Supply chain optimization with Genetic Algorithm focusing on right supplier selection at real time in apparel manufacturing

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Abstract

Apparel manufacturing industry is facing gigantic issue to meet customer demand and make them happier due to improper supplier selection. Factory does not follow the scientific and analytical techniques to select the right supplier .In this paper, we have done the right supplier selection by implementing cross-over and mutation analysis of genetic algorithm. Moreover, criteria based analysis also been done to get the right supplier at the real time. Furthermore, supply chain optimization experiment has been done with DOE-Taguchi method. Industry can save up to 30 % of their total cost by selecting right supplier .

1.Introduction

The cost of component parts and raw materials initiate a key slice of the product cost in many factories.For instance, the cost of apparatuses and parts bought from external sources by vast automotive or textile machinery manufacturers may total more than 50% - 80% of the incomes. In this process of procurement, supplier selection has long been predictable as imperatives and has been a pivotemphasisfor the majority of the industrial marketing research over the past three decades (Patton,1996). The purpose of the supplier selection is to examine how many and which suppliers should be designated as the sources of the supplies and how order quantities would be assignedmidst the nominated suppliers. Selection is said to be effectual when we attain not only a desirable solution but also an optimal solution. Traditional supplier selection decisions are mostlybased on procurement cost, product quality, delivery performance and supply capacity criteria.

The combinedthought of the above criteria complicates the selection decision even for an experienced purchase manager because competing vendors have different levels of achievement under these criteria. For example, the wholesaler with the minimum price in a given industry may not have the best delivery performance or product quality. In addition to the multi-objective nature of supplier selection, appearance of a discount pricing schedule becomes a major hindrance for procurement managers in finding the best purchasing strategy. There is numerous discount strategy like discounts depending on the quantity of each product ordered from a supplier, and discounts based on the total worth of all products ordered from a supplier end. Quantity concession models include distinct price breaks for every product.

2. Review on Supplier Selection

Advanced levels of customer satisfaction and steady performance outcome from selecting and evaluating suppliers based on their ability to provide quality components and subassemblies, reliable delivery, and product performance as per the research by Tracey and Tan (2001).The most important supplier selection criteria that would be practical

are value, timely delivery and quality which stated by the Khan Shahadat (2003). The growth of the industrial environment has adapted the comparative importance of the criteria and some more additional criteria like quantity discounts offered by the supplier are now considered to be practically useful. According to Bhutta(2002), the vendor selection methods can be broadly classified as linear weighting, cost, mathematical and statistical models. In linear weighting models, weights are given to the criteria, the major weight indicating the highest importance. The supplier with the peak overall score can then be nominated. Humphrey et al. (2005)practice weighted score method for supplier evaluation.This technique does not take qualitative factors into deliberation. Furthermore, the subjectivity of the decisionmaker in the identification of weights would be very lofty.

The proposed usage of the Analytic Hierarchy Process (AHP) to deal with fuzziness in supplier choice byBarbarosoglu and Yazgac(1997), Bhutta and Huq (2202), Cengiz Kahraman et al. (2003) Gary and Hector (2005) .While structural method such as AHP,assistsconstancy when conveying weights, a great arrangement of subjectivity remains entrenched in the method. Total Cost of Proprietorship (TCP) based models attempt to include all quantifiable costs in the supplier choice that are incurred throughout the purchased item's life cycle (Labro, et al 2005)(Ellram, L. M., 1995) (Smytka, et al 1993)

. As cost estimation involves subjectivity, the results of approximation may be vague and haphazard. The largest sources of error in cost estimation are overlooking elements of cost.

An MIP formulation and a profitable tools used to solve their model however the majority number of suppliers in their research was 30; thus, the number of binary variables was lowstated by the Dahel(2003) .Moreover, diminishing the number of suppliersselected was not agoal in this research.At last but not least, the most common quantitative methodology presented in the literature is the linearweighting scheme. The next most common methodology is the AHP process.

There are not manypapers dealing with the application of mathematical optimization to the supplier selection problem.Among them there are even fewer papers (Buffa and Jackson, 1983; Weber and Current, 1993; Karpak et al., 1999; Dahel, 2003) that explicitly model the problem as a multi-objective optimizationproblem.

3. Irregularities in conventional supplier selection

In apparel manufacturing industry**,** supplier selection performs based on more conventional way. Many factories do the supplier selection by filling up a format which given from manufactures' end and start placing orders without having right performance evaluation of supplier. Sometimes supplier makes a contact with manufacturer and then after initial communication with manufacturer, supplier can start business with producer. The core problem of this traditional system is the delay delivery from supplier and product's quality does not meet customer's standard which hassle for both suppliers and manufacturers. Once supplier distribute poor quality product, manufacture does not get time to replace and return back right product at the right time due to tight shipment schedule. In addition, either local supplier cannot maintain commitment date or overseas supplies do the same job on contrary of the selection of the supplier without proper scientific evaluation. Likewise, shipment can do by air freight which cost manufactures'. To avoid this serious barrier and liability, right supplier selection at the real time becomes crucial for the apparel manufacturing organization.

4. DOE-Taguchi

To get the more optimization result for supply chain, an experiment has been done with DOE-taguchi method in Minitab. Planned manpower versus output portrayed in figure 1. Different output figure found by analyzing different amount manpower, available minutes and standard minute value (SMV). The mean outcome for this experiment depicted in the figure 2. In order to get the optimized apparel supply chain, a more precise PCR analysis has done for getting optimized level of rejection rate (RR) and defect per hundred units (DHU) in a leading apparel manufacturing which improves the scenario of apparel supply chain optimization shown in figure 3 and 4. Illustrated contour and surface plot of RR and DHU in the figure 5 where shown that RR and DHU reduced by the implementation of quality

management system (QMS) in apparel manufacturing. Optimized predicted versus observed efficiency value represented in the figure 6 (a) by implementing line of balancing (LOB) techniques and optimal DHU and RR value found 15 and 8.12 by DOE-taguchi analysis revealed in the figure 6(b).

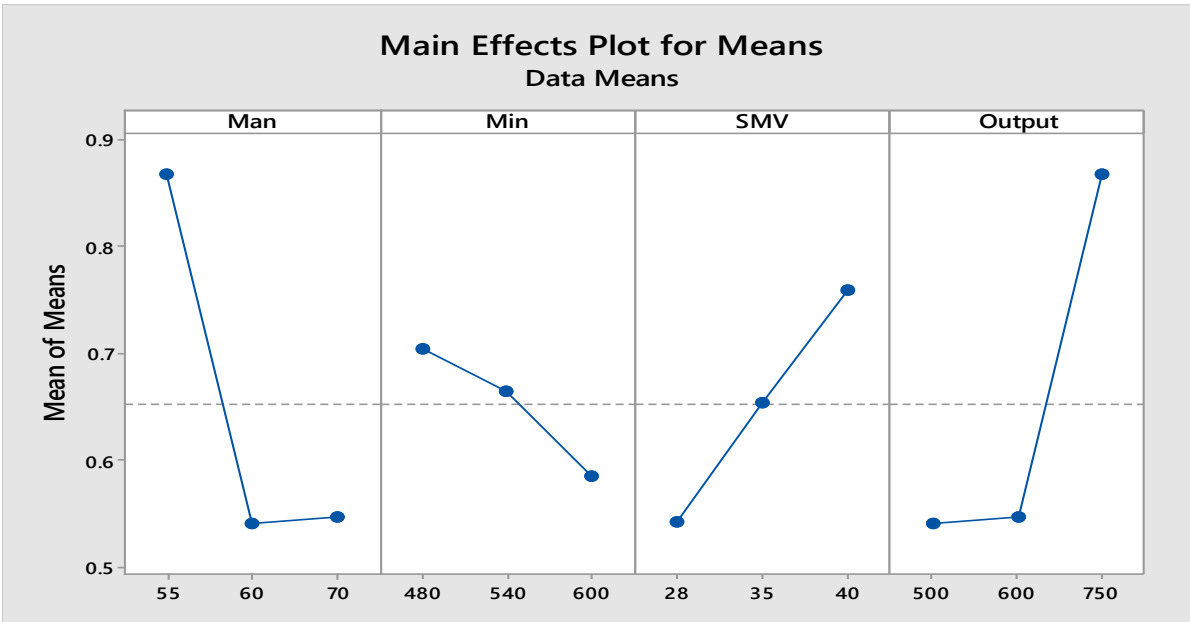

Figure 1 : man –min-smv vs output status

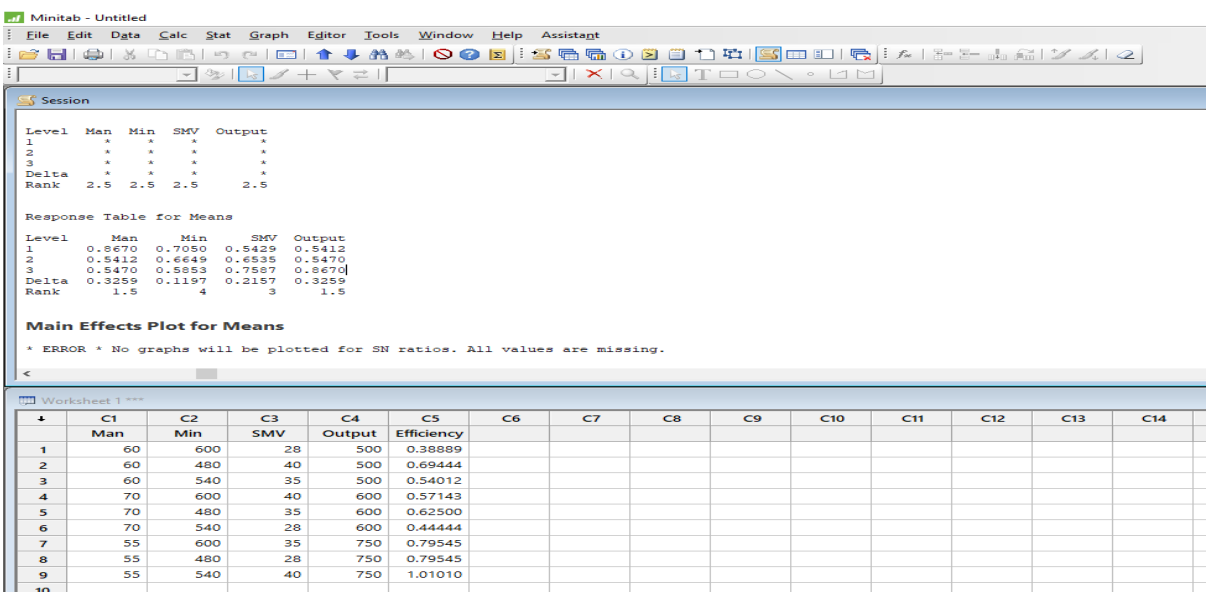

Figure 2 : main effects plots mean

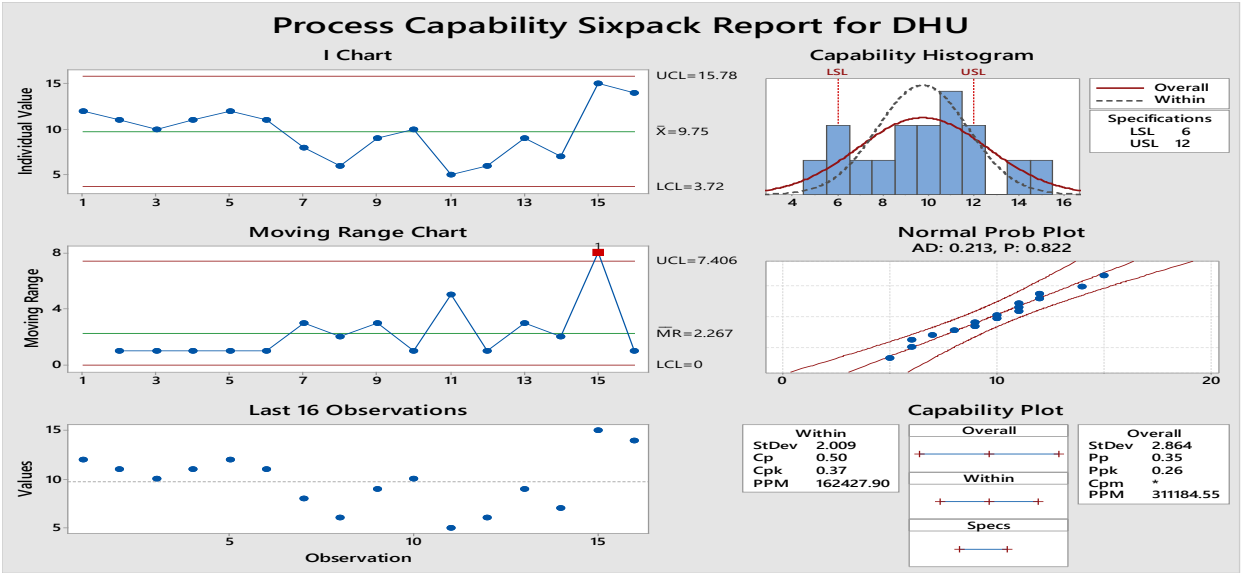

Figure 3: PCR for DHU

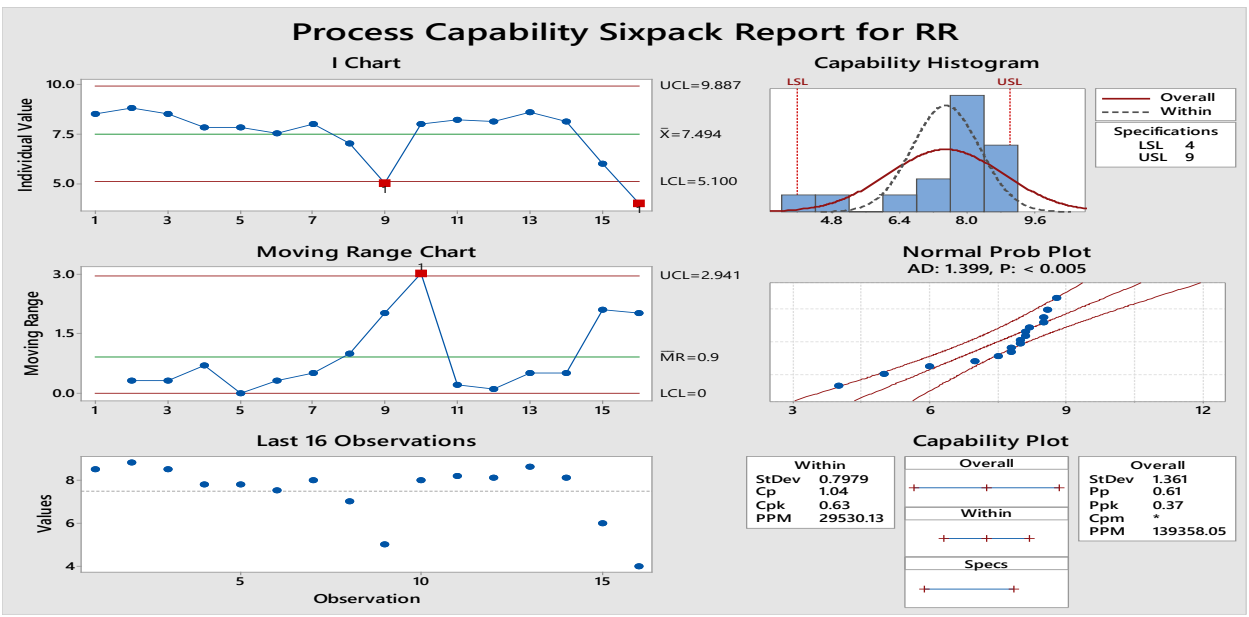

Figure 4: PCR for DHU

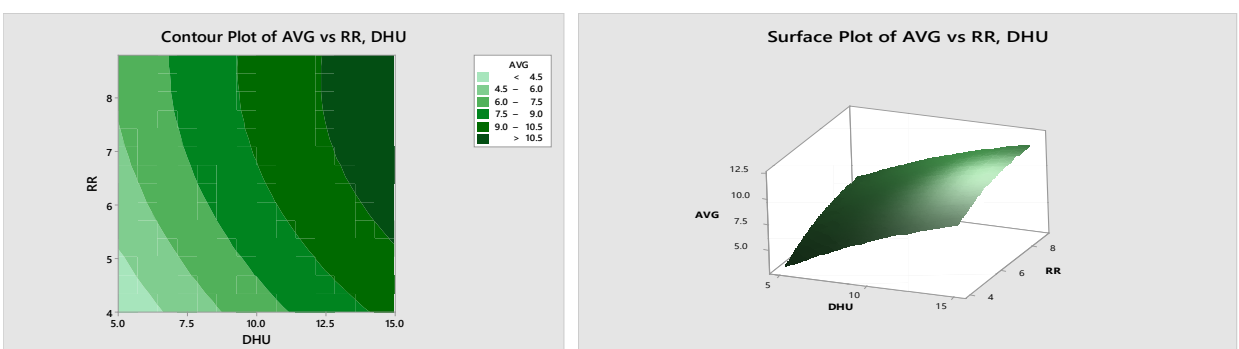

Figure 5: a) Contour plot of RR, DHU b) Surface plot of RR,DHU

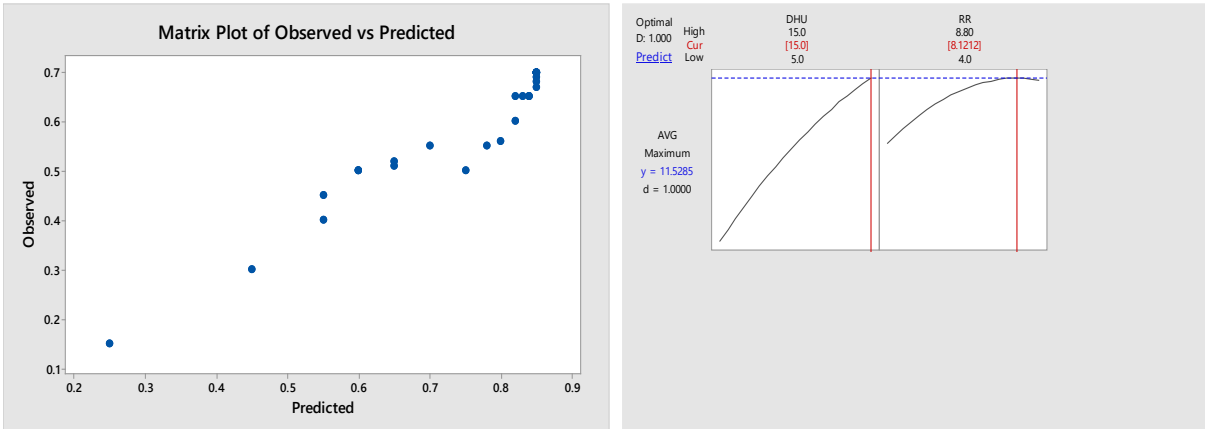

Figure 6 : a) Observed vs Predicted b) Optimal RR ,DHU

$$\hat{C}_p = \frac{USL - LSL}{6\hat{\sigma}} \quad \text{.....(1)}$$

$$\hat{C}_{p,lower} = \frac{\hat{\mu} - LSL}{3\hat{\sigma}} \quad \text{.....(2)}$$

$$\hat{C}_{p,upper} = \frac{USL - \hat{\mu}}{3\hat{\sigma}} \quad \text{.....(3)}$$

If value of μ and σ are estimated to be 8.94 μm and 1.03 μm, respectively, then

Cp = (9.88-5.11)/6*1.03 = 4.77/6.18 =0.7718. (from equation 1)

Cp,lower = (5.94-5.11)/(3*1.03) =0.26(from equation 2)

Cp,upper = (9.88-5.94)/(3*1.03) =1.78(from equation 3)

Date	Plan Qty	Actual qty	Plan Qty	Actual Qty	Plan Qty	Actual Qty	Plan Qty	Actual Qty	Plan Qty	Actual Qty	
7-3	3000	0	2000	0	1400		1260	0	1247	0	
7-4	2000	0	2000	0	1400		1260	0	1247	0	
7-5	3000	0	2000	0	1400		1260	0	1247	0	
7-6	4000	0	2000	0	1400		1260	0	1247	0	
7-7	7000	0	2000	0	1400		1260	0	1247	0	
7-9	1000	0	2000	0	1400		1260	0	1247	0	
7-10	2000	0	2000	0	1400		1260	0	1247	0	
7-11	1500	0	2000	0	1400		1260	0	1247	0	
7-12	1300	0	2000	0	1400		1260	0	1247	0	
7-13	1700	1200	2000	300	1400		1260	0	1247	0	
7-14	1700	5000	2000	500	1400	300	1260		1247		
7-16	1200	1200	2000	500	1400	500	1260	200	1247	0	
7-17	1200	1200	2000	1900	1400	1000	1260	500	1247	0	
7-20	1200	800	2200	1900	1540	1309	1386	1358	1372	1371	
7-21	1200	0	2200	1900	1540	1309	1386	1358	1372	1371	
7-23	1200	800		2000	2000	1700	1800	1764	1782	1780	
7-27	1200	1700		2200	2000	1700	1800	1764	1782	1780	
7-28	1200	1200		2200	2000	1700	1800	1764	1782	1780	
8-8						2800		2000		1800	
8-9								2000		1800	
8-10								2000		1800	
8-11								2000		1800	
8-13											
8-14											Delivere

Table 1 : Delivery Scheduling

	Supplier							
Criteria	1	2	3	4	5	6	7	8
Efficiency	0.79	0.83	0.81	0.75	0.87	0.88	0.7	0.75
On Time Delivery	0.86	0.89	0.87	0.78	0.92	0.93	0.71	0.80
Quality	0.95	0.98	0.82	0.89	0.97	0.99	0.9	0.77

Ethics	0.99	1	1	1	1	0.99	0.85	0.83
Cost	1	2	0	1	2	0	0	0

Table 2: Supplier Selection criteria

Initial Population

1	2	3	4	5	6

Before Cross over

1	2	3	4	5	6

4	5	6	1	2	3

After Cross over

Before Mutation

1	2	3	4	5	6

1	2	3	2	5	6

After Mutation

Figure 7 : Cross over and mutation

Results and Discussions

Figure 1 portrayed the genetic algorithm structure. In this paper, implemented cross over and mutation techniques of the genetic algorithm to right selection of the best supplier in terms of quality, price, cost and some other criteria. Table 1 showed the supply chain status in a leading apparel manufacturing. As per the scheduled, product deemed to start at 7th of July 26, 2019 however practically it commenced a week after due to delay materials supplied by the supplier.Consequently, productionunderway delay and production line was being awaited seven days which cost the factory.Finally, cutting operation started two week later from the plan cut date which chronologically delayed subsequent operation of sewing, finishing,packing. Delivery has been made afterwardtwo weeks and resulting in products had shipped by air.That is why, company paid $27000 as an air freight whereas total earning figure was $65000 for that style and expenseincurred $85000. Hence, factory paid $2000 amount loss for thisstyle.The loss function has been depicted in the figure 8 on the contrary of materials supply interruption.

The fact is that when one style lately commence production the following styles will automatically be hampered and delayed. Figure 2 demonstrated that style 1 supposed to start from 7thJuly and ended in 23th July 26, 2019 and then style 2 would start from 24th July 26, 2019 and end on 3rd august ,2019 which shown by figure 3 and 4. However style 2 could not start on time ,as a result all of the subsequent styles are being delayed .For this reason, right supplier selection is the vital issue in apparel manufacturing organization to make the supply chain optimized.

We have been implemented genetic algorithm to get optimal release of the materials which ensure production start at the timely manner and end with right time delivery. To do so, we have taken 7 suppliers as a testing parameter who supplied resourcesand experimented onto that suppliers to get the optimum outcomes. Initial population declaration, and cross over practice help us to take the right decision to select the right suppliers.Later on, performed mutation analysis to scrutinize the most optimized right supplier selection at the right time described by the figure 5.

In the figure 6 shown the outcomes of the right supplier selection who supplied right product at the right time with right quality.The initial making time as well as final inspection and delivery met due to the properly materials receiving shown in the figure 7. Table 2 exposed accurate supplier selection criteria. Supplier 3,6 ,8 and 7 met all the criteria which expects by the manufacturers to flinch the production on time based on the quality,cost,ethics, and commitment parameters.

Conclusion

Modern supply chain management emphasizes close integration between suppliers andpurchasers. Organizations are striving to have strategic relationships with suppliers. This callsfor a reduction or a rationalization of the number of suppliers. It is then possible to allocate scarce resources to develop relationships with the few chosen suppliers. In the earlier era of transactionalrelationships, it made sense to have as many suppliers as possible in order to find the cheapestdeal. In these days of integrative relationships, reducing the number of suppliers has become oneof the objectives of supplier selection.

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