than before and impact the country's growing economy.

From the academic perspective, these models have great accuracy and solve the disruption of the supply chain. On the other hand, the industries can follow these models in their perspective fields to solve problems. The implementation of these models is not very complicated, has incredible accuracy in solving problems, and theoretically makes the supply chain of the RMG sector more efficient. The second model, Aggregated Demand Forecasting with high-risk and low-risk products, will help to distribute the RMG product faster and grab the market.

As a brief, these three strategies will aid the RMG sector to boost up in the world market with a greater service level. Customer demand-oriented low-cost supply chain is the only key to dominate the world market, and these three strategies will Bangladesh to its goal.

6. Conclusion

In light of rapidly accelerating globalization and the expansion of technology, the world seems to be like a global village. The apparel sector is a competitive market place. To sustain in the market, BGMEA needs to make policies adopting the latest technologies. Industry 4.0 can be a significant part as it is entirely operated with IoT. It will reduce the lead time and increase customer responsiveness with optimum cost.

We proposed three frameworks in this study that will be effective, feasible, and significant for implementing Industry 4.0 in the apparel industry. These frameworks are feasible as it has simplicity. Moreover, all the technologies that we used will be standard within a few years. To overcome the traditional supply chain challenges, Bangladesh Government and BGMEA should collaborate and play a vital role in changing infrastructure and building a digital ecosystem for a better future. Industries should adopt these new revolutionary frameworks as early as possible to compete in the global market. Our study's shortcoming is the lack of physical testing of our frameworks, and it can be a future scope. Another scope is to improve transparency to reduce the bullwhip effect by applying blockchain in Bangladesh's RMG supply chain. The inclusion of data science may provide more robustness to the models. The study opens an opportunity for the researchers to analyze postponement applications in other industries' supply chain as well.

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