Multi-Criteria ABC Inventory Classification- A Case of Vehicles Spare Parts Items

Makram Ben Jeddou
Institut Supérieur des Etudes Technologiques de Radès, Tunisie
Email: Makram.benjeddou@isetr.rnu.tn

***Abstract*—The ABC classification of inventory items splits them into three different classes to which we will assign specific monitoring and control rules. The usual ABC classification is based on a single criterion, namely the value of annual use. Single criterion classification can also be done according to other criteria but considered separately. However, the inventory managers need more than one factor to take into account simultaneously in classification. Several models in literature have focused on multi-criteria classification. This article is based on Ng model to elaborate a multi-criteria classification of stocks in a company in the field of vehicle spare parts wholesale. A comparison was made with the traditional single criterion ABC classification.**

***Index Terms*—multi-criteria classification, ABC classification, NG model.**

I. Introduction

Companies often manage a large number of items in stock. It is difficult to give them the same level of control and monitoring. For this purpose the inventory managers are expected to split their stocks in several categories in order to establish priorities and specific management rules to each category. In this context, the ABC classification is one of the most used items segmentation methods. This hierarchy into three classes is based on the Pareto principle. Under this approach, the class A is composed of 10 to 20% of the items that are between 70 and 80 % of the value of total annual use. The articles of this class are very important and must be managed and monitored carefully. The second class B includes between 30 and 40% of all items representing 15-20 % of the value of total annual use. Control sections of this class can be a less flexible than the previous category. Finally, the class C may contain up to 50 % of items in stock, but only 5 to 10% of the value of total annual use. Control standards and monitoring may be reduced for the last category of items.

In addition, inventory managers often need to consider, simultaneously, many criteria in the classification of stocks such as the unit price, delivery time, the criticality of the article, the number of orders, number of clients interested by the item ... etc .

II. Literature Review

Several models [1] have been presented in literature for multi-criteria inventory classification (MCIC). We will focus more on linear and nonlinear optimization models.

Ramanathan [2], in 2006 proposed a model for the MCIC noted as the R model. The latter uses a weighed additive function to calculate a score called optimal score, for each item i, $\forall\, i = 1, \ldots, n$, according to different criteria j, $\forall\, j = 1, \ldots\ldots J$. The weights w_{ij} of y_{ij} values (evaluation of item i on criterion j) are identified by solving, for all items, a linear optimization model. This model is shown below:

$$S_{\mathrm{i}} = Max \sum_{j=1}^{J} w_{ij} y_{ij}$$

Subject to:

$$\sum_{j=1}^{J} w_{ij} y_{nj} \le 1\ , \qquad n = 1,2,\ldots,N$$

$$w_{ij} \ge 0, \qquad j = 1,2,\ldots,J$$

To get the optimal score for each article, the R model should be solved by repeatedly changing each time the objective function. These scores can then be used to classify items into three categories A, B and C.

Zhou & Fan [3] proposed in 2007 another model for MCIC noted ZF model. It uses a different approach for calculating the score. Indeed, this model uses two sets of weights that are most favorable and less favorable weight for each item. Assume that R model provides the maximum possible score for each item i noted G_i (Good index). G_i is generated using the most favorable element i weight because they derive from a maximization function. By analogy the ZF model provides the minimum score for each element i noted B_i (Bad index) based on the least favorable weight. These weights are obtained by a linear optimization model with an objective function to minimize. The new final score of an article will combine the corresponding G_i and B_i scores. The ZF model is formulated as follows:

$$G_i = Max \sum_{j=1}^{J} w_{ij} y_{ij}$$

Subject to:

$$\sum_{j=1}^{J} w_{ij} y_{ij} \le 1\ , \qquad i = 1,2,\ldots,N$$

Manuscript received October 25, 2013; revised January 21, 2014

doi: 10.12720/joams.2.3.181-185

$$w_{ij} \geq 0, \qquad j = 1,2, \dots, J$$

$$B_i = Min \sum_{j=1}^{J} w_{ij} y_{ij} \ ,$$

Subject to:

$$\sum_{j=1}^{J} w_{ij} y_{ij} \geq 1 \ , \qquad i = 1,2, \dots, N$$

$$w_{ij} \geq 0, \qquad j = 1,2, \dots, J$$

Therefore, the final score of each element i is obtained by combining the two extreme scores G_i and B_i. It is formulated as follows:

$$S_i = \lambda . \frac{G_i - G^-}{G^* - G^-} + (1 - \lambda) . \frac{B_i - B^-}{B^* - B^-}$$

with :

$$G^* = Max\,\{G_i,\ i = 1,2, \dots ,N\},$$

$$G^- = Min\,\{G_i,\ i = 1,2, \dots ,N\},$$

$$B^* = Max\,\{B_i,\ i = 1,2, \dots,N\},$$

$$B^- = Min\,\{B_i,\ i = 1,2, \dots, N\},$$

$0 \leq \lambda \leq 1$ is a control parameter that can reflect the preference of the decision maker for G_i and B_i.

The obtained scores will then be used to classify items into three categories A, B and C.

Ng [4] presented in 2007 a new model for MCIC. It retains the objective function of the model R, but introduces other constraints. Ng model assumes that the criteria are ranked in descending order of importance. This is reflected in the relationship between the weights of criteria: $w_{i1} \geq w_{i2} \geq \dots \geq w_{ij}$ and for any item i. A linear optimization model is constructed for each item i.

$$Max \sum_{j=1}^{J} w_{ij} y_{ij} \ ,$$

Subject to:

$$\sum_{j=1}^{J} w_{ij} = 1 \ ,$$

$$w_{ij} - w_{i(j+1)} \geq 0, \qquad j = 1,2, \dots, (J-1)$$

$$w_{ij} \geq 0, \qquad j = 1,2, \dots, J$$

Then, this model has undergone many changes to result in a simpler model that can be solved without using a solver of a linear program.

$$Min \quad z_i = Max \ \tfrac{1}{j} * x_{ij}$$

Subject to :

$$z_i \geq \frac{1}{j} x_{ij}, \qquad j = 1,2, \dots, J$$

$$with \ \ x_{ij} = \textstyle\sum_{k=1}^{j} y_{ik}, \ \ i = 1, 2, \dots N$$

Then, the ABC multi-criteria classification will be based on the scores calculated for each item.

In 2010, Hadi-Vencheh [5] proposed a new variant of Ng model considering the weights of factors in quadratic form. Thus, in the proposed model noted H model, we find the same logic Ng model with the exception of the constraint on the sum of the weight factors $\sum_{j=1}^{J} w_{ij} = 1$ which was replaced by a squared sum of weight factors of $\sum_{j=1}^{J} w^2{}_{ij} = 1$. The H model, which is a non-linear optimization model, is as follows:

$$Max \sum_{j=1}^{J} w_{ij} y_{ij}$$

Subject to

$$\sum_{j=1}^{J} w^2{}_{ij} = 1$$

$$w_{ij} \geq w_{i(j+1)} \geq 0, \quad j = 1,2, \dots, (J-1)$$

$$w_{ij} \geq 0, \quad j = 1,2, \dots, J$$

In 2011, Chen [6] proposed a peer-estimation model for multiple criteria ABC inventory classification. The approach is based on five steps of calculation procedures and optimization. The performance of each inventory item is estimated by criteria weights not only most favorable and least favorable itself but also to its peers. The proposed approach determines two common sets of criteria weights for the performance estimation of all items in the most favorable and least favorable senses. The resulting two performance scores in both senses are aggregated by weight coefficients derived from using the maximizing deviations method.

In this article, we will focus on multi-criteria inventory classification of a wholesale company specialized in vehicles spare parts.

III. Multicriteria Classification Case

The company “Société Tunisienne d’Equipement” (STEQ) sells several type and range of vehicles spare parts. It monitors regularly its inventory for each family of products. Given the number of references to manage, the company has adopted the method of traditional ABC classification. The latter is a single criterion ranking of stocks using the annual use value (AUV) as only criteria. This unique criteria classification gives little satisfaction but remains insufficient. In fact, the company would like to integrate in the classification of articles, other criteria such as the profit margin (PM), the annual number of orders (NO) and the number of clients (NC) who bought the article.

The company also wants to incorporate a significant effect on each criterion. Thus the criterion of annual use value would be more important than the gross margin that is more important than the annual number of orders which is more important than the number of clients interested by the article. This need of a multi-criteria classification and a consideration of an order of importance pushed us to use the Ng model for this classification.

In the following, we will apply the Ng model for multi-criteria classification of one spare part's family that contains 110 items. For a comparison purpose, first, we will carry out a single criterion ABC classification according to annual use value. Then, we will compare the obtained results with those of the multi-criteria classification according to Ng model.

For this comparison, we will fix for both classifications, the percentage of articles belonging to each class. Hence, for class A, 20% (or 22 items), class B 30% (33 items) and class C 50% (55 items).

IV. Results

The results of both classifications are summarized in the table below (Table I):

TABLE I. ABC Single and Multicriteria Classifications

	Criteria					ABC Classification	
Item	AUV	PM	NO	NC	Ng score	Multi-criteria	Single criteria
A1	80 325	19%	234	96	1,00	A	A
A2	64 204	24%	293	109	0,78	A	A
A3	53 970	26%	456	147	0,65	A	A
A4	53 507	19%	165	75	0,64	A	A
A5	51 014	23%	151	76	0,61	A	A
A6	49 570	24%	395	138	0,59	A	A
A7	46 282	27%	561	252	0,67	A	A
A8	43 432	27%	350	137	0,50	A	A
A9	43 385	17%	34	14	0,50	A	A
A10	42 319	18%	203	97	0,49	A	A
A11	37 547	24%	197	89	0,43	A	A
A12	33 505	15%	26	12	0,37	A	A
A13	31 269	24%	273	91	0,34	A	A
A14	30 471	23%	174	87	0,33	A	A
A15	26 751	27%	368	198	0,46	A	A
A16	25 463	22%	112	50	0,26	A	A
A17	25 074	18%	39	17	0,26	A	A
A18	22 260	23%	149	73	0,22	B	A
A19	22 155	23%	133	72	0,22	B	A
A20	21 649	24%	215	73	0,25	A	A
A21	21 522	23%	133	68	0,21	B	A
A22	21 506	21%	169	82	0,22	B	A
A23	20 979	23%	121	65	0,20	B	B
A24	20 779	14%	33	11	0,20	B	B
A25	20 534	23%	140	66	0,20	B	B
A26	19 800	25%	176	92	0,24	B	B
A27	19 524	28%	230	131	0,31	A	B
A28	19 314	27%	142	78	0,22	B	B
A29	18 481	25%	230	76	0,25	A	B
A30	18 460	26%	176	80	0,23	B	B
A31	18 145	23%	89	42	0,17	B	B
A32	18 065	23%	86	50	0,16	B	B
A33	17 765	14%	12	10	0,16	B	B
A34	17 248	14%	25	13	0,15	B	B
A35	16 749	23%	125	75	0,19	B	B
A36	16 676	20%	67	38	0,15	B	B
A37	14 912	23%	85	42	0,13	B	B
A38	14 823	21%	72	43	0,12	B	B
A39	14 712	23%	68	36	0,12	B	B
A40	14 111	23%	50	29	0,11	C	B
A41	13 648	27%	110	61	0,17	B	B
A42	13 507	26%	159	80	0,20	B	B
A43	13 461	26%	58	35	0,12	B	B
A44	13 361	19%	18	10	0,10	C	B
A45	13 088	23%	89	39	0,12	B	B
A46	12 751	20%	23	10	0,09	C	B
A47	11 859	25%	142	80	0,19	B	B
A48	11 845	23%	6	3	0,09	C	B
A49	11 801	23%	40	27	0,09	C	B
A50	11 584	18%	40	23	0,08	C	B
A51	11 370	15%	13	11	0,07	C	B
A52	11 346	24%	108	58	0,15	B	B
A53	10 851	22%	61	42	0,10	C	B
A54	10 782	17%	7	5	0,07	C	B
A55	10 627	24%	106	64	0,15	B	B
A56	10 501	24%	15	9	0,08	C	C
A57	10 358	23%	62	45	0,11	C	C

A58	10 262	23%	75	47	0,12	C	C
A59	10 154	23%	67	46	0,11	C	C
A60	10 039	23%	56	42	0,10	C	C
A61	9 896	15%	14	11	0,05	C	C
A62	9 888	27%	172	75	0,20	B	C
A63	9 868	24%	60	35	0,10	C	C
A64	9 844	23%	48	29	0,08	C	C
A65	9 764	23%	32	23	0,08	C	C
A66	9 716	22%	54	30	0,08	C	C
A67	9 639	31%	154	89	0,21	B	C
A68	9 587	23%	64	39	0,10	C	C
A69	9 544	29%	65	34	0,11	C	C
A70	9 534	23%	30	23	0,08	C	C
A71	9 308	23%	28	14	0,07	C	C
A72	9 217	22%	44	35	0,08	C	C
A73	9 187	20%	55	28	0,07	C	C
A74	9 100	23%	136	73	0,16	B	C
A75	8 939	22%	63	35	0,09	C	C
A76	8 908	21%	53	27	0,07	C	C
A77	8 809	22%	45	30	0,08	C	C
A78	8 775	23%	25	16	0,07	C	C
A79	8 766	20%	27	13	0,05	C	C
A80	8 530	22%	29	21	0,06	C	C
A81	8 492	17%	7	5	0,04	C	C
A82	8 207	23%	48	32	0,08	C	C
A83	8 005	24%	87	48	0,12	B	C
A84	7 872	23%	22	13	0,06	C	C
A85	7 859	19%	37	24	0,06	C	C
A86	7 727	19%	50	33	0,07	C	C
A87	7 593	17%	7	7	0,03	C	C
A88	7 592	17%	14	9	0,03	C	C
A89	7 540	22%	39	28	0,07	C	C
A90	7 539	26%	160	68	0,17	B	C
A91	7 532	32%	103	52	0,15	B	C
A92	7 403	23%	25	15	0,06	C	C
A93	7 393	23%	37	25	0,07	C	C
A94	7 389	20%	25	25	0,05	C	C
A95	7 384	24%	34	20	0,07	C	C
A96	7 311	21%	83	50	0,11	C	C
A97	6 831	24%	26	16	0,06	C	C
A98	6 789	23%	51	31	0,08	C	C
A99	6 703	22%	24	12	0,05	C	C
A100	6 622	19%	36	26	0,05	C	C
A101	6 571	15%	150	88	0,16	B	C
A102	6 563	21%	44	33	0,07	C	C
A103	6 530	18%	29	17	0,04	C	C
A104	6 467	24%	46	29	0,07	C	C
A105	6 396	23%	39	21	0,06	C	C
A106	6 286	28%	88	38	0,11	C	C
A107	6 260	15%	14	9	0,01	C	C
A108	6 243	27%	69	32	0,09	C	C
A109	6 228	28%	102	55	0,13	B	C
A110	5 803	104%	28	20	0,50	A	C

The similarity between the single and multi-criteria ABC classification is 78%. However, this hides differences in each class. In fact, the percentage of items identically classified by both methods in class A is 82%. This rate is only 67% in class B and rises to 84% for items of class C.

The differences between the two classifications must be analyzed for each class. The rate of discordance between the traditional ABC classification and the multi-criteria is 22%. This rate shows disparities between classes: 18% for class A, 33% for class B and 16% for the class C.

The four items A18, A19, A21 and A22 belonging to class A in the traditional classification were demoted in class B in the multi-criteria classification. This dumping down is due to a lower relative appreciation in the three new classification criteria.

Items A27 and A28 were promoted from Class B to Class A because of their relatively good profit margin. Nine items (A40, A44, A46, A48, A49, A50, A51, A53 and A54) were demoted in class C due to poor performance on the additional criteria used in the classification.

Finally 8 items, belonging in the single criterion classification to class C, were housed in Class B in the classification. Article A110 had the best upgrade from Class C to Class A thanks to its high profit margin.

V. Conclusion

This new multi-criteria inventory classification helped establishing a new rule of importance hierarchy in terms of monitoring and inventory control. Indeed, articles underestimated by the former classification, were better ranked by the Ng model. In contrast, references having a high value of annual use, have been downgraded because of their weakest performance upon the additional criteria. This will help the inventory manager to allocate his efforts better, in monitoring and inventory control.

This methodology of the inventory multi-criteria classification remains flexible through either the change of the classification criteria, or the integration of other new criteria according to the needs of each manager.

REFERENCES

[1] A. Kontis and V. Vrysagotis, "A literature review of multi-criteria approaches based on DEA," *Advances in Mangement and Applied Economics*, vol. 1, no. 2, pp. 207-219, 2011.

[2] R. Ramanathan, "ABC inventory classification with multiple-criteria using weighted linear optimization," *Computers and Operations Research*, no. 33, pp. 695-700, 2006.

[3] P. Zhou and L. Fan, "A note on multi-criteria ABC inventory classification using weighted linear optimization," *European Journal of Operational Research*, no. 182, pp. 1488-1491, 2007.

[4] L.W. Ng, "A simple classifier for multiple criteria ABC analysis," *European Journal of Operational Research*, no. 177, pp. 344-353, 2007.

[5] A. Hadi-Vencheh, "An improvement to multiple criteria ABC inventory classification," *European Journal of Operational Research*, no. 201, pp. 962-965, 2010.

[6] J. Chen, "Peer-estimation for multiple criteria ABC inventory classification," *Computers and Operations Research*, no. 38, pp 1784-1791, 2011.

Makram Ben Jeddou was born in Tunis, Tunisia, in March 18, 1972.
He got Bachelor in Business and Management at IHEC University, Carthage, Tunisia, 1994; Master in Management and Statistics at ESC university, Tunis, Tunisia, 1996; Aggregation in Management and Statistics, Tunis, 1997. He has been with Higher Institute of Technological Studies, Rades Tunisia since 1997. He works mainly on clustering, multi-criteria classification and their application in management.