A Simple Multi-Criteria Inventory Classification Approach

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Abstract-Organizations classify inventory for an efficient control that supports managers to make policies to procure, store, handle, manufacture and distribute items accordingly. ABC classification is a well-known technique to classify according to which very important items are in class 'A', moderately important items are in 'B' and relatively unimportant items are in class 'C'. Inventory classification on multiple criteria gives a better control for inventory handling with respect to single criteria classification. On the bases of previous work, it was found that the multi-criteria inventory classification methods are complex to be used by managers with less experience and knowledge. So a simple equal weighted normalized methodology is proposed for multi-criteria inventory classification to help inventory manager of each organization whether small, medium and large. This proposed model is implemented along with an example from literature and compared with previous work. This comparison showed that this model is simple to implement and gives a better classification on multiple criteria.

Keywords-Inventory, Inventory Classification, Model Development, Model Simplification, Inventory Optimization

I. INTRODUCTION

Organizations of all sizes may have inventory items in thousands and more than it. The required resources including finance and time are often inadequate to manage these inventories. To optimize the inventory, it is the most suitable to use available resources according to the importance of inventory items. To control SKUs efficiently, an approach is to classify SKUs into different groups when organization has huge amount of inventory SKUs. Among all inventory control methodsand techniques ABC analysis is the most widely used and ABC analysis is based in Pareto's Principle of 80,20 rule[i-iii]. ABC analysis classifies inventory items in three classes. Highly important itemswith respect to classifying criterion/criteria are usually classified in 'A' class. Items with moderate importance in 'B' class and remaining items in 'C' class. These classes of inventory items require different control levels for each class. In Silver et al work, inventory control policies have been detailed according to classes of inventory items [iv].

Traditionally ABC analysis was based on just single criteria that was annual dollar usage (ADU) of inventory items [v]. However, in addition to this criterion, inventory holding unit cost, obsolescence, certainty of supply, reparability, scarcity, order side requirement, part criticality, average unit cost, substitutability, durability, commonality , demand distribution, length and variability of replenishment lead time, stock ability, number of request per year, mode and cost of transportation and stock-out unit penalty cost may affect the items classification [ii, vi-ix]. ABC analysis is successful only when the inventory being classified is fairly homogeneous and the main difference among the items is in its annual use value. In practices inventory items are not homogeneous. As range of product or customers changes, the need to increase the variety of inventory items also increases. So it has been realized that inventory should be classified on multi-criteria bases because traditional ABC analysis is inefficient for classifying inventory items properly [x-xii].

To classify inventory on multi-criteria, several inventory classification models have been suggested in literature. In classification, there are usually three steps including selection of criteria, selection of alternatives and weight assigning with respect to criteria. It is found in literature that to assign weights to criteria, researchers used subjective judgments or artificial intelligence techniques. Weights on subjective judgment could not be optimistic and it is complex for inventory managers to find weights with the help of artificial intelligence (AI) techniques.

To cover both problems for weight assigning and complexity of previous models depending on AI techniques, a model has been proposed in this work. This model will also help inventory managers which do not have professional knowledge and skills to classify inventory and adopt policies accordingly considering relevant factors for MCIC.

II. LITERATURE REVIEW

Many decision tools of multi criteria inventory classification (MCIC) have been developed in last two decades. Flores et al classification was based on bi-criteria and they proposed cross-tabulate matrix methodology [vii]. But cross-tabulate matrix methodology given by Flores et al becomes complex when it is extended with more criteria. Authors in [xiii] identified that the multi-criteria inventory classification becomes complex when three or more criteria are involved. To group and classify items according to their similarity, multi-variate techniques is a good approach. In Flores et al work a solution procedure is described which blends operations constraints and clustering analysis in [xiv].

Many multi-criteria decision making tool have been proposed in literature to classify inventory as analytical hierarchy process (AHP) was proposed in [xiii, xv]. But AHP limitation is its requirements of subjective judgment when items are compared pair wise. Sophisticated meta-heuristic tool like artificial neural network (ANN), practical swarm optimization and genetic algorithm (GA) have been applied to solve MCIC problem [xii, xvi, xvii]. Yu discussed about application of some other artificial intelligence based classification techniques like k-nearest neighbour algorithm, support vector machines and back propagation networks [xviii].

Research work showed that these meta-heuristic techniques are complex enough to apply and to understand by inventory managers [viii, xix, xx]. Ramanathan developed a weighted linear optimization to solve MCIC problem and his model has similarity to the concept of data envelopment analysis (DEA) [ii].

In Ramanathan model a scalar score is calculated from converting all criteria measures. This scale score is a weighted sum of measures under individual criteria. Weights in Ramanathan model are generated by a DEA-like linear optimization to avoid subjectivity when weights are assigned. The items are grouped on the bases of the generated score to classify in different classes. However a linear optimization is required for each item. When inventory items are in large number as in thousands the processing time for each linear optimizationis very long.

W.L.Ng proposes a novel and easy methodology for classification that does not need a linear optimizer for ABC analysis[viii]. Besides its many advantages, Hadi-Vench [xxi] discusses that he Ng-model leads to a situation where the Ng-index for each item is independent from the obtained weights. Consequently, Hadi-Vench [xxi] improves the Ng-Model and constructs a nonlinear programming model that keeps the impacts of weights when calculating the final indices. The HV-model is solved for each inventory item repeatedly and a different set of weights is obtained for calculating the final index of each item. Both the HV and Ng model need prior assumption on the importance order of criteria which is determined subjectively by the decision maker. It should be noted that when the number of criteria is large, it is an overwhelming task for the decision maker to rank all criteria.

A fuzzy rule based system in multi-criteria classification is discussed in Rezaei and Dowlatshahi [xxii]. In their work, they took account the existing inherent ambiguities in the reasoning process of classification. Bhattacharya, Sarkar, and Mukherjee presented a distance-based multi-criteria consensus framework to classify inventory [xxiii].Their work demonstrate Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) model in inventory classification of a pharmaceutical company. They judged TOPSIS method with analysis of variance and used a simulation model to compare their results with the traditional ABC classification technique.The conclusion of their work shows that constructing fuzzy. Their conclusion is constructing fuzzy models such as fuzzy TOPSIS and neuro-fuzzy hybrid will be helpful when the values of attribute are ambiguous.

Kabir classified inventories into different categories by using a methodology in which fuzzy Delphi method and fuzzy analytic hierarchy process (FAHP) were used. In this work fuzzy Delphi method is used to identify the important criteria and the fuzzy AHP is then used to calculate the relative weights [xxiv].Hadi-Vench and Mohamad ghasemi illustrated an integrated fuzzy analytic hierarchy process-data envelopment analysis (FAHP-DEA) methodology for multi-criteria inventory classification by taking a real case study. FAHP was used to determine the weights of criteria from five levels from very high to very low and DEA was used to determine the values of linguistic term and overall score of each item was aggregated by using simple additive weighting (SAW) [xxv].

Chen et al. presented a case-base distance model for multi-criteria ABC classification [xxvi].Chen et al. used weighted Euclidean distances and quadratic optimization program are used to find preferences and optimal threshold respectively. Their work reduces the number of misclassification and lessens the impact of outliers by improving the multiple classification problem. Chen et al [xxvi] case-based distance model is extended by Ma [xxvii]. Ma developed a two-phase case-based distance methodology for inventory classification for multiple criteria. The proposed model evaluates a set of cases for alternatives classification and improves classification as well as multiple solution problems. Many author like Rezaei and Dowlatshahi [xxii], Bhattacharya, Sarkar, and Mukherjee [xxiii] and Kampen, Akkerman and Donk [xxviii] presented multi-criteria inventory classification in a comprehensive way in their work so interested reader should read their work for more detail in this field.

Teunter, Babai, and Syntetos proposed new criterion of average order quantity for MCIC [xxix]. Stanford and Martin considered constant demand for classification [xxx]. Mohammaditabar, Ghodsypour, and O'Brien integrated model classifies item as well as simultaneously finds the best policy for inventory control. Appropriate solution was found by using simulated annealing technique [xxxi]. An Approach in which classification is done on the bases of loss profit when there is a correlation in loss and profit between inventory items can be seen in Xiao, Zhang, and Kaku work [xxxii].

Many methods in MCIC deals with quantitative criteria and the methods developed for qualitative criteria are just few. Qualitative methods for inventory classification can be found in Flores, Olson, and Dorai [xiv] and Partovi and Burton [xxxiii]. Their method considers both quantitative and qualitative criteria. AHP based methods have some limitations due to its pair wise comparisons and decision maker's subjective judgment. In analysis, AHP technique becomes complex due to increased pair wise comparison when the number of criteria are increased. An optimum solution can be effected by a large matrix due to consistency and decision subjectivity [xix].

Hatefi et al. presented an extension of a linear optimized model based on Cook, Kress, and Seiford data envelopment analysis (DEA) for inventory classification [xxxiv]. Hatefi model is applicable for both quantitative and qualitative criteria at the same time. Lolli et al. introduces a new hybrid method based on the AHP and the K-means algorithm to solve the MCIC problem [xxxv].

Hatefi et al. proposed an alternative optimization-based model in which the composite performance scores of all inventory items are calculated simultaneously via a set of common weights [xx]. In his model no subjective information is required to run the proposed model which is essential in an accurate and fair decision environment.

Although the MCIC is now a well-known research area in operation management and researchers are working in this area. But the problem found is that there is so much gap between research work and its implementation. Small and Medium Enterprises (SME's) managers are unable to use these techniques. So there should be a simple and easy to implement MCIC model which can help these managers to classify their inventory on multiple criteria bases. This MCIC will help SME's managers to make policies accordingly.

The rest of the paper is organized as follows. Model development along with its formulation, solution scheme, illustration of model for acase study of inventory from literature and its comparison with MCIC models in literature. Finally, concluding remarks are given in this paper.

III. MODEL DEVELOPMENT

A. Formulation

To formulate model, it is supposed that inventory has 'Y' number of SKUs that have to classify on 'Z' number of criteria for ABC analysis. 'x_{yz}' will denote the value of inventory item 'y' with respect to 'z' criteria.

where

y=1,2,3,…………,Y

and

z=1,2,3,…………,Z

To simplify all criteria are assumed in a positive relation with the importance of inventory items. Even if there are inversely related criteria, reciprocals of the scores could be used to make them positive criteria. In the proposed model, an equal weighted additive function is used to find normalized score of items which will convert all measurements in a 0-1 scale for all items.

$$\boldsymbol{Score\ (y'th\ item\ w.r.t\ z'th\ criteia) = S_{yz}} = \frac{\boldsymbol{x_{yz} - min_{y=1,2,\ldots,Y}\{x_{yz}\}}}{\boldsymbol{max_{y=1,2,\ldots,Y}\{x_{yz}\} - min_{y=1,2,\ldots,Y}\{x_{yz}\}}} \quad (1)$$

After calculating the sum of normalized score, it may be needed for decision making process to rank the importance of criteria. But in proposed model, it is assumed that all the criteria have equal importance and weight for inventory classification and controlling of inventory items. This assumption will facilitate the inventory classification under multiple criteria for inventory managers with less skills, knowledge and experience.

The sum of item scores for all criteria will be calculated using following iteration.

$$\boldsymbol{S_y = \sum_{y=1}^{Y}\{S_{yz}\}} \quad (2)$$

where, S_y is the sum of transformed score for 'y'th item with respect to multiple criteria 'z'.

To rank the sum of items score

$$\boldsymbol{S_y - S_{(y+1)} \geq 0, y = 1, 2, \ldots, (Y-1)} \quad (3)$$

After ranking in the descending order, the classification will be done of Vilfredo Pareto rule [i]. On the bases of Pareto rule of (20, 30, 50) will be applied on of ranked S_y [i]. Top ranked 20% items of inventory will be ranked in 'A' class and lower ranked 50% items will be in 'C' class while remaining 30% in between of these classes will be in 'B' class.

B. Solution Scheme

1) Guidelines to Classify Inventory for Proposed Model

i) Collection of Data for 'Y' items with respect to 'X' criteria

In this step an inventory manager will finalized the factors for classification already have been described in literature review. After the selection of considerable criteria, the data of items for criteria will be collected.

ii) *Transforming the Items data in score of (0-1)*
The items data will be transformed for inventory items under each criterion by using Eq. (1). This scoring will be done for each criterion for each item.

iii) *Calculating the sum of scores under each criterion for each item*
After scoring each items for each criterion the sum of scores under each criterion will be calculated for '***Y***' items using Eq. (2). Sorting and Ranking of items with respect to sum of scores of items

iv) *Sorting and Ranking of items with respect to sum of scores of items*
The items will be sorted and ranked in descending order with respect to the sum of scores of items by using Eq. (3).

v) *Assigning Classes to Inventory Items*
The inventory items sorted and ranked in above 20% of total items will be assigned '**A**' class, 21%-50% of items will be assigned '**B**' class and remaining 50% items will be in 'C' class.

C. Illustration of proposed model

The base of data and the criteria for the implementation of model is described above. To implement this model MS Excel Spread Sheet has been employed. These minimum and maximum values aid in the transformation of score for each criterion. The transformed scores for each item w.r.t. each criterion are calculated using Eq.(1).

1) Steps in Model Implementation for Inventory Classification

To implement proposed model for a small enterprise inventory classification, the given below steps are followed.

i) *Collection of Data for 'I' items with respect to 'J' criteria*
As it is discussed in guidelines that first steps is to finalize criteria for inventory classification. For this classification, the criteria considered are Annual Rupee Usage (ARU), Average Unit Cost (AUC) and Lead Time (LT). After criteria finalization, data of inventory items according to these criteria is collected and extracted from purchase order, procurement list, invoices etc. This was a relatively wearisome step and it took a lot of time. But it may be easy for those enterprises which are keeping their inventory records proper and update.

ii) *Transforming the Items data in score of (0-1)*
After collecting necessary information for each item under each criteria, the minimum and maximum value of items in each criteria are calculated. These minimum and maximum values are used to transformed item data in 'x' value where 'x' is equal to 0 or 1 in in between of 0 and 1. This transformed score normalizes the items data. To calculate the transformed score for Annual rupee usage, minimum and maximum values are calculated which are 25.38 and 5840.64 respectively. The transformed score of item no. 1 which Annual rupee usage is 5840.64 is calculated as

Transformed Annual Rupee Usage score of Item no. 1

$$= \frac{(5840.64 - 25.38)}{(5840.64 - 25.38)}$$

$$= \frac{5815.26}{5815.26}$$

$$= 1.00$$

To calculate the transformed score for Average Unit Cost, minimum and maximum values are calculated which are 5.12 and 210 respectively. The transformed score of item no. 1 which Average Unit Cost usage is 49.92 is calculated as

Transformed Average Unit Cost score of Item no. 1

$$= \frac{(49.92 - 5.12)}{(210 - 5.12)}$$

$$= \frac{44.8}{204.88}$$

$$= 0.22$$

To calculate the transformed Lead Time score, minimum and maximum values are calculated which are 1 and 7 days respectively. The transformed score of item no. 1 which Lead Time is 1 is calculated as

Transformed Lead Time score of Item no. 1

$$= \frac{(2 - 1)}{(7 - 1)}$$

$$= \frac{1}{6}$$

$$= 0.17$$

This transformation of values for all inventory items has been calculated in a similar way as described above.

iii) *Calculating the sum of scores under each criterion for each item*

After scoring each items for each criterion the sum of scores under each criterion will be calculated for '*i*' items using Eq. (2). Sorting and Ranking of items with respect to sum of scores of items.

sum of scores for Item no. 1 = 1.00 + 0.22 + 0.17 = 1.39

The sum of score for all inventory items has been calculated in a similar way described above.

iv) *Sorting and Ranking of items with respect to sum of scores of items*

The items are ranked according to the sum of score if inventory items in a descending order. The item ranked 1 will have high sum of score than the item at ranking 2.

v) *Assigning a Class*

After the ranking of inventory items 20% of top ranked inventory items have been assigned 'A' class, 50% of bottom ranked have been assigned 'C' and remaining 30% have been assigned 'B' class. After this inventory data is ready to make policies for purchase and inventory control policies. Manager can make policies and implement according to the item class.

After calculating the transformed score, the sum of score is calculated and listed in a column 'Sum of Scores' in descending order. Classification percentages for A, B and C classes are similar to Reid ABC principle to compare results [v]. Table I illustrates proposed model with a case study of 47 items taken by Reid [v].

TABLE I
PROPOSED MCIC MODEL ILLUSTRATION

	Raw Data			Transformed					
Item No. [v]	Annual Dollar Usage [v, viii]	Average Unit Cost [viii]	Lead Time [viii]	Annual Dollar Usage	Average Unit Cost	Lead Time	Sum of Score	Item Rank	Proposed Model
2	5670	210	5	0.97	1.00	0.67	2.64	1	A
29	268.68	134.34	7	0.04	0.63	1.00	1.67	2	A
10	2407.5	160.5	4	0.41	0.76	0.50	1.67	3	A
9	2423.52	73.44	6	0.41	0.33	0.83	1.58	4	A
13	1038	86.5	7	0.17	0.40	1.00	1.57	5	A
3	5037.12	23.76	4	0.86	0.09	0.50	1.45	6	A
1	5840.64	49.92	2	1.00	0.22	0.17	1.39	7	A
14	883.2	110.4	5	0.15	0.51	0.67	1.33	8	A
28	313.6	78.4	6	0.05	0.36	0.83	1.24	9	A
8	2640	55	4	0.45	0.24	0.50	1.19	10	A
5	3478.8	57.98	3	0.59	0.26	0.33	1.19	11	B
18	594	49.5	6	0.10	0.22	0.83	1.15	12	B
45	34.4	34.4	7	0.00	0.14	1.00	1.14	13	B
40	103.36	51.68	6	0.01	0.23	0.83	1.07	14	B
34	190.89	7.07	7	0.03	0.01	1.00	1.04	15	B
31	216	72	5	0.03	0.33	0.67	1.03	16	B
23	432.5	86.5	4	0.07	0.40	0.50	0.97	17	B
19	570	47.5	5	0.09	0.21	0.67	0.97	18	B
6	2936.67	31.24	3	0.50	0.13	0.33	0.96	19	B
39	119.2	59.6	5	0.02	0.27	0.67	0.95	20	B
7	2820	28.2	3	0.48	0.11	0.33	0.93	21	B
4	4769.56	27.73	1	0.82	0.11	0.00	0.93	22	B
12	1043.5	20.87	5	0.18	0.08	0.67	0.92	23	B
33	197.92	49.48	5	0.03	0.22	0.67	0.91	24	B
22	455	65	4	0.07	0.29	0.50	0.87	25	C
20	467.6	58.45	4	0.08	0.26	0.50	0.84	26	C
37	150	30	5	0.02	0.12	0.67	0.81	27	C
15	854.4	71.2	3	0.14	0.32	0.33	0.80	28	C
43	59.78	29.89	5	0.01	0.12	0.67	0.79	29	C
47	25.38	8.46	5	0.00	0.02	0.67	0.68	30	C
21	463.6	24.4	4	0.08	0.09	0.50	0.67	31	C
17	703.68	14.66	4	0.12	0.05	0.50	0.66	32	C

16	810	45	3	0.13	0.19	0.33	0.66	33	C
38	134.8	67.4	3	0.02	0.30	0.33	0.66	34	C
35	181.8	60.6	3	0.03	0.27	0.33	0.63	35	C
44	48.3	48.3	3	0.00	0.21	0.33	0.55	36	C
24	398.4	33.2	3	0.06	0.14	0.33	0.53	37	C
36	163.28	40.82	3	0.02	0.17	0.33	0.53	38	C
26	338.4	33.84	3	0.05	0.14	0.33	0.53	39	C
46	28.8	28.8	3	0.00	0.12	0.33	0.45	40	C
27	336.12	84.03	1	0.05	0.39	0.00	0.44	41	C
32	212.08	53.02	2	0.03	0.23	0.17	0.43	42	C
11	1075.2	5.12	2	0.18	0.00	0.17	0.35	43	C
42	75.4	37.7	2	0.01	0.16	0.17	0.33	44	C
30	224	56	1	0.03	0.25	0.00	0.28	45	C
41	79.2	19.8	2	0.01	0.07	0.17	0.25	46	C
25	370.5	37.05	1	0.06	0.16	0.00	0.22	47	C
Minimum	25.38	5.12	1	0	0	0	0.215	1	
Maximum	5840.64	210	7	1	1	1	2.637	47	

IV. Comparison of Proposed Model with Previous Work

When it was compared with proposed model with all MCIC Models developed up till now [ii, viii, xiii, xxi, xxxvi, xxxvii] and which are discussed in Hatefi [xx], it was found that only 3 items (Item no 2, 3 and 9) are classified as Class A items among all MICIC models. There is only one item (Item no 19) which has been commonly classified in class B by all MCIC models and only 12 items coincides in class C by all MCIC models. It is also found that all models including proposed model in this study have different classification for these 47 items and no coincidence of these models have been found for all items. This comparison also clear that the items classified with proposed model have a different model and algorithm among these all multi-criteria inventory classification.

TABLE II
COMPARISON OF DEVELOPED MCIC ABC MODELS

	ABC Classification Models							
Item # [v]	Hatefi [xx]	Chen [xxxvi]	ZF [xxxvii]	R [ii]	HV [xxi]	NG [viii]	Reid [v]	Proposed Model
2	A	A	A	A	A	A	A	A
29	A	A	A	A	A	A	C	A
10	A	A	A	B	A	A	A	A
9	A	A	A	A	A	A	A	A
13	A	A	A	A	A	A	B	A
3	A	A	A	A	A	A	A	A
1	B	A	A	A	A	A	A	A
14	A	A	A	B	A	B	B	A
28	A	A	A	A	B	B	C	A
8	B	A	B	B	B	B	A	A
5	B	B	B	B	A	A	A	B
18	A	B	A	A	B	B	B	B
45	A	B	B	A	B	B	C	B
40	B	B	B	B	B	B	C	B
34	B	C	B	A	B	B	C	B
31	B	B	B	B	B	B	C	B
23	B	B	B	C	B	B	B	B
19	B	B	B	B	B	B	B	B
6	C	B	C	C	B	A	A	B
39	B	B	B	B	B	B	C	B
7	C	B	C	C	B	B	A	B
4	C	B	C	B	A	A	A	B
12	B	C	B	B	B	B	B	B
33	B	B	B	B	B	B	C	B
22	B	B	B	C	C	C	B	C
20	B	C	B	C	C	C	B	C

37	C	C	B	B	C	C	C	C
15	B	B	C	C	C	C	B	C
43	C	C	C	B	C	C	C	C
47	C	C	C	B	C	C	C	C
21	C	C	C	C	C	C	B	C
17	C	C	C	C	C	C	B	C
16	C	C	C	C	C	C	B	C
38	C	C	C	C	C	C	C	C
35	C	C	C	C	C	C	C	C
44	C	C	C	C	C	C	C	C
24	C	C	C	C	C	C	B	C
36	C	C	C	C	C	C	C	C
26	C	C	C	C	C	C	C	C
46	C	C	C	C	C	C	C	C
27	C	C	C	C	C	C	C	C
32	C	C	C	C	C	C	C	C
11	C	C	C	C	C	C	B	C
42	C	C	C	C	C	C	C	C
30	C	C	C	C	C	C	C	C
41	C	C	C	C	C	C	C	C
25	C	C	C	C	C	C	C	C

V. RESULTS & DISCUSSION

The multi-criteria inventory classification of proposed model is more effective due to its simplicity in the understanding of inventory managers of all organization especially for small and medium enterprises (SME's). This model is very simple in the comparison of previous work of inventory classification. Previous multi-criteria inventory classification models are complex ones due to the weights assigning to different factors with complex techniques which are difficult to learn for inventory managers with less skills, knowledge and experience. This weight assignment is mostly subjective in previous multi-criteria inventory classification models which cannot give accurate classification of items on these weights. But proposed model considers all weights equally due to importance of all classifying factor and part in inventory management and control for enterprise operations in production and services.

VI. CONCLUSIONS

In this paper, a simple equal weighted normalized model is proposed to classify inventory on the bases of multiple criteria. This model is based upon Ng model to make inventory classification more simple and easy to use for inventory manager of all type of organization and with some basic knowledge of inventory management. In this model, a transformation function is used to transform the item scores in a normalized score. Then items are ranked and classified on the bases of the score sum of inventory item. After the proposition of MCIC model, guidelines are given to classify inventory on multiple factors. The illustration and comparison of this model for a case study from the literature is given to check the validity of this model. The limitation of this model is that it equally ranks the criteria for inventory classification which is also an advantage to consider all the criteria under consideration for classification on equal bases. Because the ranking of criteria on the bases of different factor is either subjective or complex when AI techniques are considered to rank criteria.

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Authorship and Contribution Declaration

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2	Salman Hussain (2nd Author)	Data Analysis, Manuscript writing, Model Development	
3	Mirza Jahanzaib (3rd Author)	Assisted in overall model development during supervision and indeed quality work etc.	
4	Wasim Ahmad (4th Author)	Literature Review, Manuscript writing, Quality insurer	
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