Prioritization of Machinery Replacement through Incremental Economic Analysis and FUCOM-TOPSIS in a Furniture Company in Hidalgo

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ABSTRACT

The renewal of machinery in companies with limited financial resources requires distinguishing between the economic convenience of replacing an asset and the relative priority of the available projects. This study analyzes four proposed replacements for Mobilesco con Firmeza, a furniture company located in Hidalgo, Mexico: panel saw, industrial cutoff saw, electrostatic paint booth, and electrostatic paint oven. A quantitative, non-experimental, documentary case study was developed, based on the critical review of the provided file. The procedure reconstructed the defender–challenger cash flows, calculated present value, annual worth, and incremental internal rate of return, and used the weights attributed to FUCOM to perform a TOPSIS ranking. Inconsistencies of transcription, economic thresholds, and sensitivity scenarios were also examined. The corrected results ranked the panel saw in first place, with a closeness coefficient of 0.814232, followed by the cutoff saw, the oven, and the booth. However, the four projects presented negative incremental present values at the recorded evaluation rates. The panel saw would require additional net benefits of 8,072.21 pesos per year to reach financial equilibrium. Its first position was preserved in 21 of 22 individual weight perturbations, but passed to the cutoff saw when the relative weight of capacity was increased by 20%. The hypothesis of priority for the panel saw received conditional support; that of immediate economic viability was not supported. It is concluded that the model allows organizing the review of investments, although it does not by itself justify their execution. Its definitive application requires validating the technical valuations, homologating energy consumption, and documenting the original preferences of the evaluating team.

Keywords: machinery replacement; engineering economy; FUCOM; TOPSIS; sensitivity analysis.

INTRODUCTION

Decisions about productive assets link everyday operations with multi-year financial commitments. In small and medium-sized enterprises, an acquisition concentrates resources that also sustain inventories, maintenance, and working capital. The Organisation for Economic Co-operation and Development notes that these companies represent around 99% of the business fabric of its member countries (OECD, 2023). From the investment perspective, their economic relevance makes it necessary to evaluate the use of capital and the capacity to sustain disbursements, especially in contexts of restrictive financing (OECD, 2024).

In Mexico, the definitive results of the 2024 Economic Censuses identified 5,468,180 economic units of the private sector and parastatal enterprises, referring to the activity of 2023. Microenterprises represented 95.4% of that universe, employed 41.4% of the occupied personnel, and contributed 16.0% of the gross census value added (Instituto Nacional de Estadística y Geografía [INEGI], 2025a). These proportions describe a national context; they do not establish the classification of the studied company, whose number of workers and sales is not documented in the file. The distinction is necessary because the statistical frameworks on financing use specific coverages (OECD, 2024).

The financial restriction can also be dimensioned without automatically attributing it to all productive units. For Mexico, the OECD (2024) reports that approximately 29.6% of the MSMEs in the ENAFIN 2021 framework, integrated by companies with six workers or more, accessed some source of financing between 2019 and 2021. The same report records an average credit rate to MSMEs of 14.26% in 2022. These are dated antecedents, not current quotations nor the rate of the analyzed company; their utility consists in contextualizing the sensitivity of investments to the cost of resources (Sullivan et al., 2020).

In manufacturing, the choice of equipment incorporates dimensions that are not expressed by the purchase price. The literature on machinery selection includes economic, technical, and operational attributes that may conflict (Hagag et al., 2023). A machine with lower disbursement may offer less capacity, while another may require training or additional installations. Research on equipment replacement also identifies residual value, maintenance, and operating conditions as relevant components of the decision, although the importance of each depends on the studied context (Alshibani et al., 2024).

Approaching the analysis to Hidalgo, the census registers 142,566 economic units and 502,740 occupied persons in the private sector and parastatal enterprises during 2023. Manufacturing concentrated 117,341 jobs, equivalent to 23.3% of the total, and 50.7% of the state gross census value added (INEGI, 2025b). This concentration places the management of industrial assets in a relevant regional sphere, although it does not allow inferring the performance of a particular company. Table 1 delimits these indicators against the case data; the need to preserve that distinction also derives from the coverage differences of business statistics (OECD, 2024).

Table 1. Territorial context and investment of the case

Scope and period	Indicator	Value
Mexico, 2023	Private and parastatal economic units	5,468,180
Hidalgo, 2023	Private and parastatal economic units	142,566
Hidalgo, 2023	Occupied personnel of the same universe	502,740
Manufacturing of Hidalgo, 2023	Occupied personnel; state participation	117,341; 23.3%
Manufacturing of Hidalgo, 2023	Participation in state GVA	50.7%
Mobilesco, file without date	Sum of prices of four challengers	MXN 688,000
Mobilesco, file without date	Sum of incremental disbursements	MXN 430,500

Note. Own elaboration based on INEGI (2025a, 2025b) and Amador Pérez and Baños Escamilla (s. f.). GVA = gross census value added. Census data describe territorial universes; case amounts are calculations from the file and not census statistics.

That context leads to the specific problem of Mobilesco con Firmeza, a family furniture company located in Hidalgo. The source manuscript presents four projects: renewing a panel saw, a cutoff saw, a booth, and an electrostatic paint oven. Their proposed prices sum $688,000 and their incremental disbursements, discounting the market values of the defenders of the main scenario, sum $430,500. These calculations derive from the file of Amador Pérez and Baños Escamilla (s. f.); interpreting them as capital allocation alternatives requires separating each functional defender–challenger comparison from the subsequent ranking among projects (Sullivan et al., 2020).

The problem does not consist solely of identifying the equipment with the highest rating. The file declares a resource constraint, but does not quantify the available budget, the additional contribution margin, or the installation costs. It also combines five- and ten-year horizons and contains discrepancies between tables and figures (Amador Pérez & Baños Escamilla, s. f.). Under those conditions, recommending a purchase by its relative position may confuse a multicriteria preference with value creation; both evaluations respond to different questions and need explicit rules (Dahlquist & Knight, 2022).

To address the first question, financial equivalences are used: present value gathers the flows at the initial moment and annual worth expresses them as a uniform series comparable within each functional pair (Sullivan et al., 2020). The incremental internal rate of return identifies the return on the additional capital committed to

replacing the defender. Its interpretation depends on the pattern of flows and a minimum reference rate, so a positive IRR does not constitute, by itself, evidence of economic acceptance (Dahlquist & Knight, 2022).

The second question requires making the preferences of the decision team explicit. FUCOM proposes obtaining weights from importance comparisons and evaluating their consistency (Pamučar et al., 2018). Once the weights are fixed, TOPSIS produces an order according to the distances to ideal profiles. In this study, that ranking is used as support for the review of projects, with special attention to normalization, because different data transformations can modify the results of a multicriteria model (Krishnan et al., 2023).

The proposed contribution is a reproducible review of a case whose original order favored the panel saw, but whose financial justification and traceability required corrections. It is not claimed that the FUCOM–TOPSIS combination is new nor that its use guarantees superior decisions in any company. The gap addressed is documentary and operational: establishing which conclusions remain when correcting signs, recalculating equivalences, and varying preferences. That delimitation links the scope of the question with the available data (Creswell & Creswell, 2022) and avoids attributing automatic validity to a single ranking (Avramova et al., 2025).

Objective and Working Hypotheses

The general objective is to evaluate the economic convenience and the conditional priority of four machinery replacements in Mobilesco con Firmeza through incremental analysis and FUCOM–TOPSIS weighting. The specific objectives are: O1, reconstruct the flows and determine PV, AW, and incremental IRR; O2, recover and order the available FUCOM weights; O3, calculate and contrast the TOPSIS classification; and O4, identify through sensitivity the assumptions and thresholds that modify the recommendation. The design articulates observable objectives with delimited evidence, following Creswell and Creswell (2022), while the financial acceptance rules are linked to the equivalences of Sullivan et al. (2020).

H1 is formulated: with the corrected economic data, the reported weights, and the available technical valuations, the panel saw obtains the highest TOPSIS coefficient among the four projects. Its contrast consists of verifying $C_1 > C_2$, C_3, and C_4. H1r is added: the panel saw retains the first place against each individual variation of ±20% in the eleven weights, after renormalizing them. These are analytical hypotheses formulated during the case review, not preregistered hypotheses; therefore, independent confirmation or population significance is avoided (Creswell & Creswell, 2022; Krishnan et al., 2023).

As a complementary contrast, H2 is posed: the best-classified project satisfies $\Delta PV \geq 0$ at the recorded minimum rate. The necessary data are incremental investment, annual savings, differential salvage, horizon, and discount rate. If ΔPV is negative, H2 receives no support, even if H1 does. This separation allows testing the managerial claim that really matters: whether the first project in the ranking can be recommended for immediate investment with the documented monetary benefits (Sullivan et al., 2020; Dahlquist & Knight, 2022).

LITERATURE REVIEW

Asset Replacement and Capital Allocation

The renewal of a machine must be analyzed with respect to an explicit reference alternative. In a replacement study, the defender is the available equipment and the challenger represents the substitution proposal. The market value of the defender constitutes an opportunity cost if retaining it implies forgoing its sale (Sullivan et al., 2020). Consequently, the analysis needs to distinguish historical disbursements from the flows affected by the current decision; that separation also supports the evaluation of projects through incremental cash flows (Dahlquist & Knight, 2022).

In the studied case, the panel saw and the oven do not perform the same function, so comparing them as if they were direct substitutes would eliminate essential information. Each challenger first competes with its own defender; afterwards, the projects can compete for resources. The economic treatment of that allocation differs

from a choice between equivalent equipment (Sullivan et al., 2020). In turn, a multicriteria approach can help organize heterogeneous attributes, provided that what is being compared and for what purpose remains visible (Hagag et al., 2023).

The research of Alshibani et al. (2024), conducted on heavy construction equipment in Saudi Arabia, provides an antecedent of integration of quantitative and qualitative criteria. Its scope is not the furniture of Hidalgo and its weights are not transferred to the present case. Complementarily, Hagag et al. (2023) review applications of multicriteria methods to machinery selection in manufacturing and construction. Both antecedents justify examining multiple attributes, but do not substitute the verification of the flows nor the particular preferences of Mobilesco.

The joint application of weighting and ranking has antecedents close to the industrial problem. Sofuoğlu (2020) combined three variants of FUCOM with fuzzy TOPSIS and WASPAS to select non-conventional manufacturing processes. In another context, Çevik Aka (2025) studied material handling equipment in an automotive plant with nine experts and fourteen criteria; the acquisition price, loading and unloading speed, and adaptability stood out in its evaluation. These works support the usefulness of making preferences explicit, but their weights respond to different operations and do not constitute transferable parameters to Mobilesco.

The stability of a classification also deserves its own examination. Shanmugasundar et al. (2023) compared six decision methods in three industrial robot selection problems, which illustrates the value of contrasting results under different rules. Dhalmahapatra et al. (2022), for their part, integrated RFUCOM and RTOPSIS in an analysis of manufacturing failure modes. Both antecedents broaden industrial applications, although they do not automatically validate the replacement studied here: in this case a deterministic formulation is used and its sensitivity to weights, signs, and redundant attributes is checked.

Weighting and Quality of Comparisons

FUCOM distinguishes between ordering criteria and quantifying the importance differences between them. For k ordered criteria it uses $k - 1$ consecutive comparisons and transitive consistency restrictions (Pamučar et al., 2018). However, having a weight vector does not prove that the procedure was executed correctly. In this manuscript, the weights are conserved as reported results of the file, while the partial recovery of the comparisons prevents certifying the consistency deviation of the entire hierarchy. The review by Avramova et al. (2025) also underlines the dependence of several methods on expert judgment.

The weight of a variable and its effective influence are not equivalent. An almost constant column differentiates the alternatives little, while a column with large dispersion can affect the distances more, even with moderate weighting. This property derives from the geometric structure of TOPSIS (Hwang & Yoon, 1981). Moreover, Krishnan et al. (2023) examine how normalization influences the result; therefore, in this review the transformation used is declared and the same rule is maintained in all comparable scenarios.

Redundancy of Indicators and Interpretation Limits

PV and AW represent the same flow under two equivalent expressions when rate and horizon are fixed. Incorporating them together with investment and operation requires recognizing a possible overweighting of the monetary dimension (Sullivan et al., 2020). In the case matrix they are not proportional across all rows, because the rates and horizons differ, but they still share information. This dependence is examined through a scenario that excludes PV and AW; the analysis of related criteria is relevant because the independence assumed by additive or distance models may not hold in industrial systems (Avramova et al., 2025).

Likewise, a TOPSIS coefficient is not the probability of success of a purchase. It is a relative measure constructed with the chosen alternatives, weights, and rules (Hwang & Yoon, 1981). A change of scale or of the comparison set can alter the distances; it does not correspond to interpret 0.80 as 80% profitability nor as statistical confidence. This precaution determines the way of presenting the results and of comparing scenarios, in congruence with the evidence on sensitivity to normalization (Krishnan et al., 2023).

METHODOLOGY

Study Design and Scope

The research is applied, quantitative, non-experimental, and documentary, with a single case study. The provided manuscript is reanalyzed, without attributing to this review new field visits, interviews, or plant measurements. The source contains four replacement projects and their valuations, not a random sample of companies. According to Creswell and Creswell (2022), the design must correspond to the evidence; therefore, the scope is to evaluate coherence and sensitivity of a procedure, based on the file of Amador Pérez and Baños Escamilla (s. f.).

The methodology of Figure 1 follows a reproducible sequence: depurate inputs, reconstruct flows, verify economic acceptance, normalize preferences and attributes, calculate TOPSIS, and contrast scenarios. The two branches respond to complementary questions: the first examines whether the replacement creates value and the second organizes priorities under declared preferences. The combination is pertinent for a case with observable costs and heterogeneous technical attributes, provided that the multicriteria result does not substitute the financial acceptance criterion (Sullivan et al., 2020; Hagag et al., 2023).

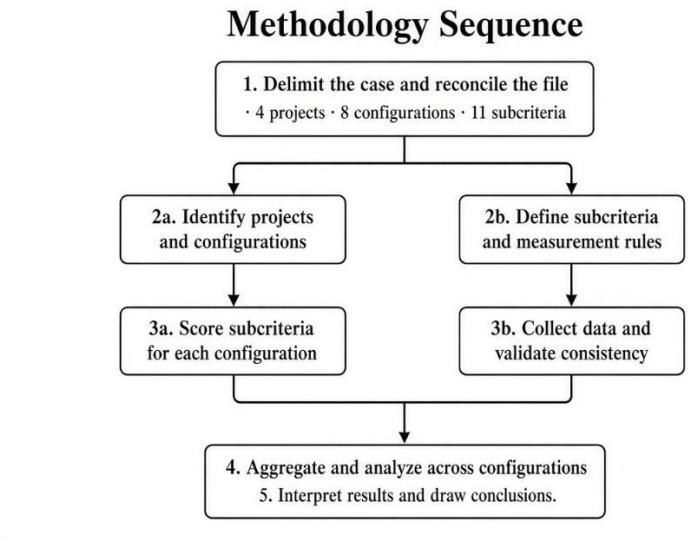


Figure 1. Sequence of the methodology applied to the case

Note. Own elaboration of the procedure of this research, based on the equivalences of Sullivan et al. (2020), the weighting of Pamučar et al. (2018), and the multicriteria selection reviewed by Hagag et al. (2023). The financial and multicriteria branches are integrated in the conclusion.

Sources and file depuración

The review distinguished input data, calculations, and interpretive statements. Tables inserted as images were reconstructed as editable tables; numbers were not accepted for coinciding with a screenshot. Concordant entries between tables and incremental flows were prioritized, and outputs were recalculated with full precision. The procedure seeks traceability from the source of Amador Pérez and Baños Escamilla (s. f.) to the financial equivalences and avoids rounding factors before obtaining the final result (Sullivan et al., 2020). Table 2 documents the discrepancies and the rule applied to each one.

Table 2. Detected inconsistencies and treatment in the review

Element	Data from source file	Treatment applied
Panel saw, defender value	$55,500 in table and $55,000 in a paragraph	Uses $55,500, consistent with ΔP = $103,500.
Panel saw, challenger AW	$38,403.20 in figure; matrix	Recalculated: −$32,475.88 per year.

	compatible with defender AW	
Booth, defender value	$95,000 in table; $145,000 in diagram	Base $95,000; alternative scenario $145,000.
Booth, IRR	−12.19% in flow; positive sign in TOPSIS	Negative incremental IRR is conserved.
Number of subcriteria	Five economic, three technical, three operational	Work is done with eleven subcriteria.
FUCOM weight and rank	Some ranks do not correspond to the weights	Rank is recalculated without changing proportions.
Bibliography	Final list on medicine, foreign to the content	Replaced by pertinent and verified sources.
Capacity and energy	Normalized profiles without verifiable comparable units	Conserved as inherited profiles and limits are declared.

Note. Audit of the manuscript of Amador Pérez and Baños Escamilla (s. f.). The corrections do not equate to validating the primary records of the company.

Economic Assumptions and Variables

All amounts are expressed in Mexican pesos. It is assumed that operation and maintenance occur at the close of each year and that salvage is received at the end of the horizon, simultaneously with the last operating flow. The model is deterministic and pre-tax; it does not incorporate inflation, financing, installation, or working capital due to lack of breakdown. Those exclusions delimit the result and do not mean that the concepts lack importance in a definitive evaluation (Sullivan et al., 2020; Dahlquist & Knight, 2022). Table 3 gathers the inputs used in the four comparisons.

Table 3. Consolidated economic data of the four pairs

Equipment	Option	P or current value	Annual CO&M	Salvage	Years	Rate
Panel saw	Defender	55,500.00	12,000.00	28,000.00	5	15%
Panel saw	Challenger	159,000.00	2,100.00	115,000.00	5	15%
Cutoff saw	Defender	49,000.00	14,800.00	18,000.00	10	10%
Cutoff saw	Challenger	172,000.00	5,300.00	98,000.00	10	10%
Booth	Defender	95,000.00	28,800.00	40,000.00	10	10%
Booth	Challenger	172,000.00	35,000.00	98,000.00	10	10%
Oven	Defender	58,000.00	32,000.00	18,000.00	10	10%
Oven	Challenger	185,000.00	18,000.00	55,000.00	10	10%

Note. Own elaboration based on Amador Pérez and Baños Escamilla (s. f.). Monetary amounts in MXN.

Present Value and Opportunity Cost

The present value allows locating all flows at t = 0. An explicit convention is adopted: negative outflows and positive inflows. For an alternative that provides a service with initial cost P, uniform annual outflow C, and salvage S, the result is calculated by means of the following equation. The equivalence corresponds to engineering economy analysis (Sullivan et al., 2020), while its interpretation as the difference of discounted inflows and outflows is consistent with Dahlquist and Knight (2022).

$$PV = -P - C[(1 - (1 + i)^{-n})/i] + S(1 + i)^{-n}$$

The symbols have a concrete function: P is the market value of the defender or the price of the challenger; C

gathers annual costs; i is the effective annual rate; n represents years and S the salvage. A negative PV does not automatically imply that providing the service is inconvenient: here common revenues were omitted. The valid comparison requires observing which configuration costs less in equivalent terms and, especially, calculating the difference between them, with the data from the file (Amador Pérez & Baños Escamilla, s. f.; Sullivan et al., 2020).

$$\Delta PV = PV_r - PV(D) = -(P_r - P(D)) + (C(D) - C_r)(P/A, i, n) + (S_r - S(D))(P/F, i, n)$$

In the panel saw, retaining the defender implies forgoing selling it for $55,500. Changing it requires $159,000, so the incremental commitment amounts to $103,500; not to $159,000 plus the historical cost of the installed machine. The documented annual savings is $9,900 and the additional salvage is $87,000. These three components explain the evaluation: the savings and the final recovery must compensate the additional capital at the required return (Amador Pérez & Baños Escamilla, s. f.; Dahlquist & Knight, 2022).

Annual Worth and Operational Meaning

The annual worth converts a PV into an equivalent uniform series. The capital recovery factor distributes the present value among the n periods considering interest, so it does not equate to dividing PV by n. This difference prevents confusing the indicator with accounting depreciation or with an outflow that will necessarily appear each year. It is an economic equivalence for comparing service alternatives, calculated with a defined temporal base (Sullivan et al., 2020; Dahlquist & Knight, 2022).

$$AW = PV(A/P, i, n) = PV[i(1 + i)^n / ((1 + i)^n - 1)]$$

To express the results as positive costs, $EUAC = -AW$ is defined, whenever the analyzed flow is of net costs. The lower EUAC represents the least costly alternative of the pair. In contrast, $\Delta AW = AW_r - AW(D)$ conserves the sign of ΔPV and allows identifying how much additional annual benefit would be needed to justify the change. This reading will be applied to the four projects without confusing the AW of the defender with that of the challenger, a discrepancy present in the original matrix of the panel saw (Amador Pérez & Baños Escamilla, s. f.; Sullivan et al., 2020). The conversion factors are presented in Table 4.

Table 4. Equivalence factors used without intermediate rounding

Parameters	P/A	P/F	A/P
15% and 5 years	3.352155	0.497177	0.298316
10% and 10 years	6.144567	0.385543	0.162745

Note. Own calculation by means of the equivalence equations. The factors are shown to six decimals only for presentation.

Incremental Internal Rate of Return

The incremental IRR is the rate r that nullifies ΔPV. Instead of calculating an isolated rate for each cost asset, the challenger minus defender flow is constructed: additional negative investment at the beginning, operating savings during the life, and differential salvage at the close. The four flows of the main scenario have a single sign change, although the booth accumulates outflows until its final recovery. An economically interpretable root is calculated in each case and contrasted with the required rate (Sullivan et al., 2020; Dahlquist & Knight, 2022).

$$0 = -\Delta P + \Sigma_{t=1}^{n} [(C(D) - C_r)/(1 + r)^t] + \Delta S/(1 + r)^n$$

The booth needs particularly careful treatment: its operating costs increase from $28,800 to $35,000, so the incremental annual flow is −$6,200. The last year receives $58,000 of differential salvage, but also pays the additional operating cost; the net terminal flow is $51,800. The resulting root is negative. Changing it to positive within TOPSIS alters the economic meaning of the indicator and artificially favors the project

(Amador Pérez & Baños Escamilla, s. f.; Dahlquist & Knight, 2022). Table 5 shows the incremental flows year by year.

Table 5. Complete annual incremental cash flows of the challenger minus defender

Year	Panel saw	Cutoff saw	Booth	Oven
0	-103,500.00	-123,000.00	-77,000.00	-127,000.00
1	9,900.00	9,500.00	-6,200.00	14,000.00
2	9,900.00	9,500.00	-6,200.00	14,000.00
3	9,900.00	9,500.00	-6,200.00	14,000.00
4	9,900.00	9,500.00	-6,200.00	14,000.00
5	96,900.00	9,500.00	-6,200.00	14,000.00
6	N/A	9,500.00	-6,200.00	14,000.00
7	N/A	9,500.00	-6,200.00	14,000.00
8	N/A	9,500.00	-6,200.00	14,000.00
9	N/A	9,500.00	-6,200.00	14,000.00
10	N/A	89,500.00	51,800.00	51,000.00

Note. Own elaboration based on Amador Pérez and Baños Escamilla (s. f.). Monetary amounts in MXN.

Figures 2–5 reconstruct the twelve cash flow diagrams: four defenders, four challengers, and four incremental differences. Each arrow is located in the period of occurrence; outflows are oriented downward and inflows upward. In the final period the salvage is conserved separately from the operating flow to make its contribution visible. Year zero of the defender represents the market value sacrificed by retaining it, while the incremental discounts that sale from the challenger's disbursement (Amador Pérez & Baños Escamilla, s. f.; Sullivan et al., 2020).

Weights and FUCOM Specification

The file organizes eleven subcriteria in three groups: five economic, three technical, and three operational. Therefore, a model of nine criteria is not described. The transcribed global weights sum 1.0000242 due to precision and rounding; they are normalized by means of $w_j = GW_j/\Sigma GW_j$. This conserves the proportions between preferences and does not equate to repeating the FUCOM estimation. The provenance of the vector remains linked to the file and to the method that it declares having used (Amador Pérez & Baños Escamilla, s. f.; Pamučar et al., 2018).

Table 6 recovers the comparisons of the three dimensions that can be read in the original FUCOM sheet. The codes E1–E3 identify records of the file, not participants interviewed in this review. To avoid confusing a reconstruction with a new consultation, Figure 6 shows the link between hierarchy, local weights, and global weights; Table 7 conserves the eleven aggregated results and allows verifying their normalization (Amador Pérez & Baños Escamilla, s. f.; Pamučar et al., 2018).

Table 6. Recovered FUCOM comparisons for the main dimensions

Record	Declared order	φ_{12}	φ_{23}	φ_{13}	C1	C2	C3
E1	C1 > C2 > C3	2	1.5	3	0.5455	0.2727	0.1818
E2	C1 > C3 > C2	2	1.5	3	0.5455	0.1818	0.2727
E3	C2 > C1 > C3	2	1.5	3	0.2727	0.5455	0.1818
Average	Weights by dimension	—	—	—	0.4545667	0.3333333	0.2121000

Note. Transcription of the dimension comparisons and aligned weights readable in the FUCOM sheet of Amador Pérez and Baños Escamilla (s. f.). C1 = economic; C2 = technical; C3 = operational. φ expresses priority between positions of the order, not between fixed codes. The averages reproduce the rounded weights

of the file. The remaining subcriteria comparisons are not transcribed as certain data due to insufficient readability; their aggregated weights are conserved in Table 7.

Table 7. Criteria and reported and normalized FUCOM weights

Code	Subcriterion	Group weight	Local weight	GW source	w corrected	Rank
C1.1	CO&M	0.4545667	0.0876	0.0398200	0.039819	11
C1.2	Challenger EUAC	0.4545667	0.1217	0.0553208	0.055319	9
C1.3	Incremental IRR	0.4545667	0.1338	0.0608210	0.060820	7
C1.4	Investment	0.4545667	0.4380	0.1991002	0.199095	1
C1.5	Present cost	0.4545667	0.2190	0.0995501	0.099548	3
C2.1	Capacity	0.3333333	0.5455	0.1818333	0.181829	2
C2.2	Useful life	0.3333333	0.1818	0.0606000	0.060599	8
C2.3	Reliability	0.3333333	0.2727	0.0909000	0.090898	5
C3.1	Energy	0.2121000	0.3333	0.0706929	0.070691	6
C3.2	Safety	0.2121000	0.4545	0.0963995	0.096397	4
C3.3	Ease	0.2121000	0.2121	0.0449864	0.044985	10

Note. Global and local weights transcribed from the manuscript. w = GW/1.0000242. The products of rounded weights may differ slightly from the reported GW. The original consistency of FUCOM is not accredited.

Evaluation Matrix and TOPSIS Normalization

The economic indicators are reconstructed with attributes of the challenger and with the incremental IRR of the project. Operation and maintenance, EUAC, price, and absolute present cost are minimized; the IRR conserves its sign and is maximized. For the non-financial attributes the published normalized profiles are retained, without inventing production or consumption units. The subsequent vector normalization absorbs the common positive scale of each column, but does not correct problems of meaning or measurement of the original data (Hwang & Yoon, 1981; Krishnan et al., 2023). Table 8 identifies the preference sense and the values of each criterion.

Table 8. Corrected input matrix for conditional prioritization

Criterion	Sense	Panel saw	Cutoff saw	Booth	Oven
CO&M	Cost	2,100.00	5,300.00	35,000.00	18,000.00
Challenger EUAC	Cost	32,475.88	27,143.16	56,843.16	44,656.90
Incremental IRR	Benefit	6.7809	4.9358	-12.1862	5.5264
Investment	Cost	159,000.00	172,000.00	172,000.00	185,000.00
Present cost	Cost	108,864.20	166,782.96	349,276.61	274,397.33
Capacity	Benefit	0.492366	0.615457	0.369274	0.492366
Useful life	Benefit	0.410997	0.410997	0.575396	0.575396
Reliability	Benefit	0.585206	0.468165	0.468165	0.468165
Energy	Cost	0.201942	0.201942	0.677657	0.677657
Safety	Benefit	0.615457	0.492366	0.492366	0.369274
Ease	Benefit	0.650945	0.390567	0.390567	0.520756

Note. Own elaboration. Economic columns in MXN, MXN/year, and % as appropriate. Capacity, useful life, reliability, energy, safety, and ease are inherited dimensionless profiles; not reconstructed physical measurements.

For each criterion j, $r_{ij} = x_{ij}/\sqrt{\Sigma_i x_{ij}^2}$ and $v_{ij} = w_j r_{ij}$ are calculated. The normalization conserves signs; therefore the negative IRR of the booth remains negative. When the negative PV is used as a benefit, its equivalent transformation to positive cost must be accompanied by the inversion of the preference sense. The present review uses $|PV_r|$ as cost, so that a lower equivalent disbursement is favorable (Hwang & Yoon, 1981; Sullivan et al., 2020).

$$D_i^+ = \sqrt{\Sigma_j (v_{ij} - v_j^+)^2} \quad D_i^- = \sqrt{\Sigma_j (v_{ij} - v_j^-)^2} \quad C_i = D_i^-/(D_i^+ + D_i^-)$$

The positive ideal takes the maximum weighted of the benefits and the minimum of the costs; the negative ideal applies the inverse rule. The distances are calculated with the eleven components and the order is established from highest to lowest C_i. The selection of vector normalization allows reproducing the source matrix, but is not presented as the only admissible transformation. Sensitivity is examined maintaining that choice to isolate the effect of corrections and weightings (Hwang & Yoon, 1981; Krishnan et al., 2023).

Contrast and Sensitivity Protocol

Three verification blocks were defined: reproduction of the published ranking; economic recalculation and correction of signs; and variation of assumptions. The first block allows identifying differences due to the algorithm, the second examines input errors, and the third checks dependence on preferences. Results are compared within each scenario, without treating their coefficients as a common cardinal scale. The contrast logic corresponds to explicit analytical hypotheses and to the need to examine the stability of the method (Creswell & Creswell, 2022; Krishnan et al., 2023). Local perturbations multiply one weight at a time by 0.8 and 1.2 and renormalize the complete vector; 22 scenarios are generated. Equal weights, exclusion of energy consumption, joint exclusion of PV and AW, and economic participations of 30% and 60% are also examined. A purely technical and operational scenario is added. The resulting frequencies describe this deterministic grid; they do not represent probabilities that a machine is the best in the population (Pamučar et al., 2018; Creswell & Creswell, 2022).

RESULTS AND DISCUSSION

Review of the Financial Results

The recalculation identifies negative incremental PVs in the four projects. The panel saw records −$27,059.29; the cutoff saw, −$33,783.15; the booth, −$92,734.81; and the oven, −$26,710.96. Each amount compares the challenger with its defender under the horizon and the rate of its own pair. Consequently, the documented monetary benefits do not justify the replacements in the main scenario, although the possibility of omitted benefits that still need to be measured remains (Amador Pérez & Baños Escamilla, s. f.; Sullivan et al., 2020). Table 9 allows contrasting the indicators of each defender with those of its challenger.

Table 9. Recalculated present value, annual worth, and IRR

Project	Option	PV	AW per year	Incremental IRR
Panel saw	Defender	-81,804.91	-24,403.68	—
Panel saw	Challenger	-108,864.20	-32,475.88	—
Panel saw	Increment	-27,059.29	-8,072.21	6.7809%
Cutoff saw	Defender	-132,999.81	-21,645.11	—
Cutoff saw	Challenger	-166,782.96	-27,143.16	—
Cutoff saw	Increment	-33,783.15	-5,498.05	4.9358%
Booth	Defender	-256,541.80	-41,751.00	—
Booth	Challenger	-349,276.61	-56,843.16	—
Booth	Increment	-92,734.81	-15,092.16	-12.1862%
Oven	Defender	-247,686.37	-40,309.82	—
Oven	Challenger	-274,397.33	-44,656.90	—
Oven	Increment	-26,710.96	-4,347.09	5.5264%

Note. Own elaboration based on Amador Pérez and Baños Escamilla (s. f.). Monetary amounts in MXN.

The recalculated incremental IRRs are 6.7809%, 4.9358%, −12.1862%, and 5.5264%, respectively. The panel saw does not reach its 15% reference, and the other three projects do not reach 10%. The conclusion derives from the comparison with the required return, not from ordering positive rates from highest to lowest. Thus, the panel saw may present the highest IRR in the group and, simultaneously, not cover its opportunity cost of capital (Sullivan et al., 2020; Dahlquist & Knight, 2022).

Detailed Interpretation of the Panel Saw

The panel saw offers the highest proportional reduction in CO&M of the file: it goes from $12,000 to $2,100 per year, equivalent to 82.5%. However, the $9,900 savings over five years has a present value of $33,186.34 at 15%; the incremental salvage of $87,000 is equivalent to $43,254.38 at the initial moment. Both components sum to $76,440.71 against $103,500 of additional investment. The difference explains the negative incremental PV without resorting to an abstract interpretation of the indicator (Amador Pérez & Baños Escamilla, s. f.; Sullivan et al., 2020).

The equivalent annual cost of the defender is $24,403.68 and that of the challenger, $32,475.88. Substituting implies an additional equivalent annual charge of $8,072.21. This result corrects two inconsistencies in the base file: one figure showed $38,403.20 for the challenger and the TOPSIS matrix incorporated a magnitude compatible with the defender's AW. The error is not merely typographical, because the column participates in the distance to the ideal and modifies the proximity coefficient (Amador Pérez & Baños Escamilla, s. f.; Hwang & Yoon, 1981).

The panel saw can justify its acquisition if it generates other net benefits not included in CO&M, but those benefits must be demonstrated. The amount of $8,072.21 per year functions as a threshold, keeping the other assumptions. If a benefit comes from less waste, it corresponds to measure avoided material and its cost; if it comes from greater production, there must be demand and incremental margin. The technical improvement becomes a financial justification only when its contribution can be incorporated into the flows in a consistent manner (Sullivan et al., 2020; Dahlquist & Knight, 2022).

Industrial Cutoff Saw and Paint Oven

The cutoff saw reduces CO&M from $14,800 to $5,300, an annual savings of $9,500 and a reduction of 64.19%. Its incremental investment of $123,000 and differential salvage of $80,000 produce an IRR of 4.9358%, lower than the required 10%. The annual gap amounts to $5,498.05. Its good multicriteria profile does not eliminate that difference; it only indicates that it deserves consideration within the set of alternatives subject to the declared preferences (Amador Pérez & Baños Escamilla, s. f.; Sullivan et al., 2020).

The oven saves $14,000 annually in CO&M, but requires $127,000 additional at the beginning and recovers $37,000 of differential salvage in the tenth year. Its ΔAW is −$4,347.09 and the IRR reaches 5.5264%. It is the smallest annual gap of the four pairs under the recorded parameters, although it occupies the third multicriteria place. This divergence shows why the magnitude of additional benefit required and the TOPSIS position must be informed separately (Dahlquist & Knight, 2022; Hwang & Yoon, 1981).

Paint Booth and Defender Discrepancy

The booth increases CO&M by 21.53% with respect to the defender. Even without discount, the incremental sum is −$81,000: $77,000 are disbursed at the beginning, $62,000 of additional operating outflows accumulate, and $58,000 are received at the close. The negative IRR is consistent with that pattern, and its sign cannot be replaced by the absolute value. The correction transforms its position with respect to the financial ideal, although the project already occupied the last place in the original order (Amador Pérez & Baños Escamilla, s. f.; Dahlquist & Knight, 2022).

If the correct value of the defender were $145,000, the incremental investment would be reduced to $27,000.

In that scenario, ΔPV would be −$42,734.81, the annual gap $6,954.89, and the IRR approximately −7.2341%. The magnitudes change importantly, but not the conclusion of economic rejection at 10%. This exercise does not resolve which figure is true: it identifies the scope of the inconsistency and allows prioritizing its documentary verification before a definitive decision (Amador Pérez & Baños Escamilla, s. f.; Sullivan et al., 2020).

Economic Thresholds for Reconsidering the Replacements

The additional net annual equilibrium benefit is obtained as $B^* = -\Delta AW$ when $\Delta AW < 0$. Another way of closing the gap is to reduce the price of the challenger keeping everything else: $P_r^* = P_r + \Delta PV$. They are indifference conditions with respect to retaining the defender, not observed market prices nor guaranteed savings. Both expressions come from clearing the terms of the incremental flow, in accordance with the equivalences used (Sullivan et al., 2020; Dahlquist & Knight, 2022). The thresholds by project are gathered in Table 10.

Table 10. Conditional thresholds of financial equilibrium

Project	ΔP	Annual CO&M savings	Extra benefit B*	Limit price
Panel saw	103,500.00	9,900.00	8,072.21	131,940.71
Cutoff saw	123,000.00	9,500.00	5,498.05	138,216.85
Booth	77,000.00	-6,200.00	15,092.16	79,265.19
Oven	127,000.00	14,000.00	4,347.09	158,289.04

Note. Own calculation. $B^* = -\Delta AW$ and $P_r^* = P_r + \Delta PV$. Thresholds before taxes, with all other parameters constant; they are not quotations nor observed benefits.

Table 11. Sensitivity of the incremental present value to common rates

Annual rate	Panel saw	Cutoff saw	Booth	Oven
0%	33,000.00	52,000.00	-81,000.00	50,000.00
5%	7,528.60	-530.46	-89,267.79	3,819.08
10%	-11,951.06	-33,783.15	-92,734.81	-26,710.96
15%	-27,059.29	-55,546.92	-93,779.65	-47,591.41
20%	-38,929.59	-70,251.07	-93,626.00	-62,329.68

Note. Calculated scenarios. The panel saw conserves a five-year horizon and the other projects ten. The values do not represent a comparison in a unique horizon.

Original Order and Corrected Order

The numerical reproduction of the original matrix recovers the published coefficients: approximately 0.718178 for the panel saw, 0.668531 for the cutoff saw, 0.273680 for the booth, and 0.335985 for the oven. This confirms the arithmetic coherence of the algorithm with that matrix, but not the correction of its inputs. An implementation can be reproducible and, at the same time, incorporate an IRR with wrong sign or an AW of a different alternative (Amador Pérez & Baños Escamilla, s. f.; Hwang & Yoon, 1981).

Upon correcting the IRR of the booth and recalculating the economic indicators, the panel saw obtains 0.814232; the cutoff saw, 0.788071; the oven, 0.544137; and the booth, 0.132068. The order is conserved, but the distance between the first two is reduced to 0.026161. It does not correspond to affirm that the correction "improved" the real performance of the panel saw: it changed the geometry of the comparison. This distinction prevents interpreting differences between scenarios as observed productivity or profitability gains (Hwang & Yoon, 1981; Krishnan et al., 2023).

Table 12. Published ranking and corrected result

Project	Original C	Corrected D+	Corrected D−	Corrected C	Rank
Panel saw	0.718177	0.024750	0.108483	0.814232	1
Cutoff saw	0.668531	0.027348	0.101696	0.788071	2
Booth	0.273679	0.113161	0.017219	0.132068	4
Oven	0.335984	0.064225	0.076661	0.544137	3

Note. Original coefficients of the file and own recalculation. Changes between scenarios are not observed changes in industrial performance.

Sensitivity of the Investment Priority

The panel saw maintains the first place with equal weights, without energy, and without PV and AW. In this last scenario, the separation from the cutoff saw is reduced to approximately 0.005929, which indicates a narrow preference when part of the redundant economic information is eliminated. That result does not prove that PV and AW should always be excluded; it shows how much the margin between alternatives depends on the specification chosen for this case (Sullivan et al., 2020; Avramova et al., 2025). Table 18 allows comparing the seven weighting configurations.

Table 13 Structural scenarios of multicriteria sensitivity

Scenario	Panel saw	Cutoff saw	Booth	Oven	First
Base	0.814232	0.788071	0.132068	0.544137	Panel saw
Equal weights	0.886933	0.791723	0.109536	0.604013	Panel saw
Without energy	0.806470	0.778239	0.137458	0.583517	Panel saw
Without PV and AW	0.795594	0.789665	0.146874	0.583362	Panel saw
Only technical operational	0.668712	0.721008	0.206931	0.342297	Cutoff saw
Economic 60%	0.877140	0.816329	0.100897	0.595673	Panel saw
Economic 30%	0.740427	0.752154	0.171158	0.458697	Cutoff saw

Note. Own calculation. All weights are renormalized after modifying or removing criteria. The coefficients must be interpreted within their scenario.

Explicit contrast of the Hypotheses

H1 receives support within the main scenario because 0.814232 exceeds the coefficients of the other three projects. H1r is not sustained in its universal formulation: the capacity +20% scenario is enough for the panel saw to cease being first. The adequate conclusion is a priority conditioned to the preferences, with stability in a good part of the local grid and an identifiable limit. The contrast is analytical and posterior to the review of the file, without pretension of independent confirmation (Creswell & Creswell, 2022; Amador Pérez & Baños Escamilla, s. f.). Table 19 synthesizes the contrast rules and their result.

H2 receives no support: the best-classified project registers $\Delta PV = -\$27{,}059.29$ and IRR = 6.7809%, against a minimum rate of 15%. The practical alternative hypothesis is that the multicriteria first place is not enough to authorize the purchase with the documented flows. To modify that conclusion, additional net benefits, a reduction of investment, or sustained changes of other parameters are required; it is not enough to raise the weight of the favorable attributes of the equipment (Sullivan et al., 2020; Dahlquist & Knight, 2022).

Table 14. Analytical contrast of the hypotheses

Hypothesis	Verifiable criterion	Result	Conclusion
H1 Base priority	$C_1 > C_2$, C_3 and C_4	0.814232 > 0.788071; 0.132068; 0.544137	Supported in the main scenario.
H1r Universal local	First place in the 22	First in 21/22; second with	Not supported as a universal

robustness	individual changes	capacity +20%	affirmation.
H2 Immediate viability	ΔPV of the first option ≥ 0	Panel saw: −$27,059.29; IRR 6.7809% < 15%	Not supported with documented flows.

Note. Own deterministic contrast. p-values or confidence intervals are not calculated, because the hypotheses do not refer to a probabilistic sample.

Implications for the Company

The immediate decision supported by the analysis is to continue the evaluation of the panel saw and the cutoff saw and to conserve a financial rule prior to any authorization. The panel saw has the best profile under the inherited weights, but its annual gap requires evidence of additional savings or contributions. The cutoff saw gains priority when capacity acquires greater importance. These two evaluation routes can coexist without affirming that the resources are sufficient for any purchase, since the amount of the budget is not documented (Amador Pérez & Baños Escamilla, s. f.; Sullivan et al., 2020).

The capital restriction cannot be reduced to "buy the first in the ranking" either. If later a budget B is known and several projects are economically acceptable, the company will need to select a feasible portfolio. Moreover, the booth and the oven could interact within the painting process; that dependence is not quantified. The integration of criteria is useful for discussing priorities, but does not replace an analysis of compatibility, restrictions, and interactions between investments (Sullivan et al., 2020; Hagag et al., 2023).

In terms of safety, the relative score does not demonstrate that an asset meets acceptable conditions. The file lacks a risk evaluation by machine; therefore, it is not inferred that retaining a defender is safe solely because its cost is lower. If a condition that obliges intervening is identified, a feasibility restriction must be incorporated and compared among acceptable options. That application avoids that a monetary advantage unduly compensates a non-negotiable operating condition (Alshibani et al., 2024; Avramova et al., 2025).

Data necessary to strengthen the validation

The next stage must close concrete gaps: confirm market values, quotations, and salvages; break down maintenance and energy; record conforming units, downtime, and waste; and document the original FUCOM comparisons. The following table proposes variables and forms of measurement, without presenting them as already collected data. This protocol derives from the problems detected in the file and allows aligning each future conclusion with observable evidence (Amador Pérez & Baños Escamilla, s. f.; Creswell & Creswell, 2022). Table 20 concretizes the variables, measurements, and foreseen uses.

Table 15. Variables to document for a subsequent business validation

Variable	Proposed measurement	Use in the decision
Total investment	Dated quotation with transport, installation, and training	Recalculate ΔP and budgetary restriction.
Market value and salvage	Appraisals or comparable quotations with date and condition	Resolve discrepancies and terminal sensitivity.
Operation and maintenance	Logs and invoices by period with separated concepts	Validate net savings without duplicating energy.
Production and quality	Conforming units per hour and rejection proportion	Estimate incremental benefits with verifiable demand.
Availability	Scheduled hours, downtime hours, and cause	Link reliability with avoidable losses.
Energy	kWh per conforming unit and production mix	Homologate the functional base of the criterion.
Safety	Identification of hazards and controls by equipment	Define restrictions prior to criteria compensation.
FUCOM preferences	Identity and function of evaluators;	Verify origin, consistency, and

	comparisons and χ	agreement of the weights.
Financing	Cost of capital, conditions, taxes, and budget	Update rates and value feasible portfolio.

Note. Methodological proposal of this review. None of these additional measurements is presented as performed.

Limitations and Scope of the Results

The first limitation is documentary: the amounts were taken from a manuscript and not from invoices, appraisals, or verifiable accounting records. The second is temporal: the date of the quotations or a homogeneous price base is not specified. The third affects the weighting algorithm: it was not possible to reconstruct the complete expert comparisons. These limitations do not prevent reproducing the calculations exposed here, but restrict the strength of a purchase recommendation (Amador Pérez & Baños Escamilla, s. f.; Pamučar et al., 2018).

Moreover, maintaining different rates and horizons affects the transversal interpretation of PV, and using inherited technical profiles limits construct validation. The exercise does not optimize a portfolio, does not model probabilistic uncertainty, and does not estimate performance after the investment. Its contribution consists of identifying errors, distinguishing acceptance criteria, and exposing conditions that modify the priority. Therefore, the results must be accompanied by the matrices and rules that allow repeating them, instead of being presented as a universal solution (Sullivan et al., 2020; Creswell & Creswell, 2022).

CONCLUSION

The general objective was achieved within the documentary scope of the study. O1 produced verifiable flows and equivalences for the four pairs; O2 allowed recovering the structure and normalizing the available weights, although not certifying the complete FUCOM consultation process; O3 established the corrected classification; and O4 identified conditions that change its first position and the financial equilibrium thresholds. Therefore, the objective of evaluating and conditionally prioritizing was resolved, while the business validation of inputs and preferences remains pending; this distinction maintains correspondence between what was proposed, what was executed, and the available evidence (Creswell & Creswell, 2022; Amador Pérez & Baños Escamilla, s. f.).

The integration of the defender–challenger analysis with FUCOM–TOPSIS allows distinguishing two results that the original file did not separate with sufficient clarity. The panel saw occupies the first place under the corrected matrix, but none of the four replacements satisfies financial acceptance at the recorded rates. The ranking serves to order the technical and economic review; the authorization of investment requires closing the monetary gaps with evidence and verifying operational feasibility (Sullivan et al., 2020; Hwang & Yoon, 1981).

The hypothesis of priority of the panel saw is sustained in the main scenario, while its absolute robustness is discarded in the face of an increase in the weight of capacity. The hypothesis of immediate viability is also not supported: $8,072.21 annual of additional net benefit are needed to balance its replacement. These results do not weaken the purpose of the study; they specify when the recommendation would be defensible and what information could change it. The scope of the conclusion remains circumscribed to the data and scenarios examined (Creswell & Creswell, 2022; Dahlquist & Knight, 2022).

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