Elaboration of a new method in the science of decision

Amal Boukili[1], Mohamed Fri[2], Mohammed El Hammoumi[3], Fouad Belmajdoub[4]

Abstract— In this article, we discuss a preliminary study on the scientific field of decision support; it aims to use the most suitable tool to improve the efficiency in implementing necessary changes in order to increase production. For this, we intend to start with a classification of workshop equipment using the Pareto chart to determine which elements introduce the most downtime based on the number of hours of stops. The histogram is based on the empirical law of 80/20, i.e. 20% of the causes often explain up to 80% of the problem. Then we will redo the classification of these devices using our CBA diagram, which sorts the performance indicator in the opposite direction from that of Pareto. An algorithm that gathers both Pareto and CBA methods to make the best decision to increase the rate of productivity will be presented at the end of the document.

In this paper, we develop a new, easy method to implement which allows businesses to increase their productivity without any costs to them.

Index Terms— Pareto, science of decision, Industrial Maintenance.

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1. Introduction

Today, maintenance of equipment is a significant and important task to ensure the smooth operation of facilities. Recent studies on the effectiveness of maintenance management show that over one third of company expenditures come from maintenance costs of unnecessary or poorly executed transactions; this inefficiency is the main reason for the lack of real information that would identify the immediate need for repair or maintenance.

Maintenance costs often represent the bulk of operating costs in a number of production units. These costs can be significantly reduced by recognizing the most suitable decisions to make in a certain situation. The choice of method of maintenance management directly influences the rate of profitability and efficiency, and therefore it is very important to prepare the methods and tools that will ensure that management. For this reason, policymakers must make a choice between several decision support tools to provide a satisfactory solution to a given problem. In this sense, the Pareto is one of the more effective tools for decision-making.

This tool is indeed a very useful part of the classification of equipment to determine the most critical problems needing treatment, but it would be desirable to obtain, for classification, a better result than that provided by the Pareto analysis. To do this, we thought to use a new tool called the "CBA" method. The latter is based on the Pareto chart of principle but sorts the facilities in the opposite direction.

The comparison of these two tools contributes to optimal decision making on the choice of equipment. Then one can identify the most critically affected pieces of equipment, and therefore, achieve optimum allocation of the budget for the improvement of the production chain and the minimization of the failure rate.

Identifying various critical equipment will make it easy to recognize the different categories of anomalies and focus on the most disastrous; we can then assign the appropriate response in the context of preventive maintenance.

In this case, we used a study that focused on a soft drink production company. Based on the conditions of this company, we were able to apply these methods using two variables: the number of hours of stops and the maintenance cost for each piece of equipment. In hopes of improving industrial maintenance, productivity and management of the company budget, actual measurements were analyzed by both methods, which lead to satisfactory results.

In this paper, we will develop a single algorithm based on two methods: Pareto and CBA. This algorithm makes a comparison between these two methods, and gives the most optimal to reduce the failure rate.

This article describes the approach used to meet this goal. It is structured as follows: The first part will be devoted to the general presentation of Pareto analysis, while the second part will focus on the presentation of our CBA methodology, and a case study will be the subject of the third part. Section IV presents the synthesis of our method with an algorithm that combines the two results, and we finish with a conclusion.

2. The Pareto (ABC method)

Without hierarchisation, all actions of organization can be long and tedious. By using the Pareto law [1][2][3] we can highlight the most important elements of a problem to guide our action. Because of this, the elements having little influence on the criterion studied will be eliminated. The ABC method is a tool for decision support, which defines priorities for actions. This means that the Pareto chart shows the most important

- *1, 2, 3, 4: University of Sidi Mohamed Ben Abdellah, Faculty of Science and Technology, Laboratoire Techniques Industrielles, Road Imouzzer B.P. 2202 Fez, Morocco*
- *1: Amal-boukili@usmba.ac.ma*
- *2: Mohamed.fri@usmba.ac.ma*
- *3: m_elhammoumi@yahoo.fr*
- *4: fbelmajdoub@yahoo.fr*

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causes that are causing most of effects.

The elements will be ranked by order of importance indicating the percentages for a given criterion. This study requires a three steps approach:

• Defininge the nature of the elements to be classified: the classification of these elements depends on the criteria studied.

These elements can be physical, causes of failures, types of failures, work orders, items in stock, etc…

• Choosing the classification criterion: The most common criteria are costs and time, according to the character studied, other criteria can be used, including: The number of accidents, the number of incidents, the number of rejects, the number of operating hours, the number of kilometers covered, annually consumed value which is often necessary for the management of stocks, etc..

• Defininge the limits of the study and classify the elements.

The Pareto chart is a column chart that presents information in descending order and thus brings out the most important elements, which explain a phenomenon or situation. Generally, 20% of the number of elements represents 80% of the criteria: it is the class A; 30% on the number of elements represents 15% of the criteria studied: it is the class B; and the remaining 50% of elements represents only 5% of the criterion studied: it is the class C.

By cumulating the decreasing values of the criterion studied, the ABC curve shows three zones, reason why it "ABC curve", see “Fig.1”, [4].

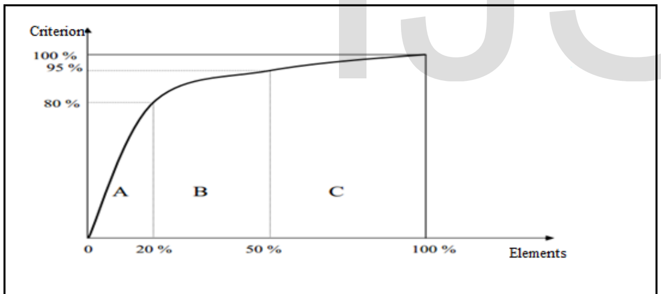

Fig. 1. Pareto ABC

After applying this method in several case studies we noticed that we did not find consistent results supporting the 80/20 law, represented in Figure 1. As a result, we must either alter the Pareto method or use another method that will help us to make decisions that yield the best and most consistent results.

This new method of classification is presented in the next section.

3. Diagram CBA

Our research objective is to make the best decision in order to improve the productivity of a company. The Pareto method is among the best known methods in decision making, but this method does not always give the expected 20/80 result; hence it is necessary to improve it or find a new way to have a more optimal decision. In this paper, we propose to classify elements in decreasing order to find a right decision. We propose to make the following steps:

1. Identify the problem to solve.
2. Make a data collection or use existing data.
3. Sort the data into categories and define a category "Miscellaneous" for categories with few items.
4. Total the data in each category and determine the percentages of the total.
5. Sort the percentages by decreasing value.
6. Calculate the cumulative percentage
7. Determine a suitable scale with which to draw the graph.
8. Place columns (bars) on the graph, starting with the smallest on the left
9. Once all the bars have been placed, plot the cumulative percentages

To assess the validity of our method we have applied it to the following case study.

4. Case study.

4.1. Introduction

All enterprises have a lucrative purpose: to maximize production, and consequently, to minimize downtime; in order to do this, enterprises reserve the part of their budget allocated to improve their productivity. In our article, we look at a case study concerning a soft-drink packaging company. We begin with a case study where we will utilize the “Pareto Method” to improve the efficiency of a production line (in this case, line 2).

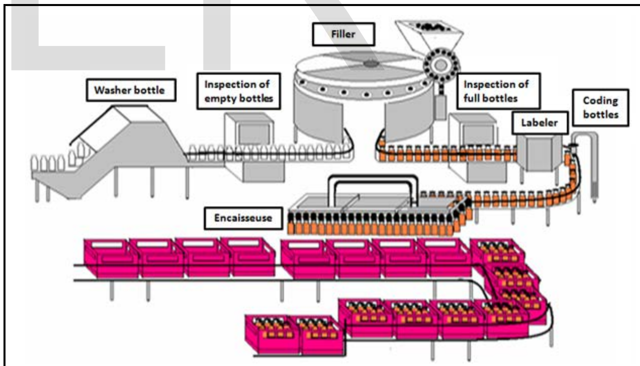

Fig. 2. Schematic illustrative of the different steps of the preparation of soft drinks

To accomplish this and maintain the majority of the line’s equipment in good condition during production (“Fig.2”), the company proposes a budget of 300,000.00 MAD. To do this we will study the downtime and the maintenance costs for each machine on line 2 over a period of 2 months; the necessary information is given in the following table “Fig. 3”:

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Reference Number	Downtime	Maintenance Costs in MAD
1	5	4000
2	15	15000
3	2	2000
4	20	22000
5	4	2100
6	4	1300
7	4	2500
8	1 ,5	850
9	4	1800
10	2	850
11	2	2500
12	10	10000
13	2	1500
14	4	2000
15	1	700

Fig. 3. The cost of maintenance and downtime for each machine of line 2

4.2. Resolution Using the Pareto Method

The Pareto Method allows us to classify machines in descending order by the severity of their problems; the severity can be calculated using the following formula: (downtime of the machine / Total downtime)*100

The table below (Table II) represents the percentage of downtime for each machine of line 2 over the course of two months Fig. 4 :

Reference Number	Repair Costs	Downtime Percentage	Cumulative Cost	Cumulative Downtime%
4	22000	24,84	22000	24,84
2	15000	18,63	37000	43,47
12	10000	12,42	47000	55,90
1	4000	6,21	51000	62,11
5	2100	4,96	53100	67,08
6	1300	4,96	54400	72,04
7	2500	4,96	56900	77,01
9	1800	4,96	58700	81,98
14	2000	4,96	60700	86,95
3	2000	2,48	62700	89,44
10	850	2,48	63550	91,92
11	2500	2,48	66050	94,40
13	1500	2,48	67550	96,89
8	850	1,86	68400	98,75
15	700	1,24	69100	100

Fig. 4. Percentage of the breakdown of each machine of the line 2

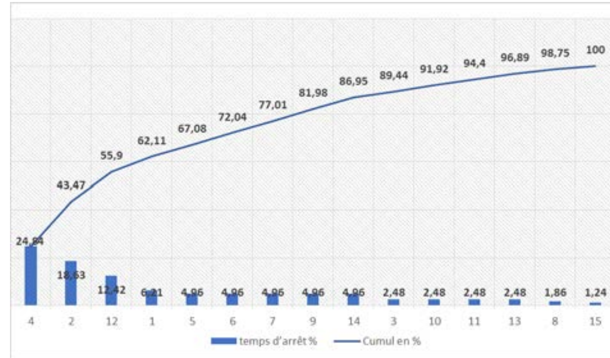

Fig. 5. Graphe of the percentage of the breakdown of each machine of the line 2

According to the Pareto chart, we see that 81.98% of shutdown problems of line 2 are due to shutdowns of machines: 4, 2, 12, 1, 5, 6, 7 and 9. These breakdown periods take up a significant part of working time and therefore contribute to the slowing and/or stopping of production.

Based on the results of the Pareto Method and using the allocated budget of 40,000.00 MAD, we can address the problems concerning machines 4 and 2. In addressing the problems with these two machines, we use 37,000.00MAD of our allotted budget and we minimize the overall downtime by 43.47%. However, two questions remain:

- Is this the best solution?

-Can we exploit the rest of the budget in a more effective way?

To answer these questions, we will use our CBA method.

4.3. Resolution by the CBA method:

The CBA Method allows us to classify machines in ascending order by the severity of their problems; the severity can be calculated by the same formula from before: (downtime of the machine / Total downtime)*100

The application of the CBA method leads to a new solution shown in the following table:

Reference Number	Repair Costs	Downtime Percentage	Cumulative Cost	Cumulative Downtime%
15	700	1,24	700	1,24
8	850	1,86	1550	3,10
3	2000	2,48	3550	5,59
10	850	2,48	4400	8,07
11	2500	2,48	6900	10,55
13	1500	2,48	8400	13,04
5	2100	4,96	10500	18,01
6	1300	4,96	11800	22,98
7	2500	4,96	14300	27,95
9	1800	4,96	16100	32,91
14	2000	4,96	18100	37,88
1	4000	6,21	22100	44,09
12	10000	12,42	32100	56,52
2	15000	18,63	47100	75,15
4	22000	24,84	69100	100

Fig. 6. Resolution of this case study with our approach

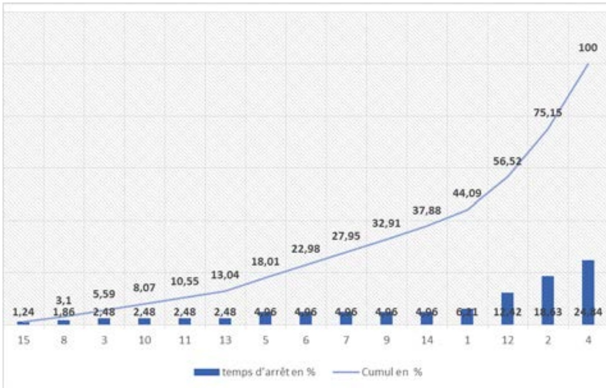

Fig. 7. The machines that cause a high% of termination of production of Line 2 (LV2) next CBA

Using the results from the CBA Method and the allocated budget (40 000.00MAD), we can address the problems of the following machines: 15, 8, 3, 10, 11, 13, 5, 6, 7, 9, 14, 1 and 12.

This solution allows us to minimize up 56.52% of downtime while using only 32,100 .00 MAD.

5. Synthesis:

The results of both methods: ABC and CBA are shown in the following table:

	% of Downtime Minimized	Cost of Repair in MAD
ABC	43,47	37 000
CBA	56.52	32 100

Fig.8. The percentage of downtime remedied and repair cost in MAD for both methods

The application of our CBA Method provides a more optimal result with respect to the ABC method: it was possible to remedy 13.05% more downtime with the CBA method, and we spent 4,900 MAD less in repair costs.

These two methods can be applied only in situations with 1 or 2 variables (in our case study we had two variables: the downtime and cost of intervention). Thus, in the case where there are more than two variables, we must seek other applicable methods, or use both methods with all possible combinations of variables and compare the end results to find the most optimal solution.

After several tests on many different case studies, we found the following results:

Case 1: CBA result better than ABC result

Case 2: ABC result better than CBA result

Case 3: ABC and CBA give the same result.

For this reason, we propose to do both methods and choose the one that gives the best result. Our proposal is summarized in the following algorithm:

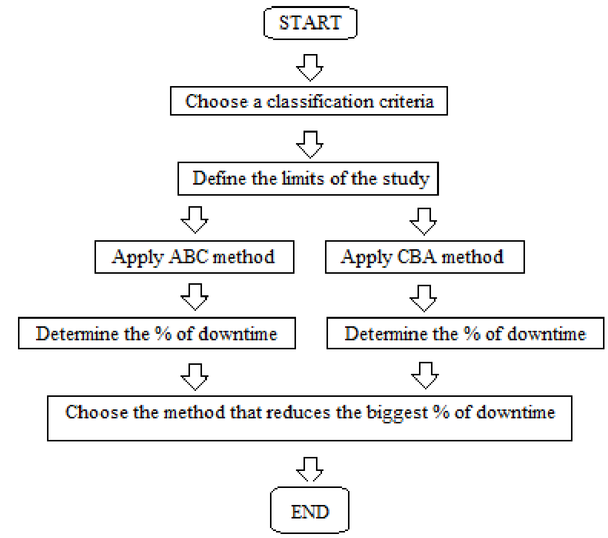

Fig. 9. Algrithm to choose the one that gives the best result

6. Conclusion

In our paper, we developed a new method that was based on the Pareto method and the method we appointed called CBA. Since increasing the efficiency of production is the major concern of industry leaders, CBA is designed to remedy the decisions and unforeseen breakdowns in chains of production. The choice of the method of maintenance management has a direct influence on the stability of the productivity and the cost of maintenance actions.

Both these methods were applied to an actual case study in order to improve industrial maintenance in the soft drink production structure. The synthesis will be based on two variables: the number of failure times for each machine and the necessary budget to repair them.

We have shown in this paper that the CBA method yields more optimal results than the Pareto method (13.05% more downtime remedied with CBA method than with Pareto), even though the Pareto Method is often cited as the best choice in the field of industrial maintenance.

Finally, we developed an algorithm based on the two chosen methods: Pareto and CBA. This algorithm makes a comparison between the individual results of the two methods and, in terms of reduced failure rate and increased productivity, indicates which of the two will give the most optimal result.

References

[1] C. Brooks," What Is a Pareto Analysis? ", Business News Daily Senior, March 29, 2014

[2] R. Cirillo, "The Economics of Vilfredo Pareto", Routledge, 12 nov. 2012 - 148 pages

[3] M. Doostparast, Narayanaswamy Balakrishnan, "Pareto analysis based on records", A Journal of Theoretical and Applied Statistics,Volume 47, Issue 5, 2013, pages 1075-1089

[4] Amal Boukili, Mohamed Fri, Mohammed El Hammoumi, Fouad Belmaj-

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doub, “Comparative study of Pareto, Knapsack and Greedy Algorithm in the field of industrial Maintenance”, International Journal of Scientific and Engineering Research (IJSER) - (ISSN 2229-5518) Volume 7, Issue 4, April 2016