

Design of ABC, Procedures Manual, EOQ, AHP and Criteria Comparison Matrix to reduce costs in a shoe manufacturing company

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I. INTRODUCTION

A. Problematic Reality

Mana Bussines SAC is a company that is dedicated to the production and sale of leather footwear for women, men and children, having as main clients the companies Viale, Vimoda, Time Chopper and Sokso offering original products adapted to the needs that Customers also require the sale of their own brand "Almendras", generating an annual sale of S / 68 748.51 in 2019. There is a workforce with knowledge both in the field and in the processes of the manufacturing sector of footwear, all of them with the capacity to produce the programmed quantities ordered. The quality and flexibility that the company offers in its products and in its service makes it one with constant growth.

However, there have been problems, which are reflected in costs by the warehouse and production areas. All of this meant that the company began to generate fewer profits due to poor management.

The first problem found is the warehouse disorder in which there are 12 different materials necessary for the production and packaging of the products which do not present any order within the warehouse, generating considerable search times, this being a total of 45.5 hr / month. The delay in the search for materials generates a stop within the production time equivalent to the search time since there is no order or prioritization of critical materials and with the highest turnover. This problem is recurrent and entails costs equivalent to S/1,137.50 per month in non-worked downtime.

The second problem detected is the number of defective products, which are presented in the amount of 25 defective units for every thousand produced, during the production process. These defective products are presented by human

error at the time of the sewing process, reflecting costs of S/1,386.55 per month.

The third problem that was found refers to excess inventory; in other words, the company stores a large quantity of materials for the manufacture of footwear, even much more than the quantities used to manufacture a pair of footwear to fulfill a specific order. Because the company works production to order, a certain number of units of the different materials are needed to manufacture the SKU, however the manager places orders for materials with volumes much greater than those needed so that his supplier can offer them to a smaller Unit cost. However, when fulfilling the order, the warehouse presents an amount of 469 excess units in inventory, which generates a cost to maintain them of S/.3,109.72.

The fourth problem is represented by production stops in the company, when it does not have materials to continue producing continuously due to the non-compliance of the suppliers based on the agreed times and quantities. Given this, they are forced to stop production and having unemployed labor expenses since they cannot produce, but in the same way they have to be paid for belonging to the payroll. The evaluated period was the semester corresponding to the months of July to December 2019, obtaining 11 days of para equivalent to a monthly expense of S/762.85.

In the same way as the previous problem, in the fifth problem detected are the returns of materials due to the fact that the suppliers fail to comply with the established requirements, generating labor costs to make and prepare the return, being 3 approximate monthly returns, as well as a fixed transportation cost (performed by a third party) obtaining monthly expenses S/273.61.

B. Problem

What is the impact of the design of ABC, Procedures Manual, EOQ, AHP and Criteria Comparison Matrix on the costs of the company Mana Bussines S.A.C.?

C. Objective

Determine the impact of the design of ABC, Procedures Manual, EOQ, AHP and Criteria Comparison Matrix on the costs of the company Mana Bussines S.A.C.

II. MATERIALS Y METHODS

A. Investigation Design

The present investigation is of experimental character of pre-experimental degree, where the unit of study It was the logistics area of the company Mana Bussines S.A.C. and the population was made up of all the processes of the logistics area and all the workers.

B. Solution Alternatives

To solve the problems mentioned above, two alternatives are presented for each one as shown in the following table 1:

TABLE I
SOLUTION ALTERNATIVES

N°	Problems	Solution Alternatives	
1	Warehouse clutter	ABC	Layout Design
2	Defective products	Poka Yoke	Procedures manual
3	Excess inventory	MRP	EOQ
4	Production stops	AHP	SRM
5	Return of materials	Criteria comparison matrix	AHP

C. Identification and Description of Realistic Constraints

To choose the option that best suits the reality of the company, the alternatives were evaluated based on realistic restrictions, considering the reality of the company and the work objective as shown in the tables II, III, IV, V.

TABLE II
REALISTIC CONSTRAINT COMPARISON FOR WAREHOUSE CLUTTER PROBLEM

Problem 1: Warehouse clutter	ABC	Layout Design
Implementation Cost	S/526.67	S/996.67
Implementation Time	12 días	14 días
Accessibility	100%	85%
Functionality	89%	75%
Usability	75%	64%
Sustainability	86%	79%

TABLE III
REALISTIC CONSTRAINT COMPARISON FOR THE DEFECTIVE PRODUCT PROBLEM

Problem 2: Defective products	Poka Yoke	Procedures Manual
Implementation Cost	S/3 847.57	S/1 031.88
Implementation Time	11 días	8 días
Accessibility	55%	95%
Functionality	54%	51%
Usability	64%	69%
Sustainability	66%	83%

TABLE IV
REALISTIC CONSTRAINT COMPARISON FOR THE WAREHOUSE OVERSTOCK PROBLEM

Problem 3: Excess inventory	MRP	EOQ
Implementation Cost	S/1112.50	S/420.00
Implementation Time	4 weeks	1 week
Accessibility	40%	60%
Functionality	45%	55%
Usability	56%	44%
Resistance to change	39%	61%

TABLE V
REALISTIC CONSTRAINT COMPARISON FOR THE PRODUCTION STOPPAGE PROBLEM

Problem 4: Production stops	AHP	SRM
Implementation Cost	S/550.00	S/795.00
Implementation Time	15 days	7 days
Accessibility	100%	95%
Functionality	60%	65%
Usability	70%	65%
Functionality	80%	70%

TABLE VI
REALISTIC CONSTRAINT COMPARISON FOR THE RETURN MATERIALS PROBLEM

Problem 5: Return of materials	Criteria comparison matrix	AHP
Implementation Cost	S/267.92	S/515.77
Implementation Time	9 days	12 days
Accessibility	51%	49%
Functionality	53%	48%
Usability	38%	62%
Resistance to change	47%	53%

D. Best Alternative Selection

Having carried out the comparative analysis between the alternative solutions based on the problematic realities, the following were chosen:

For the first problem, the application of an ABC in the company's warehouse is determined, which is a tool that improves profitability for each product and adequate costing by activities [1]. For the second problem, it was determined that the use of a Procedures Manual, because it will be possible to standardize the activities and responsibilities in the jobs allowing to develop a quality product optimizing resources [2]. Third problem EOQ will be applied, to eliminate the excess inventory present, because this will allow not only to reduce costs but also to improve the quality of the service, allowing the company to be more competitive in the sector in which it operates [3]. In addition, an AHP will be implemented which will allow the optimal selection of providers. Finally, the Criteria Comparison Matrix will be applied to the last problem, and this will solve the problem of the returns of materials that we have.

III. DESING

A. ABC Classification

In the design of the ABC tool, it was necessary to identify the rotation of the materials per month and order them from highest to lowest, that is, the materials that left the warehouse the most and the least. The following table lists the materials with their units of measure, unit cost, turnover per month and total cost.

TABLE VII
ROTATION COSTING

Materials	UM	Unit Cost	Rotation per month	Total Cost
Plant	Und	S/6.25	994	S/6,212.50
Talon buttress	Und	S/42.00	985	S/41,370.00
Buttress tip	Und	S/36.00	973	S/21,168.00
Sheepskin	Und	S/2.90	588	S/1,705.20
Leather	m ²	S/10.50	572	S/6,006.00
Napa	m ²	S/6.50	568	S/3,692.00
Hashtag	Und	S/0.06	492	S/29.52
Buckle	Und	S/1.00	479	S/479.00
Accessory	Und	S/0.50	468	S/234.00
Textile	M	S/7.50	455	S/3,412.50
Paper	m ²	S/0.15	397	S/59.55
Box	Und	S/1.80	312	S/561.60
TOTAL			7283	

TABLE VIII
ABC CLASSIFICATION OF MATERIALS ACCORDING TO THEIR ROTATION

Materials	%	% Accumulated	Zone
Plant	13.65%	13.65%	A
Talon buttress	13.52%	27.17%	A
Buttress tip	13.36%	40.53%	A
Sheepskin	8.07%	48.61%	A
Leather	7.85%	56.46%	A
Napa	7.80%	64.26%	A
Hashtag	6.76%	71.01%	A
Buckle	6.58%	77.59%	A
Accessory	6.43%	84.02%	B
Textile	6.25%	90.27%	B
Paper	5.45%	95.72%	C
Box	4.28%	100.00%	C
TOTAL	100.00%		

B. Procedures Manual

In the design of the Procedures Manual tool (MAPRO), the procedures of the production process had to be indicated in order to standardize them and thus reduce the problems of defectives due to errors in the production process, exactly in the sewing area. In the first place, the process where the failures occurred was studied, the correct procedure to be

followed was verified. Then, they were plotted and detailed and the people in charge were determined.

Finally, the procedures of the remaining production line were determined, they were plotted together, the procedures were detailed, and the corresponding responsibilities were delegated.

C. Economic Order Quantity

To apply the EOQ model, the cost of maintaining inventory was first determined, for this it was necessary to find the value of the inventory, the rental cost, the average consumption of electricity, the storekeeper's salary, the depreciation of the computer, which was obtained 81.68% of the inventory value.

TABLE IX
COST OF HOLDING INVENTORY

Item	Amount
Rent (Warehouse: 40% of the property)	S/ 600.00
Average consumption of Electric Power	S/ 70.00
Worker's salary	S/ 1,000.00
Depreciation	S/ 190.00
Total cost of maintenance inventory	S/ 1,860.00
Inventory value	S/ 1,519.22
Percentage of mant. inventory	81.68%

Subsequently, the inventory maintenance cost for each material was found based on its unit prices and the inventory maintenance percentage.

TABLE X
INVENTORY MAINTENANCE COST BY MATERIAL

Material	Unit Price	% Of mant. in inventories	Maintenance cost
Plant	S/6.25	81.68%	S/ 5.10
Talon buttress	S/42.00	81.68%	S/ 34.30
Buttress tip	S/36.00	81.68%	S/ 29.40
Sheepskin	S/2.90	81.68%	S/ 2.37
Leather	S/10.50	81.68%	S/ 8.58
Napa	S/6.50	81.68%	S/ 5.31
Hashtag	S/0.06	81.68%	S/ 0.05
Buckle	S/1.00	81.68%	S/ 0.82
Accessory	S/0.50	81.68%	S/ 0.41
Textile	S/7.50	81.68%	S/ 6.13
Paper	S/0.15	81.68%	S/ 0.12
Box	S/1.80	81.68%	S/ 1.47

While, in ordering costs, the following concepts were considered: labor, telephone calls, internet, electricity, supplies and equipment maintenance, resulting in a cost per order of S / 12.68.

TABLE XI
COST TO ORDER

Order cost	Quantity	Unit	Unit Cost	Total cost
Workforce	1.766	Hours	5.21	S/ 9.20
Phone calls	0.25	Hours	0.22	S/ 0.06
Internet	0.82	Hours	0.31	S/ 0.25
Electric power	0.38	KW-H	3.01	S/ 1.14
Supplies				S/ 2.00
Maint. of teams (3%)	0.3	Hours	0.09	S/ 0.03
TOTAL COST PER ORDER				S/12.68

With all these data, a stock management model based on EOQ was designed according to the reality of the inventory in the company. Likewise, the indicators will be calculated based on the EOQ model, which are Annual demand, Acquisition cost, Cost per order, Cost for inventory maintenance, Economic Lot (EOQ), Number of orders, Delivery time, Safety stock and Reorder point.

TABLE XII
EOQ MODEL APPLICATION FOR INVENTORY MATERIALS

Materials	U.M.	Annual demand	Unit price	Acquisition Cost	EOQ
Plant	und	11928	S/6.25	S/ 74,550.00	243
Heel counter	und	11820	S/42	S/496,440.00	94
Buttress tip	und	11676	S/36	S/420,336.00	100
Sheepskin	und	7056	S/2.90	S/ 20,462.40	275
Leather	m ²	6864	S/10.50	S/ 72,072.00	142
Napa	m ²	6816	S/6.50	S/ 44,304.00	180
Hantag	und	5904	S/0.06	S/ 354.24	1748
Buckle	und	5748	S/1.00	S/ 5,748.00	422
Accessory	und	5616	S/0.50	S/ 2,808.00	591
Textile	m	5460	S/7.50	S/ 40,950.00	150
Paper	m ²	4764	S/0.15	S/ 714.60	993
Box	und	3744	S/1.80	S/ 6,739.20	254

As could be seen, based on the EOQ model, the economic batches of each material that is present in the company's inventory have been obtained, the Safety Stock was also calculated in order to cover any unforeseen inconvenience and finally it was calculated the ROP that determines the optimal time to place a new order.

TABLE XIII
EOQ MODEL APPLICATION FOR INVENTORY MATERIALS

Materials	N° of orders	Business days	LT	Security stock	Reorder Point
Plant	50	240	5	249	249
Heel counter	126	240	5	247	247
Buttress tip	117	240	5	244	244
Sheepskin	26	240	5	147	147
Leather	49	240	5	143	143
Napa	38	240	5	142	142
Hantag	4	240	5	123	123
Buckle	14	240	5	120	120
Accessory	10	240	5	117	117
Textile	37	240	5	114	114
Paper	5	240	5	100	100
Box	15	240	5	78	78

D. Analytic hierarchy process (AHP)

The Analytic hierarchy process is worked by assigning a preference scale using the fundamental scale of Saaty to be able to evaluate the criteria together with the suppliers that the company has in order to identify the best supplier.

TABLE XIV
FUNDAMENTAL SAATY SCALE

VALUE	DEFINITION
1	Equal importance
2	Between moderate importance and equal importance
3	Moderate importance
4	Between great and moderate importance
5	Big importance
6	Between very great and great importance
7	Very great importance
8	Between extreme and very great importance
9	Extreme importance

A multi-criteria decision tree was made to order and specify the three criteria with which we work, as well as the ten alternatives that would become the leather suppliers that the company has in order to see it graphically.

After this, we worked with the criteria evaluation matrices and that of weighted criteria in order to establish a ranking of the criteria, ordering them by importance.

A 3x3 matrix was made to evaluate the criteria and 10x10 matrices to evaluate the suppliers, as well as normalized matrices to later find the priority vectors in 1x10 matrices.

TABLE XV
LIST OF LEATHER SUPPLIERS OF THE COMPANY

Leather Supplier Relationship	
A1	Curtiembre Ecologica del Norte EIRL
A2	Curtiembre Piel de Oro EIRL
A3	Grupo Manufacturero San Pedro SAC
A4	Curtiduria Orion SAC
A5	Nor Piel SRL
A6	Inversiones E Importaciones la Nueva Piel SAC
A7	Curtiembre Austral SRL
A8	Pieles del Sur EIRL
A9	Curtiembre Global SAC
A10	Curtiembre Vanu SAC

Once the priority vector of the criteria is obtained, the suppliers are evaluated in 10x10 matrices according to each criterion. Thus, it is possible to obtain 10 priority vectors for each criterion that was analyzed.

To obtain the best supplier alternative, a double entry table is made where the priority vectors of all the criteria will be located together with the alternatives, obtaining a 3x10 matrix which will be multiplied by the priority vector of the criteria that was generated at the beginning.

A 1x10 matrix will be obtained in which the priority vector is represented, and the highest value must be chosen,

which will represent the best supplier alternative based on the criteria.

TABLE XVI
PRIORITY MATRIX AND PRIORITY VECTOR

CRITERIA					
Alternative	Price	Availability	Delivery time	Vector alternatives	Alternative percentage
A1	0.1588	0.2125	0.1161	0.1608	16.08%
A2	0.2103	0.1967	0.1318	0.1665	16.66%
A3	0.0713	0.0555	0.0362	0.0476	4.76%
A4	0.0855	0.1190	0.1888	0.1496	14.97%
A5	0.1630	0.0779	0.1678	0.1292	12.93%
A6	0.0366	0.1612	0.0833	0.1118	11.19%
A7	0.0810	0.0498	0.0356	0.0458	4.59%
A8	0.0498	0.0903	0.0159	0.0505	5.06%
A9	0.0719	0.0201	0.0356	0.0324	3.24%
A10	0.0719	0.0170	0.1888	0.1052	10.52%
					100.00%
Priority Vector	0.093	0.423	0.484		

E. Criteria Comparison Matrix

In the design of the Criteria Comparison Matrix tool, all leather suppliers that Mana Bussines S.A.C. has had to be identified. since it is these that cause major inconveniences for returns of raw material.

The evaluation criteria were determined for the Delivery time (K01), Payment conditions (K02), Place of delivery (K03), Purchase price with IGV (K04) and Return for product guarantee(K05).

It was also weighted based on Good (10), Fair (5) and Bad (0).

TABLE XVII
CONDITIONS ACCORDING TO SELECTED CRITERIA

Evaluation criteria	Good (10pts.)	Fair (5)	Bad (0)
Delivery time	<6 days	Between 6 and 15	> 16 days
Payment conditions	Payment within 15 days	Payment against delivery	Prepaid
Place of delivery	Mana Bussines SAC warehouse	Midpoint	Supplier warehouse
Purchase price (572 m ² / month)	<10,000	Between 10,000 and 11,000	> 11,000
Return for product guarantee	Yes	-	No

Subsequently, a summary was made of the quotes of the leather suppliers according to the five selected variables.

Then the relative importance of each criterion was evaluated, developing a double entry matrix, where the importance of each of these factors is compared with the rest; the most important is identified.

TABLE XVIII
CRITERIA COMPARISON MATRIX

	K01	K02	K03	K04	K05
K01		K01	K01	K04	K05
K02			K02	K02	K05
K03				K04	K03
K04					K05
K05					

After making the Criteria Comparison Matrix, the frequency was determined for each criterion, and on this basis, the order of importance of the criteria was determined.

TABLE XIX
ORDER OF IMPORTANCE OF CRITERIA

	Frequency	%	Order
K01	2	20%	2
K02	2	20%	2
K03	1	10%	3
K04	2	20%	2
K05	3	30%	1
Total	10	100%	

Then, each supplier is scored (10, 5 or 0) based on their quotes, and weighting the scores obtained in a single final score per supplier.

Finally, an analysis is carried out on the table of suppliers and the ones with the best score are selected.

IV. RESULTS AND DISCUSSION

A. Economic Evaluation

TABLE XX
MONTHLY CASH FLOW

Month	Monthly Cash Flow
July	-S/ 2 796.46
August	S/ 2 391.05
September	S/ 2 391.05
October	S/ 2 391.05
November	S/ 2 391.05
December	S/ 2 391.05
January	S/ 2 391.05
February	S/ 2 391.05
March	S/ 2 391.05
April	S/ 2 391.05
May	S/ 2 391.05
June	S/ 2 391.05
July	S/ 2 391.05

With the application of improvements proposals, it was determined that it was viable using a Minimum Attractive Rate of Return (MARR) of 1.53%. Economic indicators such as the IRR equivalent to 85.45%, a NPV of S / 23 234 and a cost benefit of 2.86, were determining factors to indicate the economic viability of the improvement tools.

B. Results Discussion

For the first problem, the company presented the problem of warehouse clutter. This problem was solved thanks to the application of the ABC tool, which consisted of classifying materials according to their rotation or use, and it also allowed to establish an order within the warehouse. According to the indicator of % of classified materials, the company had 0% of materials classified as type A, B and C. In addition, the standard values for the use of items that the company should present according to the book *Fundamentals of Control and Inventory Management (2010)* by the author Carlos Julio Vidal Holguín are: 10% of items classified as type A, 20% of items classified as type B and 70% of items classified as type C.

The following simulated values were obtained: 66.67% of the materials were classified as type A, 16.67% of the materials were classified as type B and the other 16.67% were classified as type C. As can be seen, these simulated values are far away of the standard values that were presented previously because the company presents many materials classified as type A due to their high use and the rest of the materials are type B and C because they have less rotation or use.

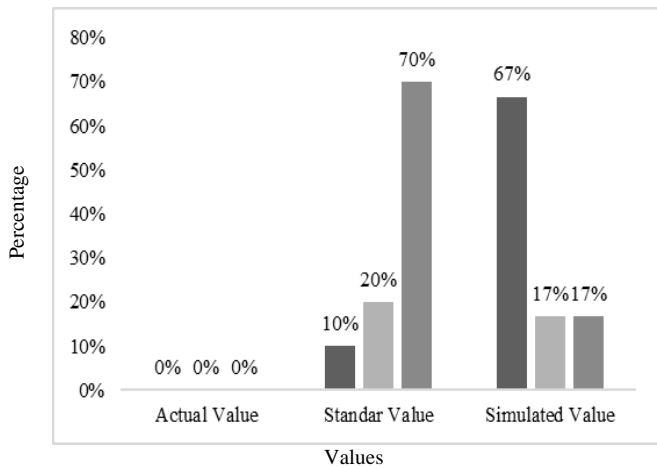


Fig. 1 Percentage of classified materials.

For the second problem, there was the presence of defective products. Based on the information collected within the company, the indicator of % of defective products could be quantified, which currently the company had a value of 2.50%, likewise, the standard value that the company should present is 0%. Since the organization must take appropriate actions based on the nature of the non-conformity and its effect on the conformity of products and services (ISO: 9001, 2015), to achieve this, the Manual of Procedures tool is applied.

It was simulated bearing in mind the current conditions of the company, obtaining a value of 1.24% of defective products.

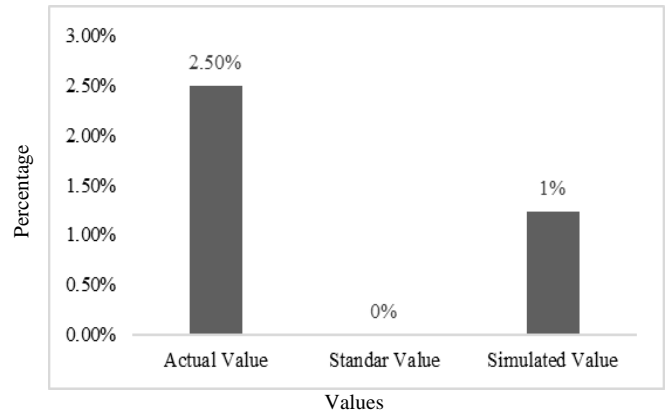


Fig. 2 Percentage of defective products.

For the third problem, initially this represented excess inventory in the materials warehouse in the company. From this, by collecting information on the problematic reality, the indicator of excess inventory % was found, which currently represented 2.74% of the total inventory value, on the other hand, the standard value that this indicator should represent in the company is 0% because the company must determine and apply the criteria and methods (including monitoring, measurements and related performance indicators) necessary to ensure the effective operation and control of these processes (ISO: 9001, 2015), that is why the Economic Order Quantity (EOQ) tool is applied in order to achieve the standard. Through the simulation in Excel taking into account the results of the EOQ, cost of ordering, cost of maintaining inventory and cost of maintaining excess inventory, it was possible to determine the percentage of excess inventory present once the tool was applied, being 0.40% excess inventory.

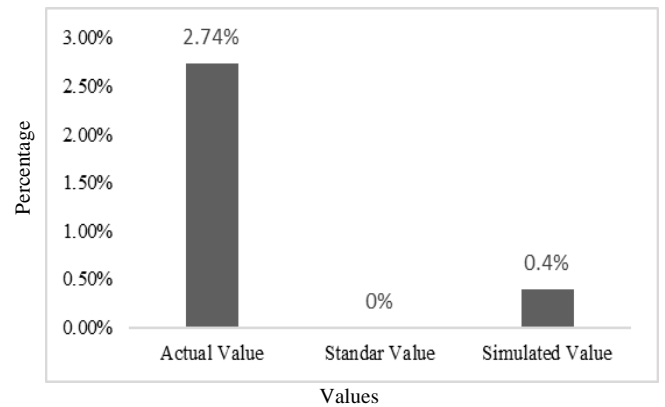


Fig. 3 Percentage of excess inventory.

For the fourth problem, production stops, this problem is caused due to shortages due to non-compliance of suppliers at the agreed date and time, based on this the indicator would be the percentage of suppliers evaluated in order to evaluate each of the different suppliers that the company has and thus make the best decision for the fulfillment of monthly production. The current situation of the company is that it has a low evaluation of its suppliers that represents 37% and according

to the ISO 9001: 2015 standard it indicates that the indicator that guarantees the optimal quality of the company's processes is 100% which would be the standard value. By applying the AHP tool, each of the suppliers is evaluated considering the price, availability, and delivery time evaluation criteria, thus achieving a simulated value of 100%.

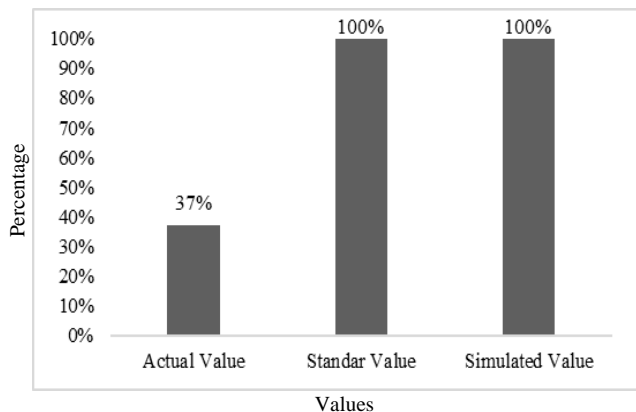


Fig. 4 Percentage of suppliers evaluated.

For the fifth problem, about the returns of materials, this is due to the lack of evaluation of the leather suppliers, which is why the percentage of returns of materials was established as an indicator for problem five, since this allows us to evaluate the amount of non-compliant raw material and make the best decisions based on it, since compliance with this is a fundamental basis for the efficient development of productive activities and not to cause delays in production. Currently, the Mana Bussines SAC company does not perform a good evaluation of its raw material suppliers, therefore it presents an indicator of 53.33%, the standard value found in the Good Marketing and Manufacturing Practices program (Version 03-2017), establishes that the ideal value of the indicator is 0% to ensure that the raw material is acquired according to the specified requirements and to achieve that value is the application of the Criteria Comparison Matrix tool.

It was simulated bearing in mind the current conditions of the company, obtaining a value of 28.58% of returns of materials. Based on the results obtained, after the simulation worked, the percentage of non-conforming raw material is minimized, the quality management system is improved through evaluations of the suppliers and their performance.

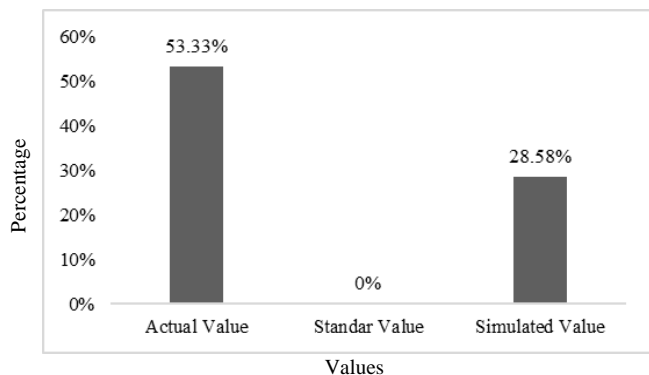


Fig. 5 Percentage of material returns.

C. Conclusions

The solution alternative consisted of the implementation of the tool's ABC, Procedures Manual, EOQ, AHP and Comparison Criteria Matrix; besides, constraints such as implementation cost, implementation time, accessibility, functionality, usability, sustainability and resistance to change. were evaluated. Also, the following appropriate engineering standards were identified: ISO 9001: 2015, Fundamentals of Control and Inventory Management (2010) and Good Marketing and Manufacturing Practices program (Version 03-2017). The impact of the implementation of the elaborated tools was evaluated, obtaining an IRR of 85.45%, a NVP of S/23,234 and a B/C of 2.86, achieving a monthly cash flow of S/2,391.05.

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