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OPTIMIZATION IN APPAREL SUPPLY CHAIN USING ARTIFICIAL NEURAL NETWORK

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ABSTRACT: *Labour costs in the apparel manufacturing industry in Bangladesh have increased dramatically. Hence, there is no alternative way to optimize the apparel supply chain to survive in the competitive market. In this study, we implemented artificial neural networks (ANN) in apparel manufacturing organizations to optimize the supply chain by convergent on the right supplier selection by analyzing their performance criteria. Moreover, data was collected from three different factories to analyze the efficiency and profit-loss status of their units. Furthermore, analyze the supplier selection criteria of three suppliers in order to select the right supplier at the right time in the apparel manufacturing industry. This study shows that it can save 18% of the total cost. Additionally, the mathematical analysis has been performed to validate the data analysis for the right supplier selection based on the performance criteria.*

KEYWORDS: Artificial neural network, right supplier selection, profit, supply chain optimization, cost.

INTRODUCTION

Upgrading supply chains is basic for the clothing fabricating industry in light of the fact that many expenses should be paid to make the store network smooth from the producer's end, and these expenses are frequently given to the general store network members has to be engaged with re-appropriating either because of helpless production network execution or reserving for abundance request amount. In addition, it has the risk element of low-quality items and on-time dispersion can't be accomplished due to helpful observing since key individuals probably won't have the option to give satisfactory time in the re-appropriating processing plant, bringing about a further charge for circulating (shipment through airship cargo) the merchandise or potentially there is a likelihood of getting a case because of low quality items. Thus, to accomplish the objective of store network streamlining, an organization needs to further develop efficiency, quality, and dissemination (PQD). To do as such, the manufacturing plant needs to find out that there is great cooperation among the representatives, and that implies the organization is going ahead by giving ideal rules and fitting preparing to its lower type and mid-level administration. Besides, giving continuous preparing to representatives to expertise advancement, which fuses esteem into production network optimization, On the other hand, both the Quality Administration Framework (QMS) and the Requirements for Quality Framework (RQS) are liable for being focused on working with facilities for the organization to gain the ideal outcome for the assembling unit. Generally speaking, it tends to be monitored for up to 30% of the absolute expense. In this

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exploration, fostering a numerical model to make the store network advanced will be the significant concentration.

While most extreme aim of western nations is to diminish engenderment costs. Then again, they will undoubtedly follow through on a significant expense for incapable coordination's when in any event, passing on the merchandise from the nearby producer in China or abroad that is associated with moderately higher coordination's costs which deteriorating item quality. Larger part of the Bangladeshi pieces of clothing producing associations source textures and trims (fundamentals needed for attire fabricating) from abroad, are the most tedious matter just as carrying materials into the distribution center is lavish. One of the center hindrances for the smooth production network is because of procurement materials from abroad for the Bangladeshi attire fabricating industry. Traditionally it requires 60 days lead time to show up materials from in a peregrine nation like China to Bangladesh later than setting requests and plant get just under 30 days lead time to inducing and transportation the items to the end clients. In the interim, separating right provider at the ideal opportunity is the critical variable to make the smooth inventory network and accomplish advanced chain execution. Thus, the centrality of the store network improvement through exact provider winnow to articles of clothing processing plant in our region is irreplaceable. Organization of fake perspicacity in provider separate can improve the strategy for action predicated costing [1]. Besides, separation is expectedly used in the inclination setting to condense the genuine capacity to track down an ideal arrangement Inclination predicated approach is likely to have a numerical articulation of the goal work. At the point when such numerical articulation can't be gotten, there is an objective to use an assessment method to initiate the arrangement technique. The assessed slopes bearing aides the inquiry interaction to peregrinate starting with one potential arrangement then onto the next in an iterative plan in a cycle called stochastic estimation [2]. Various carries out executed in provider winnow, for example, group investigation, factual techniques, information improvement examination, case predicated thinking frameworks, choice emotionally supportive networks, absolute expense of proprietorship models, numerical programming, etc [3][4][5][6]. The unique focus for the ANN practice set must be surrendered to ignore fitting estimation that clearly influences the prescient accuracy coming about out of ANN. Plan of tests (DOE) can be cumulated with ANN to conquer over-fitting difficulty [7] . A few recreation methods are as needs be executed to evaluate the assortments setups of the framework to be advanced. Such sort of improvement is called as recreation streamlining in Activity Exploration (OR) writing [8] . Then again, one more strategy used to improve the stochastic objective capacities are called direct hunt techniques, since the irregularity is dealt with straight by upgrading stochastic capacities [9] . Comprehensive unique activities of a kenned network structure with an activity irregularity. Reenactment displaying can be accustomed to evaluate SC execution for an insight design. In the second a moiety of the twentieth century, advancement has turned into a far and wide strategy, in regions, for example, synthetic and cycle designing, coordination's, financial matters, and SC plan [10]. Quality control (QC) framework is regularly an issue and the use may be raised because of high paces of renouncement, repackaging, scrap and improve, and lost deals due to out-of-stocks and slow turns [11]. Effective stock chains should be adaptable and friendly to the changing elements in the rialto, in assembling and innovation, and in buyer possibilities. This is withal genuine for general wellbeing supply chains, which should react

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and conform to dynamic conditions. Store network advancement is an ascendant, commonsense carry out that can enhance execution now and stand firm on foothold of the inventory chains for what's to come. However reenactment is quite possibly the most prosperous gear for breaking down production network processes [12]. Moreover, Fake Neural Organizations (ANNs) to be one more solid strategy to assessed subjective smooth capacities and can be tweaked using stochastic replication esteems [13]. As indicated by Papageorgiou (2009), current modern ventures comprise of various tasks, destinations and offices, which can be situated in various nations, districts, or parts of the world. The creator further contends that various exercises of SCs including arranging, participation and coordination, and responsiveness to client requests should be considered to determine adequacy, seriousness, supportability, and amplification of SCs. Inventory network the executives (SCM) includes kineticism of material and facilities from upstream to downstream activities of SCs. In the present ecumenical and serious climate, SCM and dynamic interaction emerges both from key and functional stances [14] . Any "plan" of a SC traditionally includes tradeoffs between clashing targets and, according to the supportability point of view, between monetary, ecological and pleasant goals. Therefore, reasonable turn of events and multi-rules improvement in SC network configuration is a captivating point deserving of study [15] . Multi-objective streamlining is generally applied to various dynamic pickles and the execution of improvement in navigation has outwardly seen developing interest as of late [16]. Increased globalization and furious rivalry are pressuring organizations to be more productive and adaptable. Organizations should match injuctively approving financial targets and simultaneously working in a maintainable way just as they should address customer issues [17]. The objective of SCM is to methodicallly coordinate providers, producers and customers for merchandise and facilities to be made and appropriated perfectly located, exact time, and in the perfect sum, while at the same time learning greatest SC execution [18]. Practical advancement of SCs is a critical piece of any business and proficient SCs are basic for great items and for on-time appropriation. Therefore, working SCs in a feasible way is an involute undertaking, whose involution relies upon the quantity of echelons, materials, and facilities inside SCs [19]. As indicated by Papageorgiou (2009), a wide range of plans and approaches of numerical models are used in SC advancement. The most pervasive methodologies are numerical programming, recreation, or a combination of the two techniques. Their application relies upon the issue to be settled. Numerical programming and numerical demonstrating is ordinarily used for advancement of choices that include nascent setups, with mixed part of elements and construction of activities, for example, SC network structure plan. A few survey papers are distributed in the last two decenniums that address various parts of SCs, e.g., SC the executives, green parts of SCs [21] , ecumenical SC models and plan [22] ,and multi-objective advancement [23] .Whereas reenactment models consider SC network configuration can be separated into two plan types, specifically, open circle organizations and shut circle networks where the reversal stream is joined [24] . In this paper, we will be fostered a strategy for fitting provider winnow by executing AHP Model just as foster an outcome situated method for improving inventory network enhancement in attire fabricating associations.

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ANALYSIS

The supplier selection criteria are demonstrated in tables 1 to 3 respectively for the diverse apparel manufacturing industry. The best supplier was selected based on the highest average score obtained from the various criteria. In this research, it took into consideration several principles, for instance, quality, capacity, service, cost, delivery, sustainability, CSR, and ethics, in order to select the best and right supplier. The best supplier was selected as S3, S5, and S1 for the manufacturing units 1 to 3 respectively.

Table 1. Supplier criteria criteria of PU1

Supplier	Average Rating
S1	0.64125
S2	0.65625
S3	0.66625
S4	0.65875
S5	0.6275

The data collected from three different apparel manufacturing companies has been implemented through software like R Studio, Python, and Minitab and has got different outcomes and can be used to take a decision on which supplier to select scientifically and manually from their criteria.

Table 2. Supplier criteria criteria of PU2

Supplier	Average Rating
S1	0.62125
S2	0.60125
S3	0.5925
S4	0.60125
S5	0.6425

In addition, data validation analysis has been done through Python. Input is treated as the input criteria of the supplier selection and output is deemed as the currently delivering performance criteria. Data analysis showed that expected input and output could be attainable with the respective weights provided by the Python code.

Table 3. Supplier criteria criteria of PU3

Supplier	Average Rating
S1	0.68375
S2	0.6225
S3	0.625
S4	0.6325
S5	0.61125

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Artificial neural network (ANN)

$$net_{h1} = w_1 * i_2 + w_2 * i_2 + b_1 * 1 \quad (1)$$

$$out_{h1} = \frac{1}{1 + e^{-net_{h1}}} \quad (2)$$

$$net_{o1} = w_5 * out_{h1} + w_6 * out_{h2} + b_2 * 1 \quad (3)$$

$$out_{o1} = \frac{1}{1 + e^{-net_{o1}}} \quad (4)$$

$$E_{total} = \sum \frac{1}{2} (target - output)^2 \quad (5)$$

$$E_{01} = \sum \frac{1}{2} (target_{01} - out_{o1})^2 \quad (6)$$

$$E_{02} = \sum \frac{1}{2} (target_{02} - out_{O2})^2 \quad (7)$$

$$E_{total} = E_{o1} + E_{o2} \quad (8)$$

$$\frac{\partial E_{total}}{\partial out_{o1}} = -(target_{o1} - out_{o1}) \quad (9)$$

$$\frac{\partial out_{o1}}{\partial net_{o1}} = out_{o1} - (1 - out_{o1}) \quad (10)$$

$$net_{o1} = w_5 * out_{h1} + w_6 * out_{h2} + b_2 * 1$$

$$\frac{\partial E_{totral}}{\partial w_5} = -(target_{o1} - out_{o1}) * out_{o1}(1 - out_{o1}) * out_{h1} \quad (11)$$

$$\delta_{o1} = -(target_{01} - out_{o1}) * out_{o1}(1 - out_{o1}) \quad (12)$$

$$\frac{\partial E_{totral}}{\partial w_5} = \delta_{o1} out_{h1} \quad (13)$$

$$\frac{\partial E_{totral}}{\partial w_5} = -\delta_{o1} out_{h1} \quad (14)$$

$$w_5^+ = w_5 - \eta * \frac{\partial E_{total}}{\partial_{w5}} \quad (15)$$

$$\frac{\partial E_{total}}{\partial_{w1}} = \frac{\partial E_{total}}{\partial out_{h1}} * \frac{\partial out_{h1}}{\partial net_{h1}} * \frac{\partial net_{h1}}{\partial_{w1}} \quad (16)$$

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$$\frac{\partial E_{total}}{\partial out_{h1}} = \frac{\partial E_{01}}{\partial out_{h1}} * \frac{\partial E_{02}}{\partial out_{h1}} \quad (17)$$

$$E_{total} = E_{01} + E_{02} \quad (18)$$

$$net_{o1} = w_5 * out_{h1} + w_6 * out_{h2} + b_2 * 1 \quad (19)$$

$$\frac{\partial net_{o1}}{\partial out_{h1}} = w_5 \quad (20)$$

$$out_{h1} = \frac{1}{1 + e^{net_{h1}}} \quad (21)$$

$$\frac{\partial out_{h1}}{\partial net_{h1}} = out_{h1}(1 - out_{h1}) \quad (22)$$

$$\frac{\partial E_{total}}{\partial_{w1}} = i_1 \quad (23)$$

$$\frac{\partial E_{total}}{\partial_{w1}} = (\sum_0 \delta_o * w_{ho}) * out_{h1}(1 - out_{h1}) * i_1 \quad (24)$$

$$\frac{\partial E_{total}}{\partial_{w1}} = \delta_{h1}{}^{i1} \quad (25)$$

$$w_1^+ = w_1 - \eta * \frac{\partial E_{total}}{\partial_{w1}} \quad (26)$$

Nomenclature

E: (Effective) work potential
E_0: Exergy
E_{00} : Energy of a system
K : Kelvin temperature scale
S: Entropy
T : Temperature or Celsius temperature scale
W : Effective work

Mathematical analysis

The data has been analyzed through an artificial neural network, which is shown in figure 1. The analysis has been performed with three parameters, i.e., input data, hidden data, and output data. Both forward and backward propagation have been taken into consideration for getting the real outcome. A mathematical analysis has been done on three production units (PU) and found a net value error. Table 1 depicted that the calculated error found was 0.0014 for PU 1, which is very close to zero, and hence supply chain optimization

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improved to an acceptable level for the apparel manufacturing organization. The net value of outh1 and outh2 is 0.86956 and 0.99552, respectively. At the same time, the values of Outo1 and Outo2 are 0.05470 and 0.99985 correspondingly.

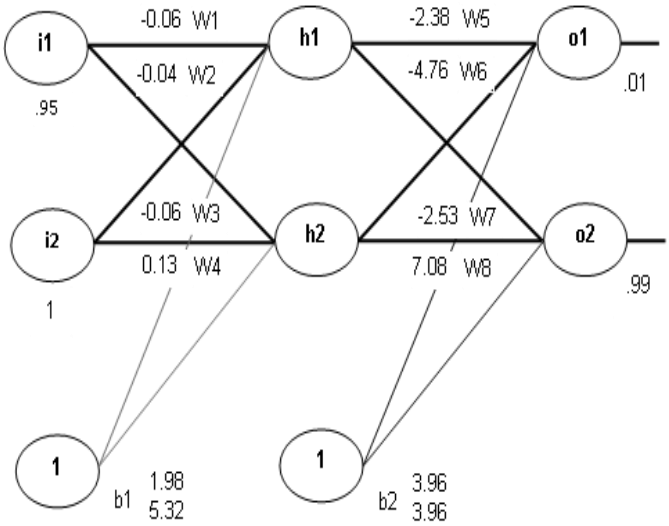

Figure 1. Artificial neural network analysis

Table 4 portrayed that the calculated error found was 0.0014 for PU 1, which is very close to zero, and hence supply chain optimization ameliorated to an acceptable level for the apparel manufacturing organization.

Table 4. Calculated outcomes of PU1

Parameters	Calculated outcome
Net_{h1}	1.88458
Net_{h2}	5.39414
Out_{h1}	0.86956
Out_{h2}	0.99552
Net_{o1}	2.84824
Net_{o2}	8.80828
Out_{o1}	0.05470
Out_{o2}	0.99985
E_{o1}	0.00099
E_{o2}	0.00048
E_{total}	0.0014

Table 5 showed that the calculated error found was 0.0001 for PU 2, which is very close to zero, and hence supply

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chain optimization improved to an acceptable level for the apparel manufacturing organization.

Table 5. Calculated outcomes of PU2

Parameters	Calculated outcome
Net_{h1}	1.9525
Net_{h2}	7.3528
Out_{h1}	0.7825
Out_{h2}	0.8702
Net_{o1}	-3.7825
Net_{o2}	8.5088
Out_{o1}	0.0372
Out_{o2}	0.9925
Eo1	0.0009
Eo2	0.0002
Etotal	0.0001

Table 6 depicted that the calculated error found was 0.0000 for PU 3, which is very close to zero and hence supply chain optimization ameliorated to an acceptable level for the apparel manufacturing organization.

Table 6. Calculated outcomes of PU3

Parameters	Calculated outcome
Net_{h1}	2.0525
Net_{h2}	6.9522
Out_{h1}	0.7921
Out_{h2}	0.8301
Net_{o1}	-4.0130
Net_{o2}	9.0011
Out_{o1}	0.0401
Out_{o2}	0.9901
Eo1	0.0009
Eo2	0.0001
Etotal	0.0000

Software validity

Figure 1 depicts the analysis of the supplier selection considering data collection from manufacturing unit 1, where 28579 steps were taken by R studio to validate the weights in ANN and also found an error of 0.00025 during the analysis, which is very negligible.

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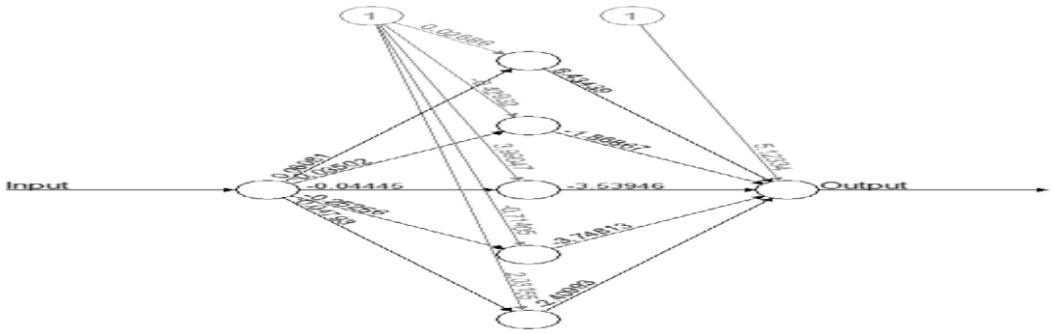

Figure 2. Neural network developed through R studio of PU1.
Similarly, figures 2, 3, 4 and 5 portrayed the supplier selection validation through R software and found steps taken 3086, 4282, 8182, and 12673 as well as errors rates of 0.000618, 0.002863, 0.00095, and 0.000593 respectively for the manufacturing units 2, 3, 4, and 5.

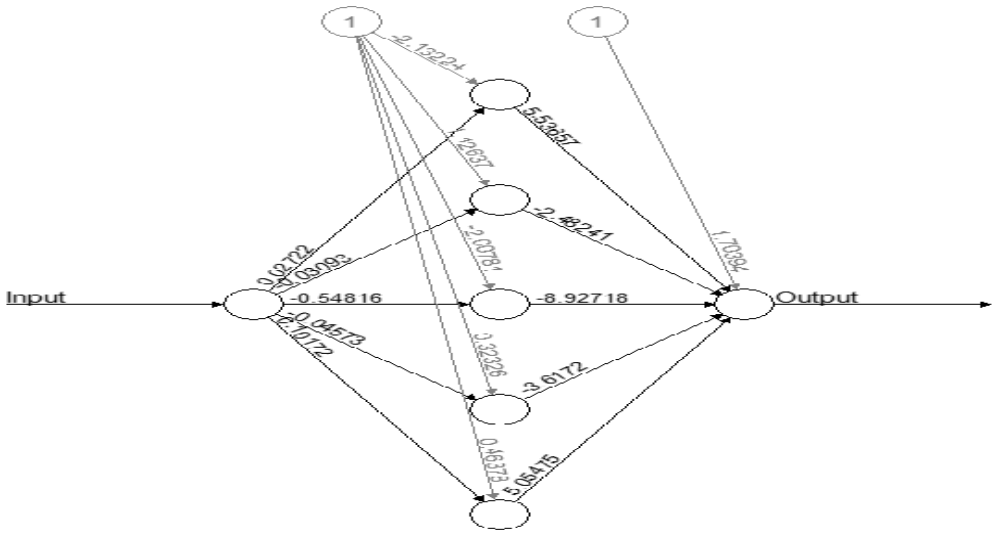

Figure. 3. Coded ANN of PU2

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Figure. 4. Coded ANN of PU3

RESULTS

In this research, data analysis has been conducted for five renowned apparel manufacturing factories in Bangladesh. The efficiency status of these factories is really worsening in the course of the production gap.

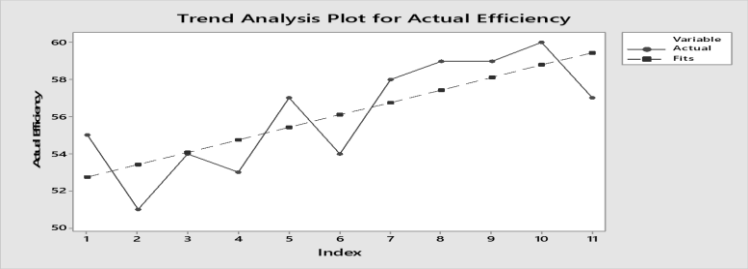

Figure. 5. Efficiency trend of PU1.

This gap happened due to a delay in receiving raw materials. The delay in receiving the raw materials was due to the inappropriate supplier's selection focusing on the conventional method.

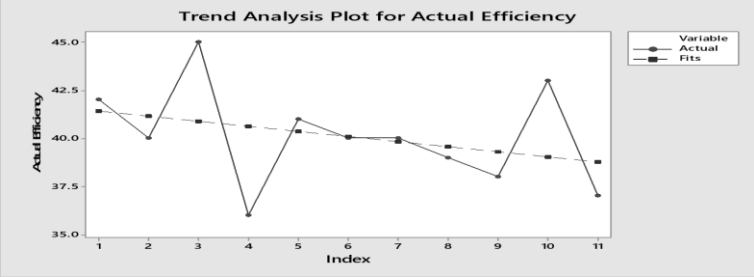

Figure.6. Efficiency trend of PU2.

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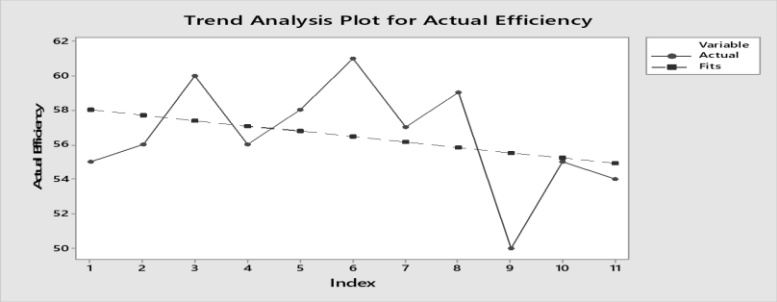

Figure. 7. Efficiency trend of PU3.

Hence, the profitability of the company has declined. Therefore, the optimization of the supply chain in the apparel manufacturing industry is a very crucial phenomenon. The data analysis has been done through Minitab software.

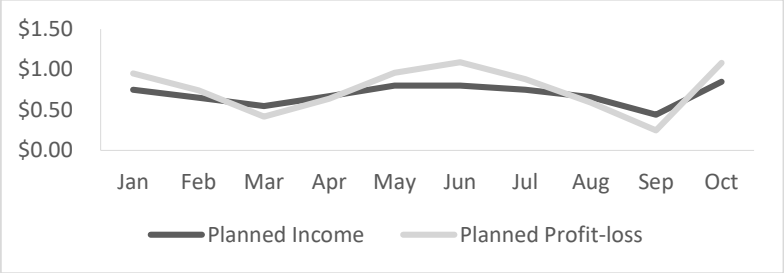

Figure. 8. Profit and loss analysis of PU1.

The planned efficiency of the PU2 is 65%. Figure 6 shows that the scenarios of the efficiency level of that factory for the last eleven months came in between 53% and 58%, which means almost 8% of the efficiency loss for this factory. Similarly, from Figure 7, the efficiency status of the PU3 has been depicted. It showed that the planned target efficiency was 58% for the manufacturing unit, whereas their achievement was 44% to 48%. As a result, the factory lost 8% to 12% efficiency since the materials had not been received in a timely manner, which is the result of poor supplier selection.

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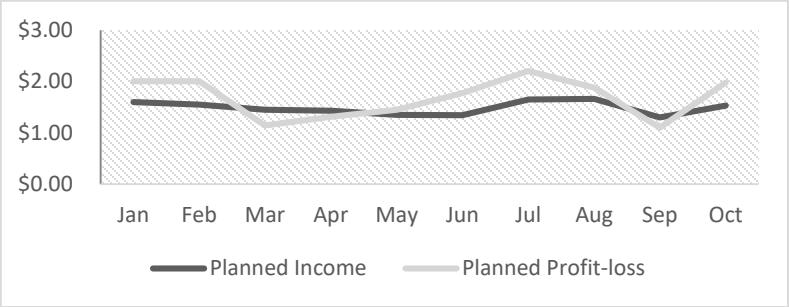

Figure. 9. Profit and loss analysis of PU2

As a result, they had to agonize over paying the workers in a timely manner. Irregular payments lead to unrest at the factory, which leads to cancellation of the orders as well as, at the end of the hour, the factory might be at a risk of not being able to survive in the market. In this context, the selection of the right supplier in real time by the proper method is an important event. From figures 8, 9, and 10, it demonstrated the planned income versus planned profit-loss analysis for manufacturing units 1, 2, and 3. The company's profit margin is very close to the planned target.

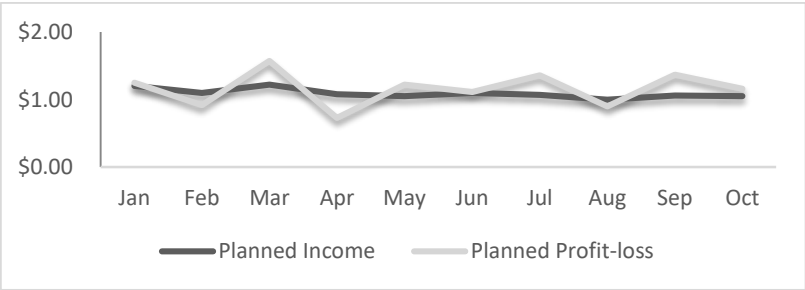

Figure. 10. Profit and loss analysis of PU3

CONCLUSIONS

Supply chain optimization is the crucial point for the apparel manufacturing industry as labor costs have been increasing day by day quickly, which has lessened profit margins. In this research, we have analyzed data to optimize the supply chain in the selected apparel manufacturing organization. This study showed that 15% efficiency has been improved through the implementation of an optimization strategy. The cost of air freight and imposing a discount on goods for the delayed shipment has been reduced to very negligible amounts, which was almost 15 to 20% of the total cost. Analyzing supply chain optimization in at least ten garment manufacturing industries to get the authentic scenario of the chain optimization and the cost of delayed shipment would be the future research recommendation. In Bangladesh, the apparel manufacturing industry has been losing the opportunity to make money due to a lack of receiving materials on time. In this context, the factory has lost target efficiency and it has gradually become

a survival question because of the competitive market all over the world. Bangladeshi garments manufacturers have direct competitors from Myanmar, China, Cambodia, and some other countries that used to make garments. There is no option to optimize the supply chain by choosing the right supplier.

References

[1] ROODHOOFT, F. AND KONINGS, J. (1996) 'Vendor selection and evaluation an activity-based costing approach', European journal of operation research, Vol. 96, pp.97–102.
[2] H.Robbins et al (1951), A Stochastic Approximation method, Ann. Math. Statist. 22(3): 400-407 (September, 1951). DOI: 10.1214/aoms/1177729586.
[3] DE BOER, L., LABRO, E. AND MORLACCHI, P. (2001) 'A review of methods supporting supplier selection', European Journal of Purchasing Supply Management, Vol. 7, pp.75–89.
[4] TALLURI, S. (2002) 'A buyer seller game model for selection and negotiation of purchasing bids',European Journal of Operation Research, Vol. 143, pp.171–180.
[5] CHOY, K.L., LEE, W.B. AND LO, V. (2003) 'Design of a case based intelligent supplier relationship management system-the integration of supplier rating system and product coding system', Expert System Application, Vol. 25, pp.87–100.
[6] ZHU, J. (2004) 'A buyer seller game model for selection and negotiation of purchasing bids:an extensions and new models', European Journal of Operation Research,Vol. 134, pp.150–156.
[7] ALAM, F. M., MCNAUGHT, K. R. & RINGROSE, T. J. (2004) A comparison of experimental designs in the development of a neural network simulation metamodel. Simulation Modelling Practice and Theory, 12, 559-578.
[8] TEKIN, E. & SABUNCUOGLU, I. (2004) Simulation optimization: A comprehensive review on theoryand applications. IIE Transactions, 36, 1067-1081.
[9] TERZI, S. & CAVALIERI, S. (2004) Simulation in the supply chain context : a survey computers in industry ,53, 3-16.
[10] Sahinidis, N. V. (2004). Optimization under Uncertainty: State-of-the-Art and Opportunities.Computers & Chemical Engineering, 28(6-7), pp.971-983.
[11] NASSIMBENI GUIDO, SARTOR MARCO. (2006) Sourcing in China, Palgrave.
[12] BEYER, H. G. & SENDHOFF, B. (2007) Robust optimization–A comprehensive survey. Computer methods in applied mechanics and engineering, 196, 3190-3218.
[13] HAYKIN, S. (2008) Neural networks: a comprehensive foundation, Prentice Hall.
[14] Papageorgiou, L. G. (2009). Supply Chain Optimization for the Process Industries: Advances and Opportunities. Computers & Chemical Engineering, 33(12), pp. 1931-1938.
[15] Wang, F., Lai, X., & Shi, N. (2011). A Multi-Objective Optimization for Green Supply Chain Network Design.Decision Support Systems, 51(2), pp. 262269.
[16] Jamshidi, R., Fatemi Ghomi, S. M. T., & Karimi, B. (2012). Multi-Objective Green Supply Chain Optimization with a New Hybrid Memetic Algorithm Using the Taguchi Method. . Scientia Iranica, 19(6), pp.1876-1886.
[17] Barbosa-Póvoa, A. P. (2012). Progresses and Challenges in Process Industry Supply Chains Optimization. Current Opinion in Chemical Engineering, 1(4), pp. 446-452.
[18] Ruiz-Femenia, R., Guillén-Gosálbez, G., Jiménez, L., & Caballero, J. A. (2013). Multi-Objective Optimization of Environmentally Conscious Chemical Supply Chains under DemandUncertainty.Chemical Engineering Science, 95,pp. 1-11.
[19] Barbosa-Póvoa, A. P. (2014). Process Supply Chains Management Â€“ Where Are We? Where to Go Next? Frontiers in Energy Research, 2.
[20] Croom, S., Romano, P., & Giannakis, M. (2000). Supply Chain Management: An AnalyticalFramework for Critical Literature Review. European Journal of Purchasing & Supply Management, 6(1), pp. 67-83.

[21] Srivastava, S. K. (2007). Green Supply-Chain Management: A State-of-the-Art Literature Review. International Journal of Management Reviews, 9(1), pp.53-80.
[22] Meixell, M. J., & Gargeya, V. B. (2005). Global Supply Chain Design: A Literature Review and Critique. Transportation Research Part E: Logistics and Transportation Review,41(6), pp. 531-550.
[23] Trisna, T., Marimin, M., Arkeman, Y., & Sunarti, T. C. (2016). Multi-Objective Optimization for Supply Chain Management Problem: A Literature Review. Decision Science Letters,pp. 283-316.
[24] Nurjanni, K. P., Carvalho, M. S., & Costa, L. (2017). Green Supply Chain Design: A Mathematical Modeling Approach Based on a Multi-Objective Optimization Model.. International Journal of Production Economics, 183, pp. 421-432.