A HYBRID MULTI CRITERIA DECISION MAKING USING AHP-GRA FOR DISRUPTED INTEGRATED SUPPLY CHAIN

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Abstract

Predicting the customers want and fulfilling their necessities are challengeable task for the present day business gatherings. The perspective of customer towards the purchase moreover changed from on shop getting tied up with on door receipt of the stock. Due to this change in customer behavior and high market competitiveness, the organizations need to be capable of handling any disruptions in their planned schedules. When the disruptions arrive one of the most typical issues is to reschedule without affecting the performance of the organization. Household goods manufacturing unit is considered for our present investigation. The disruption considered in this investigation is order cancellation, raw material delay and return of goods from customer due to various reasons and the performance measure considered is delivery performance, delivery delay and average waiting time. The most effective job sequence and their by priority rule for each disruption is analyzed, in the process a decision on multi criteria by AHP-GRA is also analyzed which has clearly shown that FCFS is the best priority rule to handle the above stated three disruptions and performance measures for the house hold goods manufacturing problem.

Index Terms: Integrated Supply Chain, Hybrid Multi-Criteria Decision, AHP-GRA, Disruptions.

I. INTRODUCTION

The people needs to give cautious thought on the transport execution, movement delay, holding up time of the things, on time transport and demand fulfillment lead time. The changed age timetable should meet the transport affirmation with sensible measure of the demand. Machine discrete, Order wipe out, mastermind prepone, orchestrate put off, surge organize, supply delay, stochastic taking care of time are the basic intrusions looked by gathering systems. Right move rescheduling, impacted operations rescheduling, left move rescheduling are notable rescheduling methodologies which are extensively declared in the compositions. Right and left move rescheduling system can be associated with prepone and put off the viably arranged livelihoods. Dispatching standard enabled rescheduling approaches are comprehensively seen for rescheduling essential initiative at the particular periods of the timetable. Multi criteria fundamental authority in like manner accept critical part to compose the distinctive rescheduling decisions and energize for picking best decision to beat the irregularity raised in light of the hazardous event without haggling the movement ensure.

Rescheduling practices in face of the unsettling influence in house hold items manufacturing industry is shown in this paper. The effect of the rescheduling need leads on the execution measures are analyzed under the event of various dangerous events. Multi criteria essential administration procedure is used to rank particular rescheduling choice and pick the finest other alternative to manage the interference. The present paper is composed in to seven regions. Study of the immovably related composition with case portrayal is displayed moreover deals the examination of the logical investigation. The examination and talk of the result are done up.

II. LITERATURE REVIEW

A rescheduling problem at shop floor base has become limitless thought. Rescheduling issue for the customer driven execution was especially obliged [1]. Thusly, an undertaking has been had to inquire about the effect of the rescheduling need oversees on customer driven execution measures and multi criteria fundamental administration of the rescheduling need control in defy interruption[2].

A rescheduling issue in an unclear parallel machine system to manage the aggravation in light of the entry of patch up, polynomial time figuring is associated with redesign the make navigate and timetable soundness. Numerical examination comes to fruition that the proposed count is suitably dealing with the interference [3].

A two echelon store arrange structure with amassing confinement in two machines for setting different normal time windows, pseudo polynomial dynamic figuring is associated with enhance the advantage, accumulating cost, size of the demand, and transportation cost. Most constrained taking care of time require oversee is taken after for asking for the rough material [4, 5]. The result exhibits that, the pseudo-polynomial estimation satisfactorily forms the stock system at speedier time.

A wide written work consider on the multi criteria fundamental initiative in the single, parallel and stream shop machining structure [6].

They developed a three stage diagram work, the essential sort out focus the progression of a model, the second stage deals criteria assurance and third stage covers the arranging issue and fundamental authority [7].

Problem Description:

A company manufacturing THREE varieties of products on TWO parallel machines where considered for our study. Each product has different order quantities (ABC) with standard inspection time of 20sec per product and packing time of 25sec per product. Order quantities of various orders, their due times and daily number of units of products A, B and C be manufactured were collected.

III. METHODOLOGY

The order quantities of various orders and their due times were shown in the table 1.

Table 1: Order quantities and due times for various orders

Order No.	Order quantity			Due time (Hours)
	Product A	Product B	Product C	
1	960	920	850	116
2	750	500	790	120
3	600	450	550	123
4	575	615	420	127
5	680	520	815	131
6	380	510	510	134
7	680	415	580	137
8	825	720	540	141
9	615	980	435	145
10	625	380	580	148
11	540	590	725	152
12	--	850	320	155
13	75	81	88	160

From the table.1, one can understand that, the firm makes three types of products viz. product A, product B and product C. Also, it can be seen that, the order quantity is varying. It can be noted that, order no.12 is placed for only products B and C and order no.13 is returned goods from after sales service network. The daily number of units of products A, B and C be manufactured is given in the table 2.

Table 2: Daily number of units of products A, B and C

S.No.	Product	Daily number of units manufactured
1	A	600
2	B	650
3	C	700

From the data collected, the processing times of various orders in hours may be computed by the relation

Processing time of order = (Order quantity x 8)/Daily number of units be manufactured

Similarly the standard inspection time and standard packing times are calculated as given below:

Inspection time of order in hours =(Number of units of the order x standard inspection time)/3600

Packaging time of order in hours = (Number of units of the order x standard packaging time)/3600

Similarly, the processing times of other orders, standard inspection time and standard packing time for the considered manufacturing organization were calculated and are shown in table 3.

Based on the timing calculations as shown in the above table the sequence is formulated by using FCFS, SPT, SRT, LPT and LRT priority rules.

Table 3: sequence order for priority rules

Priority rule	Sequence order for		
	Product A	Product B	Product C
FCFS	A1-A2-A3-A4-A5-A6-A7-A8-A9-A10-A11	B1-B2-B3-B4-B5-B6-B7-B8-B9-B10-B11-B12	C1-C2-C3-C4-C5-C6-C7-C8-C9-C10-C11-C12
SPT	A6-A11-A4-A3-A9-A10-A5-A7-A2-A8-A1	B10-B7-B3-B2-B6-B5-B11-B4-B8-B12-B1-B9	C12-C4-C9-C6-C8-C3-C7-C10-C11-C2-C5-C1
LPT	A1-A8-A2-A7-A5-A10-A9-A3-A4-A11-A6.	B9-B1-B12-B8-B4-B11-B5-B6-B2-B3-B7-B10	C1-C5-C2-C11-C10-C7-C3-C8-C6-C9-C4-C12.
LRT	7-11-5-2-3-6-8-4-12-10-9-1		
SRT	1-9-10-12-4-8-6-3-2-5-11-7		

From the historical analysis of the organization the most severe disruptions are: 1) order cancellation 2) raw material delay and 3) return of goods from customer.

AHP divides a complex MCDM problem to a system of hierarchies. It deals with the structure of m x n matrix, where m is the number of alternatives and n is the number of criteria. The matrix may be constructed by using the relative importance of alternatives in terms of each criterion. The method calls for assigning numerical values from 1 to 9 to subjective judgments on the relative importance of each criterion, so as to determine the overall priorities of criteria or alternatives. Eigen vector approach is used to calculate the priorities or weights of the criteria or alternatives for the given pair wise comparison matrix. Grey relational analysis is very much useful when there is a specific concept of information is available. GRA defines the situation with no information as black and those with perfect information as white. The situation in between these two extremes may be termed as grey, i.e. some information is known and some other information is unknown. At the other extreme, a system with perfect information has a unique solution. In the middle, grey systems will give a variety of available solutions. Grey analysis doesn't attempt to find the best solution, but does provide techniques for determining a good solution, an appropriate solution for real world problems.

A. Disruptions Considered is Order cancellation

The pair wise comparison matrix of the priority rules (alternatives) for order cancel disruption may be formed by referring the table 4 and 5.

Table 4: Performance measures for order cancel disruption

Performance measure	LPT	SRT	LRT	SPT	FCFS
Delivery Performance (%)	91.6	91.6	91.6	91.6	100
Delivery Delay (Hours)	7.0	14.7	23.0	26.0	0.0
Waiting Time (Hours)	16	13	22	20	23

The pair wise comparison matrix of priority rules for delivery performance in view of order cancel disruption was tabulated and is shown in table 5.

Table 5: Impact of Order Cancel Disruption

Performance Measure	LPT	SRT	LRT	SPT	FCFS
Delivery Performance (%)	91.6	91.6	91.6	91.6	100
Delivery Delay (Hours)	7.0	14.7	23.0	26.0	0.0
Average waiting time (Hours)	16	13	22	20	23

From the data in table 5, normalized matrix may be formed by summing the values in each column and dividing each value by column sum value. Therefore, the normalized matrix of priority rules for delivery performance for order cancel disruption is tabulated in 6.

Table 6: Pair-wise comparison matrix of priority rules for delivery performance (Order cancel)

Priority rules	LPT	SRT	LRT	SPT	FCFS
LPT	1	1	1	1	0.2
SRT	1	1	1	1	0.2
LRT	1	1	1	1	0.2
SPT	1	1	1	1	0.2
FCFS	5	5	5	5	1
Column Sum	9	9	9	9	1.8

From the data in table 6, normalized matrix may be formed by summing the values in each column and dividing each value by column sum value. Therefore, the normalized matrix of priority rules for delivery performance for order cancel disruption is tabulated in 7.

Table 7: Normalized matrix of priority rules for delivery performance (Order cancel)

Priority rules	LPT	SRT	LRT	SPT	FCFS	Weight
LPT	0.111	0.111	0.111	0.111	0.111	0.111
SRT	0.111	0.111	0.111	0.111	0.111	0.111
LRT	0.111	0.111	0.111	0.111	0.111	0.111
SPT	0.111	0.111	0.111	0.111	0.111	0.111
FCFS	0.555	0.555	0.555	0.555	0.555	0.555
Column Sum	1	1	1	1	1	1

Similarly, pair wise comparison matrix and normalized matrix of the priority rules for the remaining performance measures viz. delivery delay and waiting time have been formed and are tabulated. The pair wise comparison matrix of various priority rules for delivery delay in connection with order cancel disruption is presented in table 8.

Table 8: Normalized matrix of priority rules for delivery delay (Order cancel)

Priority rules	LPT	SRT	LRT	SPT	FCFS	Weight
LPT	0.214	0.314	0.306	0.28	0.185	0.260
SRT	0.070	0.104	0.183	0.2	0.112	0.134
LRT	0.042	0.034	0.061	0.12	0.078	0.067
SPT	0.029	0.020	0.020	0.04	0.061	0.034
FCFS	0.642	0.524	0.428	0.36	0.561	0.503
Column Sum	1	1	1	1	1	1

Table 9: Normalized matrix of priority rules for waiting time (Order cancel)

Priority rules	LPT	SRT	LRT	SPT	FCFS
LPT	0.214	0.185	0.306	0.314	0.28
SRT	0.642	0.561	0.428	0.524	0.36
LRT	0.042	0.078	0.061	0.034	0.12
SPT	0.070	0.112	0.183	0.104	0.2
FCFS	0.029	0.061	0.020	0.020	0.04
Column Sum	1	1	1	1	1

After computing the pair wise comparison matrices for various alternatives (priority rules) in case of order cancel disruption, the same procedure may be followed to compute pair wise and normalized matrices for the criteria and are tabulated as follows, The pair wise comparison matrix of various performance measures in case of order cancel disruption was presented in table 10.

Table 10: Pair-wise comparison matrix for the criteria
(Order cancel)

Performance measure	Delivery Performance	Delivery Delay	Waiting Time
Delivery Performance	1	3	0.2
Delivery Delay	0.33	1	3
Waiting Time	5	0.33	1

Similarly, pair wise comparison matrix and normalized matrix of the priority rules for the remaining performance measures viz. delivery delay and waiting time have been formed and are tabulated. The pair wise comparison matrix of various priority rules for delivery delay in connection with order cancel disruption is presented in table 5.4 which is obtained by referring table 4 and 5.

From the data in table 10, normalized matrix may be formed by summing the values in each column and dividing each value by column sum value. Therefore, the normalized matrix of performance measures (criteria) for order cancel disruption is presented in table 11.

Table 11: Normalized matrix for the criteria (Order cancel)

Performance measure	Delivery Performance	Delivery Delay	Waiting Time	Weights
Delivery Performance	0.157	0.692	0.047	0.30
Delivery Delay	0.052	0.230	0.714	0.33
Waiting Time	0.789	0.076	0.238	0.37

Work out the preference of each priority rule in achieving the goal of hierarchy by using the results from the above steps. The preference may be computed by multiplying the weights of the criteria and priority rules and are presented in table 12.

Table 12: Preference matrix (Order cancel)

Priority rules	Delivery Performance	Delivery Delay	Waiting Time	Weights
LPT	0.033	0.085	0.096	0.215
SRT	0.033	0.044	0.186	0.263
LRT	0.033	0.022	0.024	0.080
SPT	0.033	0.011	0.049	0.094
FCFS	**0.166**	**0.166**	**0.012**	**0.345**

From the preference matrix we can say that, FCFS priority rule is preferred more than SRT and SRT is better than LPT to mitigate order cancel disruption.

Table 13: Preference Matrix (Raw material delay)

Priority rules	Delivery Performance	Delivery Delay	Waiting Time	Weights
LPT	0.010	0.066	0.175	0.252
SRT	0.040	0.029	0.099	0.169
LRT	0.020	0.014	0.052	0.086
SPT	0.078	0.066	0.016	0.161
FCFS	0.151	0.153	0.026	0.330

From the preference matrix given in table 5.19, it can be seen that, FCFS rule is preferred to other rules and LPT rule is ahead of SRT and SPT rules.

Table 14: Preference Matrix (Returned goods)

Priority rules	Delivery Performance	Delivery Delay	Waiting Time	Weights
LPT	0.011	0.022	0.171	0.205
SRT	0.022	0.044	0.074	0.141
LRT	0.046	0.011	0.074	0.132
SPT	0.097	0.085	0.016	0.199
FCFS	0.122	0.166	0.032	0.321

From table 14, FCFS rule is preferred over other rules and LPT is preferred over SPT to absorb returned goods disruption.

APPLICATION OF GRA

The steps followed for carrying out grey analysis to rank the priority rules for various disruptions viz. order cancel, raw material delay and returned goods is presented in this section.

B. GRA for order cancel disruption

For carrying out GRA for order cancel disruption, the normalized response values table may be formed by referring the preference matrix for order cancel disruption as obtained from AHP.

The normalized response values for delivery performance were computed by following the relation, "The higher is the better" and for delivery delay and waiting time were computed by following the relation, " The lower is the better" and is presented in table 15.

The higher is better:

$$X*_i(k) = \frac{X_{i(0)}(k) - \min X_{i(0)}(k)}{\max X_{i(0)}(k) - \min X_{i(0)}(k)}$$

The lower is better：

$$X*_i(k) = \frac{\max X_{i(0)}(k) - X_{i(0)}(k)}{\max X_{i(0)}(k) - \min X_{i(0)}(k)}$$

Where: X * I (k) is the generating value of Grey relational analysis

$\min X_{i(0)}(k)$ is the minimum value of $X_{i(0)}(k)$;

$\max X_{i(0)}(k)$ is the maximum value of $X_{i(0)}(k)$

Table 15: Normalized response values (Order cancel)

Priority Rule	Delivery Performance	Delivery Delay	Waiting Time
LPT	0.519	0.519	0
SRT	0.787	0	0
LRT	0.929	0.929	0
SPT	1	0.787	0
FCFS	0	1	1

The values in table 16 are obtained by subtracting the values obtained in the normalized response table (Referring table 15) from unity. From the above table it can be seen that, the maximum values of the performance measures are one and the minimum values of the same are zero.

Table 16: Unit normalized values (Order cancel)

Priority Rule	Delivery Performance	Delivery Delay	Waiting Time
LPT	0.480	0.480	1
SRT	0.212	1	1
LRT	0.070	0.070	1
SPT	0	0.212	1
FCFS	1	0	0

The grey relational co-efficient €i(k) can be expressed as

$$\notin_i (k) = \frac{(\Delta \min + \zeta \Delta \max)}{\Delta(0)_i + \zeta \Delta \max}$$

Where Δ0i is the deviation sequence, Δ max is the largest value in Δ0i , Δ min is the smallest value in Δ0i and ζ is the distinguishing co-efficient which may be taken as 0.5.

By using the relation, the grey relational co-efficient values were calculated and are presented in table 17.

Table 17: Grey relational co efficient (Order cancel)

Priority Rule	Delivery Performance	Delivery Delay	Waiting Time
LPT	0.509	0.509	0.333
SRT	0.701	0.333	0.333
LRT	0.877	0.877	0.333
SPT	1	0.701	0.333
FCFS	0.333	1	1

Now, the grey relational grade may be computed by calculating the average of performance measures for various priority rules. For example for LPT rule the grey relational grade = (0.509+0.509+0.333) / 3 = 0.45.

Similarly, the same relation was used to compute the grey relational grade for other rules and is tabulated in table 18. Based on the grade, the priority rule is given a rank, which is also presented in table 18.

Table 18: Grey relational grade (Order cancel)

Priority Rule	Grey Relational Grade	Rank
LPT	0.450	5
SRT	0.456	4
LRT	0.695	2
SPT	0.678	3
FCFS	0.777	1

Table 19: Grey relational grade (Raw material delay)

Priority Rule	Grey Relational Grade	Rank
LPT	0.592	4
SRT	0.516	5
LRT	0.633	3
SPT	0.651	2
FCFS	0.741	1

Table 20: Grey relational grade (Returned goods)

Priority Rule	Grey Relational Grade	Rank
LPT	0.561	4
SRT	0.599	3
LRT	0.505	5
SPT	0.627	2
FCFS	0.718	1

From table 20, it can be seen that, FCFS rule is ranked first with highest grey relational grade. Therefore, it may be chosen to handle returned goods disruption.

IV. CONCLUSION

The importance of the work or suggest applications and extensions. From the performance measures evaluated for order cancel disruption the following are evident. FCFS rule has achieved 100 % delivery performance whereas other rules have 91.6 % delivery performance. FCFS rule has zero delivery delay and SPT has highest delay of 26 hours. For waiting time measure SRT has 13 hours as waiting time while FCFS has 23 hours of waiting time which are minimum and maximum values respectively. The performance measures are evaluated for raw material delay disruption. The following were observed. FCFS has highest delivery performance of 100% whereas LPT has least delivery performance with 66.6%. FCFS has resulted in zero delivery delay and LRT has highest delay of 41 hours. LPT has minimum waiting time of 10 hours and SPT has highest waiting time of 28 hours. For returned goods disruption the performance measures were evaluated and the following were observed. FCFS has highest delivery performance of 100% and LPT has least delivery performance with 61.5 %. For delivery delay, FCFS has zero delivery delay whereas LRT has highest delivery delay of 50 hours. LPT has minimum waiting time of 11 hours and SPT has maximum waiting time of 19 hours. The performance measures for various disruptions were calculated and the following are worth noting. Order cancel has highest delivery performance of 93.3% whereas returned goods have a delivery performance of 78.5 %. For delivery delay measure, order cancel has less delay with 14 hours and returned goods have highest delay of 30.6 hours. Returned goods have less waiting time with 14 hours and the other disruptions have 19 hours waiting time. The order cancel disruption has least impact, raw material delay disruption has moderate impact and returned goods disruption has more impact on the production schedule. Among the various priority rules, FCFS rule is more successful to manage the disruptive events in terms of delivery performance and delivery delay. SRT rule has minimum waiting time for handling order cancel, LPT rule has least waiting time for managing the raw material delay and returned goods. Right-Left shift rescheduling method effectively handles disruption by preponing or postponing the jobs in order to minimize the impact of the disruption. AHP was carried out to weight the priority rules and the following were found. In view of order cancel disruption, FCFS has highest weightage of 0.34 and LRT has less weightage of 0.08. For raw material delay disruption, FCFS has highest weightage of 0.33 and LRT has less weightage of 0.08. In case of returned goods disruption, FCFS has maximum weightage of 0.32 and LRT has minimum weightage of 0.13. In the present work, GRA is used to rank various priority rules by calculating grey relational grade and the following were noted. For order cancel disruption FCFS has highest grey relational grade which is 0.77 and LPT has lowest value and is 0.45. In case of returned goods FCFS has 0.74 and SRT has 0.51 which are the highest and lowest values of grey relational grade respectively. In view of returned goods disruption FCFS has highest value of grey relational grade and is 0.71 while LRT has least value which is 0.50. AHP-GRA based multi criteria decision making method is employed to identify the effective priority rule to overcome disruption with optimal performance measures. Analysis of the Grey relational grade shows that, the FCFS priority rule is most suitable for handling the disruptions. AHP- GRA can be used effectively for the rescheduling decision making. Findings are useful for the shop floor managers to overcome the disruption and to meet the delivery commitments.

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