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INVENTORY CLASSIFICATION WITH ABC ANALYSIS

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Abstract

For a substantial organization, managing the expansive inventory is a serious problem. One of the methods to solve this problem used widely is classifying the inventory according to some criteria and managing inventory according to this classisifation. In this study, ABC classification methods are researched and Ng's model, which is one of the most widely used, selected for further investigation. An illustrative example is presented to show the usability of the Ng's method.

ABC ANALİZİ YÖNTEMİ İLE ENVANTER SINIFLANDIRMASI

Özetçe

Hatırı sayılır miktarda organizasyon için büyük ölçekli envanteri yönetmek çok ciddi bir sorun teşkil etmektedir. Bu sorunu çözmek için sıkça kullanılan yöntemlerden biri, envanteri bazı kriterlere göre sınıflandırmak ve envanteri bu sınıflandırmaya göre yönetmektir. Bu çalışmada, ABC sınıflandırma yöntemleri araştırılmış ve en çok kullanılan yöntemlerinden biri olan Ng'nin modeli daha detaylı inceleme için seçilmiştir. Ng'nin metodunun kullanılabilirliğini göstermek amacıyla açıklayıcı bir örnek sunulmuştur.

Keywords: *ABC analysis, inventory management, multiple criteria inventory classification (MCIC).*

Anahtar Kelimeler: *ABC analizi, envanter yönetimi, çoklu kriter envanter sınıflandırması.*

1. INTRODUCTION:

Every organization has its own inventory and some of them have to manage an enormous number of distinct items that is called stock keeping units (SKUs) in their inventory. An organization's Inventory may include raw materials, supplies used in operations, finished goods and spare parts. Every SKU needs some time to be manageable by logisticans and time is one of the most important players in nowadays economical situations. One of the most widely used methods to solve this conflict is the ABC classification method. By classifying the SKUs in inventory, a manager can spend much more time to the SKUs that is more important relatively.

ABC analysis is based on the Pareto principle. The Pareto principle was first applied to inventory systems by Dickie (1951) for General Electric and it was called ABC analysis (Kiris, 2013).

Conventional ABC analysis accounts for only one criterion, mostly ''annual dollar usage'', for classification of inventory items. However, there are too many other criteria (both quantitative and qualitative) that may significantly affect the classification such as: inventory holding unit cost, part criticality, the length and variability of replenishment lead time, commonality, substitutability, scarcity, durability and stock-out unit penalty (Torabi et al., 2012).

The ABC analysis classifies SKUs into three subgroups; A, B and C, as easily can be deduced from the name of the ABC analysis. The SKUs belong to "Group A" are the most important items for the organization. The SKUs belong to "Group B" are the items that has moderate importance to the organization and the SKUs belong to "Group C" are the items that has least importance for the organization. Usually, the most important group is about 20 % of the total SKUs approximately, as the Pareto principle dictates. Figure 1 shows the mentality of the Pareto principle over inventory problem.

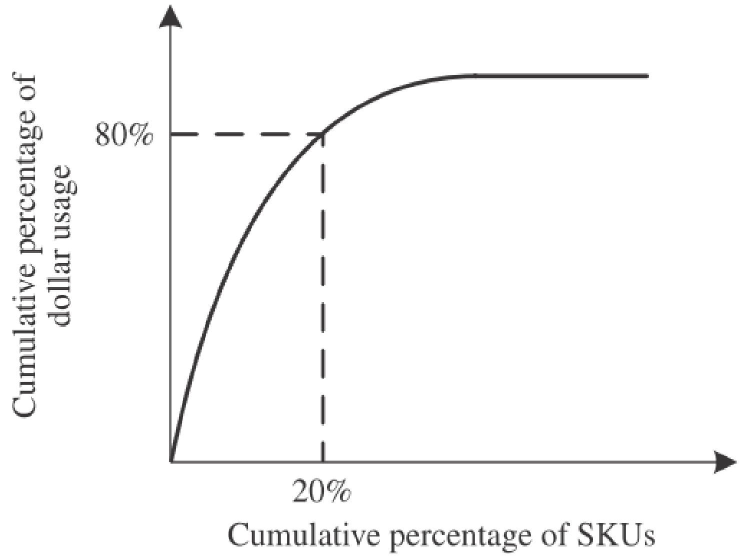

Figure 1: Chen et al.(2006)'s mentality of Pareto principle over inventory problem.

In this paper, Ng's weight linear optimization model for the MCIC (Multi Criteria Inventory Classification) problems is investigated. The literature review is presented in Section 2. The mathematical formulation of Ng is presented in Section. An example is provided in Section 4 and conclusions is given in Section 5.

2. LITERATURE REVIEW

The chronological review of ABC analysis related literature can be found in following paragraphs.

One of the first article about using ABC analysis in inventory classification is the study of Schomer [1]. As one of the premier studies, it has only one criteria for classification which is dollar value.

Flowers and O'Neill [2] have used classical ABC analysis to analyze a spare parts inventory of a manufacturing facility in an effort to obtain better inventory control. Their method has only one criteria also.

Partovi and Anandarajan [3] presented artificial neural network (ANN) for ABC classification of SKUs in a pharmaceutical company. The learning methods of ANN were back propagation and genetic algorithms.

Ng [4] has proposed a model for multiple criteria inventory classification. His model converted all criteria measures of an inventory item into a scalar score. The classification based on the calculated score using the ABC principle was then applied.

Ramanathan [5] proposed a weighted linear optimization model for multi criteria ABC inventory classification. Despite its many advantages, Ramanathan's model (R-model) could lead to a situation where an item with a high value in an unimportant criterion is inappropriately classified as a class A item.

Bhattacharya et al. [6] have demonstrated a way of classifying inventory items using the TOPSIS ('Technique for Order Preference by Similarity to Ideal Solution') model. Their technique took into account various conflicting criteria having incommensurable units of measurement. Unit cost, lead time, consumption rate, the perishability of items and the cost of storing of raw materials have been considered for the case study. By using TOPSIS, the items are ranked in categories A, B and C.

Zhou and Fan [7] presented an extended version of the Ramanathan's R-model for multi-criteria inventory classification. Their model provided a more reasonable and encompassing index since it used two sets of weights that were most favorable and least favorable for each item. An illustrative example was presented to compare their model and the R-model.

Simunovic et al. [8] have compared the traditional one criteria ABS classification model with multi criteria one. They have applied to the classification of parts fort he assembly of agricultural machine. The parts were classified using the traditional ABC classification based only on one criterion and analytical process (AHP) methodology.

Hadi-Vencheh [9] presented an extended version of the Ng - model for multi criteria inventory classification. Their model not only incorporates multiple criteria for ABC classification, but also maintains the effects of weights in the final solution, an improvement over the model proposed by Ng.

Chen [10] has proposed an approach by using two virtual items and incorporating the TOPSIS. His approach improved some previous allied methods as it provides a more reasonable and comprehensive performance index and a unique inventory classification without any subjectivity.

Hadi-Vencheh and Mohamadghasemi [11] have proposed an integrated fuzzy analytic hierarchy process-data envelopment analysis (FAHP-DEA) for multiple criteria ABC inventory classification. The proposed FAHP–DEA methodology uses the FAHP to determine the weights of criteria, linguistic terms such as Very High, High, Medium, Low and Very Low to assess each item under each criterion, the data envelopment analysis (DEA) method to determine the values of the linguistic terms, and the simple additive weighting (SAW) method to aggregate item scores under different criteria into an overall score for each item.

Mohamadghasemi and Hadi-Vencheh [12] performed multiple criteria ABC inventory classification using the Hadi-Vencheh model (2010) first. Then suitable ordering policies are determined for items of classes A and C. Finally, they extracted fuzzy rules from the policies of these two classes for determining the policies of items class B.

Molenaers et al. [13] proposed a spare part classification method based on item criticality. Their model presented the multi criteria classification problem in a logic decision diagram where AHP is used to solve the multi criteria decision sub-problems at the different decision nodes of the diagram.

Torabi et al. [14] proposed a modified version of an existing common weight DEA-like (Data Envelopment Analysis) model by using some concepts in the current imprecise DEA models and then applied it for the ABC inventory classification in the case where there exist both quantitative and qualitative criteria.

Kiris [15] proposed a fuzzy analytic network process approach to determine the weights of the criteria and the scores of the inventory items were determined with simple additive weighting by using linguistic terms. Applying fuzzy ANP to a multi-criteria inventory classification problem was the novelty of his study in the related literature.

Soylu and Akyol [16] proposed a model that the preferences of the decision maker are incorporated into the decision making process in terms of reference items into each class on account of the weights of criteria and categorization preferences can change from industry to industry. They applied two utility functions based sorting methods to the problem.

3. MATHEMATICAL FORMULATION:

Ng firstly transformed all measures to comparable base. For the aim of converting all the measurements in a 0-1 scale for all items, he used the formula;

Ng secondly presented the (P_1) model in order to facilitate the inventory classification under multiple criteria. w_{ij} is the non-negative weight that shows the performance of the i_{th} item under the j_{th} criteria. He assumed the criteria are ranked in a descending order such that $w_{i1} > w_{i2} > w_{ij}$ for all item i . The score of the i_{th} item (denoted as S_i) is expressed as a weighted sum of performance measures under multiple criteria. The linear optimization model is shown below:

$$(P_1) \quad \max S_i = \sum_{j=1}^{J} w_{ij} y_{ij}$$

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

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

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

Based on the transformations described in Ng's paper in detail, (P_1) model is converted to the following (P_2) model for all inventory items:

$$(P_2) \quad \max S_i = \sum_{j=1}^{J} u_{ij} x_{ij}$$

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

$$u_{ij} \geq 0, \qquad j = 1,2,...,J \ .$$

After the transformation, the multiple criteria inventory classification procedure is much more simple and efficient.

We perform the following steps on a spreadsheet package for each inventory item.

Step 1: Calculate all partial averages, $\frac{1}{j}\sum_{k=1}^{j} x_{ik}, \quad j = 1,2,...,J$

Step 2: Compare and locate the maximum among these partial averages. The corresponding value is the score S_i of the i_{th} item.

Step 3: Sort the scores S_i 's in the descending order.

Step 4: Group the inventory items by principle of ABC analysis.

1. Illustrative Example

The test data used in this research is obtained from Bhattacharya et al.'s paper [6].

Table 1.

Item No.	Unit cost	Consumption rate	Lead time	Unit cost transformed	Consumption rate transformed	Lead time transformed
I1	1108.29	216.00	4.5	0.29233862	0.00425584	0.58333333
I2	370.00	24.90	2.5	0.09310233	0.00045364	0.25000000
I3	88.00	666.50	4.5	0.01700130	0.01321915	0.58333333
I4	1144.00	249.40	3.5	0.30197539	0.00492037	0.41666667
I5	318.40	874.55	4.5	0.07917746	0.01735860	0.58333333
I6	1081.76	86.30	3.5	0.28517919	0.00167528	0.41666667
I7	3730.60	20.00	4.5	1.00000000	0.00035615	0.58333333
I8	65.00	418.00	3.5	0.01079447	0.00827490	0.41666667
I9	75.08	50262.50	4.0	0.01351468	1.00000000	0.50000000
I10	25.00	1000.00	4.5	0.00000000	0.01985460	0.58333333
I11	2413.72	4935.78	4.0	0.64462435	0.09816237	0.50000000
I12	2134.00	109.00	4.0	0.56913860	0.00212692	0.50000000
I13	1062.37	873.60	7.0	0.27994657	0.01733969	1.00000000
I14	186.04	25.80	3.5	0.04345855	0.00047154	0.41666667
I15	560.00	4.60	3.5	0.14437608	0.00004974	0.41666667
I16	761.08	73.00	4.5	0.19863990	0.00141065	0.58333333
I17	45.30	11.70	3.5	0.00547820	0.00019101	0.41666667
I18	316.00	7.90	3.5	0.07852979	0.00011540	0.41666667
I19	270.00	39.40	3.5	0.06611615	0.00074213	0.41666667
I20	576.80	139.60	3.5	0.14890976	0.00273575	0.41666667
I21	800.00	2.10	3.5	0.20914292	0.00000000	0.41666667
I22	181.30	55.90	3.5	0.04217940	0.00107043	0.41666667

I23	39.54	1234.10	1.0	0.00392379	0.02451234	0.00000000
I24	148.33	194.30	1.0	0.03328206	0.00382408	0.00000000
I25	768.98	140.00	4.5	0.20077180	0.00274371	0.58333333
I26	360.00	11.70	3.5	0.09040371	0.00019101	0.41666667
I27	55.00	232.30	3.5	0.00809585	0.00458015	0.41666667
I28	1100.00	4.60	4.5	0.29010147	0.00004974	0.58333333
I29	233.68	4511.30	4.5	0.05631477	0.08971676	0.58333333
I30	340.20	121.80	4.5	0.08506045	0.00238160	0.58333333
I31	2006.00	6930.00	4.5	0.53459629	0.13784013	0.58333333
I32	2006.13	11860.30	4.5	0.53463137	0.23593525	0.58333333
I33	1442.00	14.60	4.5	0.38239421	0.00024870	0.58333333
I34	62.00	1685.40	3.5	0.00998489	0.03349158	0.41666667
I35	237.20	492.30	4.5	0.05726468	0.00975321	0.58333333
I36	274.92	3820.40	4.5	0.06744387	0.07597035	0.58333333
I37	988.88	2.50	4.5	0.26011442	0.00000796	0.58333333
I38	1838.00	38.30	4.5	0.48925950	0.00072025	0.58333333
I39	3306.30	7.90	2.5	0.88549763	0.00011540	0.25000000
I40	2038.61	21.00	4.5	0.54339648	0.00037604	0.58333333
I41	277.47	848.50	4.5	0.06813202	0.01684030	0.58333333
I42	222.74	742.30	4.5	0.05336248	0.01472730	0.58333333
I43	575.45	240.40	7.0	0.14854544	0.00474131	1.00000000
I44	228.16	129.50	4.5	0.05482513	0.00253480	0.58333333
I45	526.88	9.04	5.5	0.13543826	0.00013808	0.75000000
I46	188.66	1214.20	4.5	0.04416559	0.02411640	0.58333333
I47	80.25	14116.90	4.5	0.01490987	0.28083342	0.58333333
I48	66.95	573.50	4.5	0.01132070	0.01136879	0.58333333
I49	66.95	10623.60	7.0	0.01132070	0.21132940	1.00000000
I50	118.45	195.00	4.5	0.02521859	0.00383801	0.58333333
Min	25.00	2.10	1.0			
Max	3730.60	50262.50	7.0			

Table 2.

Item No.	Unit cost transfo r-med	Consump-tion rate transfor-med	Lead time transfor -med	Partial Average			Maximum of Partial Average	ABC Class
				1	2	3		
I7	1.0000000	0.0003561	0.5833333	1.0000000	0.5001781	0.5278965	1.0000000	A
I39	0.8854976	0.0001154	0.2500000	0.8854976	0.4428065	0.3785377	0.8854976	A
I11	0.6446244	0.0981624	0.5000000	0.6446244	0.3713934	0.4142622	0.6446244	A
I12	0.5691386	0.0021269	0.5000000	0.5691386	0.2856328	0.3570885	0.5691386	A
I40	0.5433965	0.0003760	0.5833333	0.5433965	0.2718863	0.3757020	0.5433965	A
I32	0.5346314	0.2359352	0.5833333	0.5346314	0.3852833	0.4513000	0.5346314	A
I31	0.5345963	0.1378401	0.5833333	0.5345963	0.3362182	0.4185899	0.5345963	A
I9	0.0135147	1.0000000	0.5000000	0.0135147	0.5067573	0.5045049	0.5067573	A
I38	0.4892595	0.0007202	0.5833333	0.4892595	0.2449899	0.3577710	0.4892595	B
I13	0.2799466	0.0173397	1.0000000	0.2799466	0.1486431	0.4324288	0.4324288	B
I49	0.0113207	0.2113294	1.0000000	0.0113207	0.1113251	0.4075500	0.4075500	B
I43	0.1485454	0.0047413	1.0000000	0.1485454	0.0766434	0.3844289	0.3844289	B
I33	0.3823942	0.0002487	0.5833333	0.3823942	0.1913215	0.3219921	0.3823942	B
I4	0.3019754	0.0049204	0.4166667	0.3019754	0.1534479	0.2411875	0.3019754	B
I45	0.1354383	0.0001381	0.7500000	0.1354383	0.0677882	0.2951921	0.2951921	C
I1	0.2923386	0.0042558	0.5833333	0.2923386	0.1482972	0.2933093	0.2933093	C
I47	0.0149099	0.2808334	0.5833333	0.0149099	0.1478716	0.2930255	0.2930255	C
I28	0.2901015	0.0000497	0.5833333	0.2901015	0.1450756	0.2911615	0.2911615	C
I6	0.2851792	0.0016753	0.4166667	0.2851792	0.1434272	0.2345070	0.2851792	C
I37	0.2601144	0.0000080	0.5833333	0.2601144	0.1300612	0.2811519	0.2811519	C
I25	0.2007718	0.0027437	0.5833333	0.2007718	0.1017578	0.2622829	0.2622829	C
I16	0.1986399	0.0014107	0.5833333	0.1986399	0.1000253	0.2611280	0.2611280	C
I29	0.0563148	0.0897168	0.5833333	0.0563148	0.0730158	0.2431216	0.2431216	C
I36	0.0674439	0.0759703	0.5833333	0.0674439	0.0717071	0.2422492	0.2422492	C
I5	0.0791775	0.0173586	0.5833333	0.0791775	0.0482680	0.2266231	0.2266231	C
I30	0.0850604	0.0023816	0.5833333	0.0850604	0.0437210	0.2235918	0.2235918	C

I41	0.0681320	0.0168403	0.5833333	0.0681320	0.0424862	0.2227685	0.2227685	C
I46	0.0441656	0.0241164	0.5833333	0.0441656	0.0341410	0.2172051	0.2172051	C
I42	0.0533625	0.0147273	0.5833333	0.0533625	0.0340449	0.2171410	0.2171410	C
I35	0.0572647	0.0097532	0.5833333	0.0572647	0.0335089	0.2167837	0.2167837	C
I44	0.0548251	0.0025348	0.5833333	0.0548251	0.0286800	0.2135644	0.2135644	C
I21	0.2091429	0.0000000	0.4166667	0.2091429	0.1045715	0.2086032	0.2091429	C
I3	0.0170013	0.0132192	0.5833333	0.0170013	0.0151102	0.2045179	0.2045179	C
I50	0.0252186	0.0038380	0.5833333	0.0252186	0.0145283	0.2041300	0.2041300	C
I48	0.0113207	0.0113688	0.5833333	0.0113207	0.0113447	0.2020076	0.2020076	C
I10	0.0000000	0.0198546	0.5833333	0.0000000	0.0099273	0.2010626	0.2010626	C
I20	0.1489098	0.0027358	0.4166667	0.1489098	0.0758228	0.1894374	0.1894374	C
I15	0.1443761	0.0000497	0.4166667	0.1443761	0.0722129	0.1870308	0.1870308	C
I26	0.0904037	0.0001910	0.4166667	0.0904037	0.0452974	0.1690871	0.1690871	C
I18	0.0785298	0.0001154	0.4166667	0.0785298	0.0393226	0.1651040	0.1651040	C
I19	0.0661161	0.0007421	0.4166667	0.0661161	0.0334291	0.1611750	0.1611750	C
I14	0.0434585	0.0004715	0.4166667	0.0434585	0.0219650	0.1535323	0.1535323	C
I34	0.0099849	0.0334916	0.4166667	0.0099849	0.0217382	0.1533810	0.1533810	C
I22	0.0421794	0.0010704	0.4166667	0.0421794	0.0216249	0.1533055	0.1533055	C
I8	0.0107945	0.0082749	0.4166667	0.0107945	0.0095347	0.1452453	0.1452453	C
I27	0.0080959	0.0045801	0.4166667	0.0080959	0.0063380	0.1431142	0.1431142	C
I17	0.0054782	0.0001910	0.4166667	0.0054782	0.0028346	0.1407786	0.1407786	C
I2	0.0931023	0.0004536	0.2500000	0.0931023	0.0467780	0.1145187	0.1145187	C
I24	0.0332821	0.0038241	0.0000000	0.0332821	0.0185531	0.0123687	0.0332821	C
I23	0.0039238	0.0245123	0.0000000	0.0039238	0.0142181	0.0094787	0.0142181	C

4. CONCLUSIONS:

The last column of Table 2 shows the ABC classification of all items as A, B or C. 8 of 50 items are classified as A, 6 of 50 items are classified as B and 36 of 50 items are classified as C. This classification is very important for an organization. By the help of this classification, an organization may conclude to manage items according to their classification. As a conclusion, an organization may focus most of it's efforts to the items that have an "A" classification, some of it's efforts to the items that have an "B" classification and trace quantity of it's efforts to the items that have an "C" classification. This kind of management approach will increase the productivity of the organization.

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