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1 A MULTI-CRITERIA DECISION-MAKING FRAMEWORK FOR PRODUCTIVITY MEASUREMENT IN CALIBRATION FACILITIES BASED ON OMAX AND AHP

Abstract

Calibration facilities are required to maintain measurement accuracy while meeting operational targets; however, productivity monitoring is often fragmented because multiple performance ratios must be evaluated simultaneously. This study proposes a multi-criteria decision-making framework that integrates the Objective Matrix (OMAX) for productivity measurement with the Analytical Hierarchy Process (AHP) for deriving ratio weights, applied as a case study in the Calibration & Measurement Facility of an automotive manufacturing company. AHP pairwise comparisons (aggregated using the geometric mean) were used to prioritize four productivity ratios, producing weights of 0.30 (R1), 0.40 (R2), 0.23 (R3), and 0.06 (R4), with a strong consistency result (CR = 0.004 < 0.10), indicating reliable judgments. The resulting weights were embedded into OMAX scoring to compute monthly productivity indices for January–July 2025. The OMAX results show substantial fluctuations: productivity decreased in January (−46%), improved sharply in February (+109.67%), dropped again in March (−79%) and April (−60%), recovered in May (+16%), peaked in June (+204%), and declined in July (−28%). Overall, the integrated OMAX–AHP framework provides a transparent and consistent way to (i) weight productivity ratios based on expert priorities and (ii) track productivity dynamics over time, supporting managerial diagnosis and targeted improvement in calibration operations.

Keywords: Objective Matrix (OMAX); Analytical Hierarchy Process (AHP); productivity measurement; multi-criteria decision making; calibration facility; manufacturing operations.

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Introduction: 2 Productivity measurement has become a central managerial requirement as organizations face stronger pressure to 3 deliver faster, more reliable, and more cost-effective services while maintaining compliance and risk control. In 4 highly regulated technical environments, productivity cannot be interpreted only as “output volume”, but must reflect multi-dimensional performance such as timeliness, resource efficiency, service quality, and conformance to standards so that improvement decisions are evidence-based and defensible. Contemporary performance measurement literature also emphasizes the need for measurement systems that are adaptable to uncertainty and dynamic operational contexts, rather than relying on single indicators or static reporting routines [1]. Calibration facilities represent a special case of productivity management. Besides operational targets (throughput, turnaround time, utilization), calibration laboratories must ensure metrological traceability and measurement reliability, which are fundamental to the credibility and comparability of results. Traceability is not merely an administrative requirement; it is a technical chain linking measurements to standards with known uncertainties, and different traceability chains can directly affect measurement uncertainty and risk exposure [2]. In practice, calibration facilities often struggle to balance the competing needs of maintaining technical competence, managing calibration schedules, controlling cost, and meeting customer expectations especially under accreditation frameworks such as ISO/IEC 17025, where competence, impartiality, and consistent operation are explicitly required and audited [3]. Empirical and review-based studies in the ISO/IEC 17025 context show that operational performance improvement is tightly connected to systematic management practices and critical success factors (CSFs), including process control, competence management, documentation discipline, and continual improvement mechanisms [3].

2 Given this multi-constraint environment, productivity measurement in calibration facilities requires tools that can (i) incorporate multiple operational criteria, (ii) convert heterogeneous indicators into a single interpretable index, and (iii) assign criterion importance transparently. The Objective Matrix (OMAX) method is widely used to convert multiple productivity ratios into a structured matrix score and aggregate them into a productivity index, enabling organizations to detect which criteria drive performance deterioration or improvement over time. Recent applied studies show

OMAX can support partial-to-total productivity analysis and can be paired with structured improvement actions [4]. However, OMAX requires weighting of criteria; if weighting is ad-hoc, the resulting productivity index may be questioned and less useful as a decision basis. To address this, Analytical Hierarchy Process (AHP) offers a rigorous multi-criteria decision-making mechanism for deriving weights through pairwise comparisons, making the weighting logic explicit and auditable. Recent applications integrating OMAX and AHP demonstrate that the combined approach improves interpretability: OMAX provides the scoring and index structure, while AHP provides defensible weights reflecting expert priorities [4], [5]. A key methodological requirement in AHP is the consistency of expert judgments; recent research confirms the central role of consistency evaluation (e.g., consistency ratio thresholds) to ensure that pairwise comparisons are reliable enough to support valid weighting outcomes [6]. Therefore, this study proposes a multi-criteria decision-making framework for productivity measurement in calibration facilities by integrating OMAX and AHP. The framework is designed to: (1) structure productivity indicators relevant to calibration operations, (2) compute a composite productivity index using OMAX, and (3) derive criterion weights using AHP with consistency checking, thereby strengthening the transparency and defensibility of improvement decisions. This approach is expected to be particularly relevant for calibration facilities operating under ISO/IEC 17025-driven demands for reliable, traceable, and consistent service delivery [3], while still pursuing operational efficiency and resource optimization [7]. Related Works and Literature Review: Recent work suggests that productivity is no longer treated as a single, straightforward construct. Instead, researchers increasingly view it as a multi-dimensional outcome shaped by the realities of modern industrial operations. In many settings, productivity cannot be explained by output and labor alone; it is also influenced by quality performance, reliability, risk controls, and the demands of regulatory compliance[1]. In response, performance measurement has gradually moved toward approaches that combine operational metrics with expert judgment, so that “what matters” in practice is captured alongside what is easiest to count[7]. Using

OMAX for productivity measurement

3 The Objective Matrix (OMAX) method remains widely used when organizations need to evaluate productivity across several ratios at once. Its strength lies in the way it structures scoring and consolidates different indicators into a single index, which makes productivity changes easier to monitor over time. Recent empirical studies report that OMAX has been applied in both manufacturing and service environments to trace productivity shifts, reveal bottlenecks, and identify areas where improvement efforts should be prioritized[4], [5]. Kotimah and Aryanny, for instance, show that OMAX can highlight underperformance in specific dimensions even when total output appears unchangeduseful for managerial diagnosis rather than simple reporting. A recurring point in the literature, however, is that OMAX results depend heavily on the weighting scheme used for the productivity ratios. When weights are selected arbitrarily or without a clear rationale, the resulting index can become difficult to justify and less persuasive for managerial decision-making[5]. This concern has motivated researchers to integrate OMAX with more formal multi-criteria decision-making (MCDM) techniques, where the logic behind weighting can be made explicit[8].

3 Integrating AHP into productivity and performance assessment

Among MCDM methods, the Analytical Hierarchy Process (AHP) is one of the most commonly adopted tools for assigning weights to performance criteria. AHP works by structuring the decision problem into a hierarchy and deriving priority weights from pairwise comparisons. In practice, this allows expert judgments to be used in a disciplined way rather than informally. Recent studies indicate that AHP-based weighting can strengthen the transparency and robustness of productivity evaluation, particularly when multiple indicators must be reconciled into a single assessment[6]. Putri and Sahbana report that introducing AHP into productivity analysis makes the weighting process more systematic and improves confidence in the conclusions drawn from the model. Salomon et al. also emphasize the importance of checking the consistency ratio (CR) to ensure that expert comparisons are logically coherent and 74 therefore defensible. Taken together, these findings support pairing AHP with OMAX, especially in contexts where 75 decisions are subject to scrutiny and must be clearly justified[9], [10]. 76 Productivity measurement in calibration facilities and ISO/IEC 17025 77 Calibration and measurement facilities face a different set of constraints compared with typical production units. 78 Beyond efficiency targets, calibration laboratories must manage uncertainty, maintain traceability, and comply with 79 international standards such as ISO/IEC 17025. Recent evidence highlights that metrological traceability has 80 practical and strategic implications because it shapes measurement risk, operational credibility, and customer 81 trust[2]. 82 Studies on ISO/IEC 17025-accredited laboratories further suggest that strong operational performance is closely 83 associated with systematic management practicessuch as standardized procedures, competence management, and 84 continuous improvement routines[3]. Velásquez et al. also show that calibration planning plays a meaningful role in 85 productivity outcomes, affecting turnaround times and overall resource utilization. 86 Even so, much of the existing work in calibration settings tends to focus on scheduling optimization, compliance 87 assessment, or uncertainty analysis, rather than integrated productivity measurement frameworks. Comparatively 88 few studies combine productivity indexing with structured weighting methods specifically for calibration facilities. 89 This gap indicates the need for an approach that evaluates operational productivity and technical performance 90 together within a single, coherent framework[11], [12]. 91 Research gap and study contribution 92 Three gaps stand out. First, although OMAX is widely accepted for productivity measurement, many applications 93 still rely on subjective or ad-hoc weighting. Second, while AHP is well established for multi-criteria weighting, its 94 integration with productivity index models in calibration contexts remains limited. Third, empirical productivity 95 studies centered on calibration facilities are still relatively scarce, despite the critical role these facilities play in 96 safeguarding measurement reliability and overall industrial quality[13], [14]. 97 2 To address these gaps, this paper proposes an integrated productivity measurement framework for calibration 98 facilities based on OMAX and AHP. The approach combines OMAX scoring with AHP-derived weights and consistency testing, offering a clearer rationale for weighting, stronger methodological discipline, and more actionable results for managers[15], [16]. This is particularly relevant for ISO/IEC 17025-oriented environments, where productivity decisions must be balanced against reliability requirements and regulatory expectations. Methods:

Research Design

4 This study employs a quantitative case study to measure and monitor productivity performance in a Calibration & Measurement Facility within an automotive manufacturing company. The proposed framework integrates the Objective Matrix (OMAX) method to compute a composite productivity index and the Analytical Hierarchy Process (AHP) [1] to determine the relative importance (weights) of productivity ratios (criteria). This integration is intended to improve objectivity and transparency by combining ratio-based measurement with a structured multi-criteria weighting approach. The methodological stages include: (1) identifying productivity ratios relevant to calibration activities, (2) deriving ratio weights using AHP, (3) converting ratio achievements into standardized OMAX scores and computing productivity indices, and (4) analyzing productivity trends across the observation period. Case Study and Data Collection Operational data were obtained as historical records for the calibration unit covering January–July 2025, consisting of calibration output, defect counts, number of workers, and total working hours. The dataset includes monthly calibration output (units), defect (units), number of workers (persons), and working hours (hours). In addition to operational data, expert judgments were collected using structured pairwise-comparison questionnaires to support AHP weighting among the four productivity ratios. The pairwise comparisons were later aggregated using the geometric mean to obtain a single comparison matrix. Productivity Ratios Definition The OMAX criteria in this study are defined as four productivity ratios reflecting effectiveness, efficiency, and quality in calibration operations. The ratios are aligned

with the calibration context: R1 effectiveness, R2 labor efficiency, R3 time efficiency, and R4 quality/defect. Let, for month t: Q_t: number of instruments successfully calibrated (output) P_t: number of instruments planned/scheduled for calibration L_t: number of workers involved H_t: total working hours used D_t: number of calibration defects/nonconforming results Based on the operational meaning described in the dataset processing section (output vs plan, output per labor, output per hour, and defects as quality indicator), the ratios are formulated as: (1) Effectiveness ratio (R1) $R1_t = \frac{Q_t}{P_t}$

(2) Labor efficiency ratio (R2) $R2_t = \frac{Q_t}{L_t}$ (3) Time efficiency ratio (R3) $R3_t = \frac{Q_t}{H_t}$ (4) Quality/defect ratio (R4) cost criterion Because R4 represents defect/quality (higher defects indicate poorer quality), it is treated as a cost-type criterion: $R4_t = \frac{D_t}{Q_t}$ The monthly computed ratio values for January–July 2025 are provided in the ratio processing results table. Analytical Hierarchy Process (AHP) for Weighting AHP Hierarchy The AHP structure consists of: Goal: determine ratio weights for productivity measurement Criteria: $R1, R2, R3, R4$ (productivity ratios) A supporting explanation of the hierarchy (including sub-criteria such as calibration output, workers, hours, and defect) is provided as the basis for constructing the pairwise matrix. Pairwise Comparison and Aggregation Experts compare criteria using Saaty's scale (1–9). The individual matrices are aggregated into a single matrix using the geometric mean, as shown by the geometric mean weighting table. Let the aggregated pairwise comparison matrix be: $\boldsymbol{A} = [a_{ij}]$, $a_{ij} > 0$, $a_{ji} = \frac{1}{a_{ij}}$ Priority Weights Weights are derived by normalizing the matrix and averaging row priorities (or equivalently approximating the principal eigenvector). The final criterion weights used for OMAX weighting are: $\boldsymbol{w} = [w_{R1}, w_{R2}, w_{R3}, w_{R4}] = [0.30, 0.40, 0.23, 0.06]$ These weights are reported as the ratio-weight output used in OMAX computation. Consistency Test Judgment consistency is verified using:

6 $CI = \lambda max - n\ n - 1$, $CR = CI\ RI$ where n is the number of criteria and RI is the Random Index. The calculated values are λmax=4.010, CI=0.003, and CR=0.004, and the weighting is accepted because CR<0.1. Objective Matrix (OMAX) Productivity Measurement OMAX Scoring Scale (0–10) and Level Setting OMAX converts each ratio achievement into a standardized score (0–10), where level 0 represents the worst performance, level 3 is the standard/average, and level 10 is the best/target. The level table for each ratio (R1–R4) is defined and used as the scoring reference in OMAX computation. Let $x_{i,t}$ be the actual value of ratio i in month t. Let W_i, S_i, and T_i denote the worst (level 0), standard (level 3), and target/best (level 10) values for ratio i. Because the OMAX scale is based on these three anchors, the score $s_{i,t}\in[0,10]$ can be computed by linear interpolation: Benefit-type criteria (higher is better): $i\in\{R1,R2,R3\}$ $s_{i,t}$ = 0, $x_{i,t} \le W\ i$ $3 \cdot x_{i,t} - W\ i\ s_i - W\ i$, $W\ i < x_{i,t} < S_i$ $3 + 7 \cdot x_{i,t} - S_i\ T\ i - S_i$, $S_i \le x_{i,t} < T\ i$

10, $x_{i,t} \ge T\ i$ Cost-type criterion (lower is better): $R4$ $s_{R4,t}$ = 10, $x_{R4,t} \le T\ R4$ $3 + 7 \cdot SR4 - x_{R4,t}\ SR4 - T\ R4$, $T\ R4 < x_{R4,t} \le SR4$ $3 \cdot W\ R4 - x_{R4,t}\ W\ R4 - SR4$, $SR4 < x_{R4,t} < W\ R4$

0, $x_{R4,t} \ge W\ R4$ Composite OMAX Performance Score After scoring, the monthly OMAX performance score is computed as the weighted sum of the ratio scores: $Performance_t = w_i\ s_{i,t}$ 4 i=1 where w_i denotes the AHP-derived weight of ratio i and s_i, t is the OMAX score (0–10) of ratio i in month t. Productivity Index (PI) Based on Reference Score To facilitate interpretation, the productivity index (PI) is expressed as the percentage deviation of the monthly OMAX performance score from the standard reference value (baseline = 300):

7 PI_t % = $Performance_t$ − 300 300 × 100% Accordingly, negative PI values indicate performance below the reference level, rather than negative productivity. The absolute OMAX performance score $Performance_t$ remains non-negative because it is derived from weighted scores mapped onto a 0–10 scale. The reference value of 300

represents the standard OMAX performance level, corresponding to normal operating 179 conditions. This baseline allows productivity performance to be expressed as a relative deviation from the standard 180 level, facilitating intuitive interpretation of overperformance and underperformance. 181 Month-to-Month Performance Variation 182 Month-to-month dynamics are reported as the percentage change in the OMAX performance score: 183 $\Delta Performance_t = \frac{Performance_t - Performance_{t-1}}{Performance_{t-1}} \times 100\%$ Integrated OMAX–AHP Framework 184 The integrated framework uses AHP to provide validated criterion weights and OMAX to provide standardized 185 scoring and a composite index. The calibration context emphasizes that OMAX indicators include output, defects, 186 labor, and working time, and each is weighted based on its influence on total productivity. 187 Flow Diagram 188 The workflow starts by collecting monthly operational data from the calibration facility, including calibration 189 output, defect counts, the number of workers, and total working hours. These data are used to compute the 190 productivity ratios (R1–R4) representing effectiveness, labor efficiency, time efficiency, and quality/defect 191 performance. Expert judgments are then gathered to build the AHP pairwise comparison matrices, which are 192 aggregated using the geometric mean. Criterion weights are subsequently derived and validated through a 193 consistency test (CR < 0.10). Next, OMAX performance levels are specified and each ratio achievement is 194 converted into a standardized score. The monthly OMAX performance score is then obtained through weighted 195 scoring, and it is finally expressed as a productivity index (PI) relative to the reference value (baseline = 300) to 196 support trend analysis and managerial decision-making. 197

8 198 Figure 1. Workflow of the proposed OMAX–AHP productivity measurement framework. 199 Data Processing Tools 200 All computations (ratio calculations, AHP weighting and consistency checking, OMAX scoring, and productivity 201 index computation) were implemented using spreadsheet-based tools to ensure traceability and reproducibility. 202 Results and Discussion: 203 Results 204 AHP Weighting Results 205

The Analytic Hierarchy Process (AHP) was used to translate expert judgments into a clear set of weights for the four productivity ratios (R1–R4). The weighting results assign 0.30 to R1 (effectiveness), 0.40 to R2 (labor efficiency), 0.23 to R3 (time efficiency), and 0.06 to R4 (quality/defect). This weighting pattern suggests that, in the context of the calibration facility, labor efficiency (R2) is viewed as the primary driver of productivity, with effectiveness (R1) and time efficiency (R3) playing secondary roles, while the defect ratio (R4) contributes relatively less to the overall assessment. The consistency test supports the soundness of these judgments. The analysis produced λmax = 4.010, CI = 0.003, and CR = 0.004, which is far below the commonly accepted threshold of 0.10. Therefore, the pairwise comparisons are considered consistent, and the resulting weights can be confidently applied in the subsequent OMAX calculations. OMAX Productivity Index Results Using the weights obtained from AHP, we then applied the Objective Matrix (OMAX) method to compute the calibration facility′s monthly productivity index for January–July 2025. The resulting performance scores and productivity indices are reported in Table 1. Table 1. Monthly OMAX performance score, productivity index PI (%) based on baseline 300, and month-to-month performance change (Jan–Jul 2025) Start / Research Objective Productivity Measurement in Calibration Facility Monthly Operational Data Collection • Calibration output (Qt) • Number of defects (Dt) • Number of workers (Lt) • Total working hours (Ht) Productivity Ratios Computation • R1 = Qt / Pt (Effectiveness) • R2 = Qt / Lt (Labor efficiency) • R3 = Qt / Ht (Time efficiency) • R4 = Dt / Qt (Quality/defect – cost) Expert Judgment Acquisition • Pairwise comparison of R1–R4 • Saaty scale (1–9) AHP Pairwise Matrix Aggregation • Geometric mean of expert judgments • Priority vector (weights) calculation Consistency Evaluation (AHP) • CI and CR calculation • Accept weights if CR < 0.10 OMAX Level Determination • Level 0 : Worst performance • Level 3 : Standard performance • Level 10: Target performance • Linear interpolation OMAX Scoring for Each Ratio • Convert R1–R4 into scores (0–10) • Benefit & cost criteria handling Composite OMAX Performance Score $Performance_t = \sum (w_i \times s_{i,t})$ Productivity Index (PI) ⟦PI⟧

$_t\ (\%) = (\llbracket Performance \rrbracket_t - 300)/300 \times 100\%$ Productivity Evaluation & Decision Support for Management Improvement

9 Month (2025) OMAX Performance Score Productivity Index (PI, %) Performance change vs. previous month (%) January 162 −46.00 - February 629 109.67 288.27 March 63 −79.00 −89.98 April 120 −60.00 90.48 May 348 16.00 190.00 June 912 204.00 162.07 July 215 −28.00 −76.43 The productivity results fluctuate markedly across the observation period. The strongest performance was recorded in June, when the productivity index reached 204%, showing a pronounced improvement relative to the reference level. By contrast, productivity fell to its lowest point in March, with an index of −79%, suggesting that the facility experienced its most severe operational shortfall during that month. Productivity Trend Analysis The month-to-month results show pronounced swings, which suggests that productivity in the calibration facility is highly responsive to day-to-day operational conditions. The most notable improvement occurred between January and February, when productivity rose by 288.27%, pointing to a rapid rebound from a weak starting point possibly driven by better workload handling, staffing alignment, or smoother process execution. The trend then reversed sharply from February to March, with productivity dropping by 89.98%, representing the steepest decline observed during the study period. After March, the pattern becomes one of intermittent recovery followed by renewed decline. Productivity improved from April to May, surged strongly in June, and then fell again in July. Taken together, these movements indicate that productivity was not sustained at a stable level over time. Instead, it appears to be shaped by shifting performance across key drivers' effectiveness, labor utilization, time efficiency, and quality/defect outcomes. Overall, these findings underline the practical value of the integrated OMAX–AHP approach: it does not only summarize performance into a single index, but also makes it possible to track productivity dynamics clearly, identifying both high-performing periods and critical downturns that merit managerial attention. Discussion The findings suggest that the proposed

OMAX–AHP integrated framework can capture productivity changes in a 242 calibration facility within an automotive manufacturing setting in a meaningful way. By pairing a ratio-based 243 productivity measure (OMAX) with a transparent, multi-criteria weighting procedure (AHP), the approach offers a 244 clearer and more informative picture than relying on a single productivity indicator. 245 Interpretation of AHP Weighting Results 246 The AHP results place labor efficiency (R2) as the strongest contributor to the overall productivity assessment, 247 followed by effectiveness (R1) and time efficiency (R3), while the defect ratio (R4) receives the smallest weight. 248 This pattern is in line with recent work in productivity and operations management, which consistently highlights 249 workforce utilization as a major determinant of performance in technical service settings especially when outcomes 250 depend on specialized skills, tacit knowledge, and expert judgment. 251

10 In a calibration facility, labor efficiency has practical consequences: it shapes throughput, influences turnaround 252 time, and ultimately affects service reliability. The relatively large weight assigned to R2 therefore suggests that 253 shifts in staffing availability, skill mix, or workload allocation are more likely to drive productivity swings than 254 short-term changes in defect rates. This interpretation also fits the broader ISO/IEC 17025 context, where 255 competence management and effective deployment of qualified personnel are frequently emphasized as key 256 conditions for sustaining both operational performance and compliance. 257 It is also important to interpret the low weight of R4 carefully. A smaller weight does not mean quality is ignored; 258 rather, it may indicate that defect levels are comparatively less variable than the other drivers over the period 259 observed. In accredited calibration environments, defect-related outcomes are often constrained by standardized 260 procedures, verification steps, and quality assurance controls. As a result, defects may contribute less to short-term 261 productivity variation than factors related to labor and process execution, even though quality remains fundamental 262 to the integrity of calibration services. 263 Analysis of OMAX Productivity

Fluctuations

The OMAX analysis shows pronounced month-to-month swings, suggesting that productivity in the calibration facility is highly dependent on operational conditions. The improvement observed in February points to a period when resources were used more effectively and the process ran with better coordination. In contrast, the sharp drop in March highlights how quickly productivity can deteriorate when the operation is disrupted whether due to workload imbalance, staffing limitations, or less effective scheduling. The strong performance recorded in June illustrates what the facility can achieve when the main productivity drivers especially labor efficiency and effectiveness are managed well. However, the declines that follow high-performing periods indicate that these gains are not yet consistently maintained. This pattern suggests that productivity improvements may still depend on temporary conditions rather than being supported by stable control practices or standardized routines that sustain performance over time. Overall, the observed fluctuation aligns with recent discussions in the technical service and operations literature, which note that productivity improvements often occur in bursts unless they are reinforced by continuous monitoring, structured feedback, and disciplined follow-up actions. In this regard, the integrated OMAX–AHP framework is useful not only for tracking when performance rises or falls, but also for clarifying which criteria are most responsible for the changes making it easier to focus managerial attention on the true drivers of variation.

Contribution of the Integrated OMAX–AHP Framework

Compared with using OMAX on its own, combining it with AHP strengthens the methodological foundation of the analysis. The integration replaces subjective or ad-hoc weighting with a structured procedure, supported by a consistency check, so the weighting decisions are easier to justify. This matters in calibration facilities, where productivity evaluations can carry practical consequences for example, informing resource allocation, shaping improvement priorities, and supporting management reviews in environments aligned with ISO/IEC 17025. The integrated approach also makes the results easier to act on. OMAX produces a single productivity index, but AHP clarifies the logic behind that index by showing which ratios matter most and how strongly they influence the 287 overall score. With this added transparency, managers can concentrate improvement efforts on the highest-impact 288 levers such as workforce deployment and process effectiveness rather than spreading attention evenly across all 289 indicators. This type of “measurement plus prioritization” aligns with broader multi-criteria decision-making 290 perspectives that emphasize turning performance data into actionable guidance. 291 Finally, applying the OMAX–AHP framework in a calibration facility contributes to the productivity measurement 292 literature by extending it beyond the settings where it is most commonly tested (e.g., production lines or output293

11 oriented manufacturing processes). Calibration operations are technically constrained and quality-critical by design, 294 and demonstrating that the framework remains usable in this context helps broaden the empirical evidence for 295 OMAX–AHP integration. 296 Managerial Implications 297 From a practical standpoint, the results imply that productivity improvement in calibration facilities is likely to 298 benefit most from stronger labor-efficiency management for example, balancing workloads, aligning tasks with staff 299 competencies, and improving scheduling. Using the proposed framework to track productivity over time also helps 300 managers spot early signs of performance deterioration, so corrective actions can be taken before issues escalate. 301 Beyond day-to-day operations, the framework can function as a structured decision-support aid for management 302 reviews, internal audits, and continuous improvement initiatives. Because the weighting 1 process is transparent and 303 supported by a consistency check, the resulting productivity assessment is easier to explain and defend both to 304 internal stakeholders and, when needed, to external auditors. 305 2 Limitations and Future Research 306 While this study offers useful insights, several limitations should be noted. First, the findings are drawn from a 307 single facility and cover only a seven-month period, so the results may not fully represent productivity behavior in 308 other calibration settings or over longer time horizons. Second, the weighting stage depends on expert

judgments. Although the consistency test indicates that these judgments are coherent, the priorities may still reflect local conditions, practices, or managerial preferences specific to the case context. Future work could strengthen and extend the framework in several ways. Applying it over a longer period and across multiple calibration facilities would allow more robust comparisons and improve generalizability. Methodologically, the framework could also be expanded using approaches such as fuzzy AHP or other hybrid MCDM techniques to better account for uncertainty in expert assessments. Finally, connecting productivity indices with additional outcomessuch as measurement uncertainty indicators and customer satisfaction measures would provide a more comprehensive view of calibration performance and its operational impact.

Conclusion: This study developed and implemented an integrated OMAX–AHP framework to quantify and interpret productivity performance in a calibration facility within an automotive manufacturing setting. The main motivation was to strengthen conventional productivity measurement by addressing one of its most common weaknesses how criterion weights are assigned. By combining OMAX with AHP, the weighting stage becomes more transparent and defensible, rather than relying on informal or purely subjective judgment. The AHP results highlight labor efficiency as the most influential contributor to productivity, followed by effectiveness and time efficiency, while the defect ratio plays a comparatively smaller role in the overall index. The consistency test confirms that the underlying expert comparisons are coherent, which supports the credibility of the resulting weight structure. When incorporated into OMAX, these weights produce productivity indices that are straightforward to interpret and useful for tracking month-to-month performance movements. Across the January–July 2025 period, the OMAX analysis shows clear fluctuations, including marked improvements and sharp downturns. This pattern indicates that productivity in calibration operations is sensitive to changing operational conditions particularly how resources are utilized and how work is organized. A practical advantage of the proposed approach is that it helps managers go beyond simply noting that productivity has changed. It also clarifies which criteria are most responsible for the change, making it easier to prioritize corrective actions and focus improvement efforts on the most influential drivers.

12 From an implementation standpoint, the framework functions as a structured decision-support tool for calibration and measurement facilities working under technical and regulatory requirements such as ISO/IEC 17025. Because it links operational records to an explicit weighting logic, the output can support routine performance reviews, internal audit discussions, and continuous improvement programs especially in environments where performance judgments must be clearly explained and justified. Several limitations should be acknowledged. The study is based on a single case and a relatively short observation window, which may constrain broader generalization. In addition, although AHP includes a consistency check, the weights still reflect expert priorities that may be shaped by local practices and contextual conditions. Future research could apply the framework across multiple facilities and longer time horizons, or extend it using advanced MCDM variants (e.g., fuzzy or hybrid approaches) to better accommodate uncertainty and operational variability. Even with these limitations, the present 2 findings indicate that the OMAX–AHP integration provides a practical, credible, and effective approach for productivity measurement and monitoring in calibration operations.

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