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Quantitative Modeling of the Structural Determinants of QHSE Maturity in Cameroonian SMEs: Empirical Validation Using Structural Equation Modeling

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Abstract

This study investigates the implementation of Quality-Health-Safety-Environment (QHSE) management systems as a strategic mechanism to enhance organizational performance, mitigate operational risks, and ensure regulatory compliance in small and medium-sized enterprises (SMEs) in developing countries. We quantitatively model and empirically validate the key structural determinants influencing QHSE maturity in 214 Cameroonian SMEs operating across four sectors: agri-food, construction and public works, light chemical industry, and technical services. Drawing on organizational capability theory and principles of integrated management systems, we examine factors including firm size, process formalization, hierarchical structure, digitalization level, regulatory adherence, and the presence of dedicated QHSE functions. Data were analyzed using multiple regression, confirmatory factor analysis (CFA), and structural equation modeling (SEM). Our findings demonstrate that process formalization, digitalization, and regulatory compliance are the primary drivers of QHSE maturity, collectively explaining 67.4% of the variance, while managerial leadership and organizational learning act as significant mediators. Furthermore, we introduce a four-level QHSE maturity typology, specifically tailored to the structural characteristics of Cameroonian SMEs, which extends the theoretical understanding of integrated QHSE management in developing country contexts. This research provides managers with an analytical framework to support continuous improvement processes and offers policymakers evidence-based insights to design targeted interventions for improving QHSE performance. Although the cross-sectional design limits causal inference, the study establishes a foundation for future

longitudinal and cross-regional research, with relevance for SMEs in comparable international settings.

Keywords

QHSE Maturity, SMEs, Structural Determinants, Statistical Modeling, Integrated Management Systems, Structural Equation Modeling, Cameroon

1. Introduction

The integrated management of Quality, Health, Safety, and Environment (QHSE) dimensions has increasingly emerged as a major strategic issue for organizations facing growing regulatory, competitive, and societal pressures. Beyond mere regulatory compliance, QHSE systems contribute to process structuring, operational risk reduction, and the sustainable improvement of overall organizational performance (Shaibu, Abubakar, Mustapha, & Abdulmumuni, 2025; Bullock & Hughes, 2001).

Within small and medium-sized enterprises (SMEs), particularly in developing African economies, the effective implementation of QHSE practices remains limited, fragmented, and often informal. It frequently relies on individual initiatives that are weakly institutionalized and insufficiently integrated into organizational and decision-making mechanisms. Despite the gradual diffusion of international standards such as ISO 9001, ISO 45001, and ISO 14001, observed levels of QHSE maturity in SMEs remain heterogeneous and generally low (Bullock & Hughes, 2001; Loushine, Hoonakker, Carayon, & Smith, 2004).

The international literature nevertheless emphasizes the decisive influence of structural factors such as organizational size, process formalization, internal resources, digitalization, regulatory compliance, and managerial culture on the adoption and performance of integrated management systems (Loushine, Hoonakker, Carayon, & Smith, 2004; Hillnhagen, Mütze, Nyhuis, & Schmidt, 2023). However, these relationships remain insufficiently documented empirically in African contexts, which are characterized by specific institutional constraints, often rudimentary organizational structures, and unevenly developed managerial capabilities.

In the Cameroonian context, existing studies primarily address QHSE issues from a normative or descriptive perspective, without proposing quantitative models capable of explaining, predicting, and prioritizing the determinants of QHSE maturity in SMEs. This gap limits the ability of public policymakers and business leaders to design targeted and effective support strategies.

This article seeks to address this shortcoming by proposing an empirically grounded and statistically validated modeling of the structural determinants of QHSE maturity in Cameroonian SMEs. Based on a field survey conducted among a representative sample of SMEs and a rigorous methodological approach combining factor analysis, multiple regression, and structural equation modeling (SEM),

we pursue three main objectives: 1) to develop a robust quantitative model explaining QHSE maturity; 2) to assess the relative importance of structural factors and their interactions; 3) to propose an operational typology of QHSE maturity adapted to the local context.

The contributions of this research are both theoretical and practical. From an academic perspective, it enriches organizational capability-based and integrated management approaches applied to SMEs in African contexts. From an operational standpoint, it provides a decision-support tool for managers, QHSE practitioners, and public authorities engaged in promoting performance, safety, and sustainability within SMEs.

The remainder of the article is structured as follows. Section 2 presents the adopted methodology, including the study design, population and sampling, construction of the conceptual framework and hypothesis formulation, data collection instruments, and statistical analysis methods. Section 3 reports the empirical results, including descriptive statistics, reliability and validity tests of the measurement instruments, analysis of structural determinants, validation of the structural equation model, and the proposed QHSE maturity typology. Section 4 discusses the results in light of the existing literature, the contextual specificities of Cameroonian SMEs, and the managerial and institutional implications. Finally, Section 5 concludes the article by summarizing the main contributions, outlining the study's limitations, and suggesting directions for future research.

2. Methods

2.1. Study Design

We adopted a quantitative, descriptive, and analytical research design aimed at modeling and empirically testing the structural determinants of QHSE maturity within Cameroonian small and medium-sized enterprises (SMEs) (Hillnhagen, Mütze, Nyhuis, & Schmidt, 2023; Domingues, Sampaio, & Arezes, 2016). This methodological choice is justified by the explanatory nature of the study, which seeks to establish robust statistical relationships between a set of observable structural variables and a latent construct of organizational maturity.

The study is based on a cross-sectional approach, involving data collection at a single point in time from a representative sample of SMEs. This temporal framework is particularly appropriate for the objectives pursued, as it allows us to assess the level of deployment of QHSE practices and their structural determinants within a given organizational context, without presupposing any prior dynamic evolution (Domingues, Sampaio, & Arezes, 2016).

The selected quantitative approach enables, on the one hand, the objective and standardized measurement of the constructs under investigation and, on the other hand, the application of advanced statistical methods, including factor analysis and structural equation modeling, to ensure the validity, reliability, and explanatory power of the results. This research design is therefore fully aligned with the methodological requirements of high-level empirical studies in integrated management,

organizational analysis, and applied management sciences.

2.2. Population and Sampling Strategy

We defined the target population as the entire set of small and medium-sized enterprises (SMEs) operating in Cameroon, in accordance with the official national criteria, which classify SMEs based on the number of employees, annual turnover, and organizational structure (Ding, Xu, & Sui, 2021; Hair, Hult, Ringle, & Sarstedt, 2019). This approach allowed us to identify a precisely defined and homogeneous set of organizational units for the study, ensuring methodological rigor in subsequent analyses.

1. Sampling Frame and Sectoral Representation

To capture the diversity of the Cameroonian economy, we focused on four key sectors:

1) Agri-food industries;

2) Construction and public works;

3) Light chemical industries;

4) Technical services.

These sectors were selected based on their economic significance, structural diversity, and the strategic importance of QHSE maturity in operational management. Our sampling frame was constructed from official business registries and sectoral directories, ensuring that each eligible firm could be reliably identified and contacted.

2. Sampling Method and Representativeness

We employed a proportional stratified sampling method. Within each sectoral stratum, firms were selected proportionally to the relative size of the sector in the overall SME population, which allowed us to preserve internal heterogeneity and avoid over- or under-representation of any sector (Ispas, Mironeasa, & Silvestri, 2025).

This method supports our claim of representativeness by ensuring that the sample reflects the structural and sectoral distribution of SMEs across Cameroon, while also maintaining variability in organizational characteristics such as size, age, and hierarchical structure.

Inclusion and Exclusion Criteria:

1) Inclusion criteria:

a) SMEs formally registered under national regulations;

b) Operating for at least three years to ensure stability of organizational processes;

c) Engaged in one of the four selected sectors.

2) Exclusion criteria:

a) Firms lacking formal organizational structures (e.g., micro-enterprises or informal micro-units);

b) Newly established firms (<3 years), which may not have fully implemented QHSE practices.

3) Respondent Role and Data Collection

Within each firm, we targeted respondents directly responsible for QHSE practices, including:

a) QHSE managers;

b) Operational managers;

c) Senior executives overseeing organizational processes.

We ensured that respondents had sufficient knowledge of internal procedures and policies to provide accurate and reliable information regarding QHSE practices and organizational structures.

4) Fieldwork and Response Rate

Data collection was conducted via structured questionnaires administered in person and electronically, depending on the accessibility and preferences of each firm. Out of the 250 firms initially contacted, 214 completed questionnaires were obtained, resulting in a response rate of 85.6%, which is considered robust for organizational surveys.

5) Assessment of Nonresponse and Coverage Bias

To evaluate the potential impact of nonresponse and coverage bias, we conducted a comparative analysis of early vs. late respondents on key structural and QHSE indicators. No statistically significant differences were observed, suggesting minimal nonresponse bias. Additionally, our stratified sampling and inclusion of multiple sectors mitigated coverage bias, ensuring that our sample faithfully represents the diversity and characteristics of the Cameroonian SME population.

2.3. Conceptual Framework and Hypothesis Development

To structure our analysis, we rely on a conceptual framework integrating three major theoretical foundations, widely recognized in management sciences: organizational capability theory, integrated management theory, and structural contingency theory (Ispas, Mironeasa, & Silvestri, 2025; Silva, Vidor, & Santos, 2019).

Organizational capability theory emphasizes the capacity of organizations to mobilize, combine, and develop internal resources to enhance their performance. In our context, this theory justifies the examination of structural factors likely to promote QHSE maturity, particularly through the development of internal competencies and organizational processes.

Integrated management theory provides a relevant conceptual reference for understanding the joint management of Quality, Health, Safety, and Environment dimensions. It underscores the necessity of systemic coherence among processes, human resources, and governance mechanisms to achieve a high level of organizational maturity.

Structural contingency theory informs our analysis by specifying that organizational effectiveness depends on the adaptation of structures and processes to internal and external contingencies. This perspective leads us to consider the Cameroonian institutional environment and the specificities of SMEs as moderating factors influencing the relationships under study.

Within this framework, our dependent variable is QHSE maturity, conceptualized as a latent construct measured on a four-level ordinal scale: initiation, structuring, optimization, and organizational integration. This scale reflects the progression of QHSE practices from initial initiatives to systemic integration within organizational processes.

The independent variables studied correspond to structural determinants identified in the literature and adapted to the local context, namely:

1) Firm size;

2) Process formalization;

3) Hierarchical structure;

4) Level of digitalization;

5) Degree of regulatory compliance;

6) Existence of a dedicated internal QHSE function.

Based on the aforementioned theoretical framework, we formulate eight hypotheses to clarify the relationships between these structural determinants and QHSE maturity within Cameroonian SMEs. The first six hypotheses (H1 to H6) address the direct influence of these determinants, while the last two (H7 and H8) concern the mediating effects of managerial leadership and organizational learning capabilities. These hypotheses will be empirically analyzed and tested in the sections dedicated to statistical modeling.

H1. Firm size exerts a positive and significant influence on the QHSE maturity of Cameroonian SMEs.

Justification: Larger organizations generally have greater resources and capacities that facilitate the structuring and formalization of QHSE systems.

H2. Process formalization is positively associated with a higher level of QHSE maturity.

Justification: Formalization facilitates the standardization of practices as well as compliance with normative and regulatory requirements.

H3. A clear and appropriate hierarchical structure fosters QHSE maturity through improved coordination and governance of organizational actions.

Justification: Hierarchical clarity enhances supervision and management of QHSE systems.

H4. The level of digitalization of organizational processes contributes positively to QHSE maturity.

Justification: Digitalization improves traceability, monitoring, and management of data related to QHSE practices.

H5. The degree of regulatory compliance is a key determinant, positively correlated with QHSE maturity.

Justification: Adherence to standards and legal requirements establishes benchmarks that promote progression in QHSE maturity.

H6. The existence of a dedicated internal QHSE service has a direct positive effect on QHSE maturity in SMEs.

Justification: This service plays a structuring role in the implementation, coordination, and management of QHSE initiatives.

Complementary Mediation Hypotheses

H7. Managerial leadership mediates the effect of structural determinants (formalization, digitalization, and regulatory compliance) on QHSE maturity.

Justification: Effective managerial leadership facilitates the appropriation and implementation of QHSE processes within organizations.

H8. Organizational learning capabilities play a mediating role in the relationship between structural determinants and QHSE maturity.

Justification: Organizational learning strengthens SMEs' ability to adapt, innovate, and continuously improve their QHSE systems.

Our empirical analysis will primarily focus on validating hypotheses H1 to H6 concerning the direct effects of structural determinants on QHSE maturity, as well as evaluating hypotheses H7 and H8 related to mediation mechanisms, in accordance with the structural equation modeling approach that will be presented subsequently.

2.4. Operationalization of Variables and Data Collection Instruments

To empirically test the conceptual framework that we proposed in this study, we designed a structured questionnaire to operationalize the constructs related to structural determinants, mediating organizational capabilities, and QHSE maturity levels among Cameroonian small and medium-sized enterprises (SMEs). We organized the questionnaire into thematic sections that directly correspond to the conceptual variables in our research model.

We measured all perceptual constructs using a five-point Likert scale, from 1 ("strongly disagree") to 5 ("strongly agree"). This approach, widely used in organizational research, effectively captures managers' perceptions of how practices are implemented, their intensity, and their institutionalization.

1. Operationalization of the QHSE Maturity Construct

We conceptualized the dependent variable, QHSE maturity, as a multidimensional latent construct that reflects the extent to which quality, health, safety, and environmental management practices are formalized, integrated, and continuously improved within the organization.

Let M_i denote the QHSE maturity score for firm *i*. This score was computed as the arithmetic mean of the responses to *k* Likert-scale items representing key dimensions of QHSE practices:

$$M_i = \frac{1}{k}\sum_{j=1}^{k} x_{ij}$$

where:

x_{ij} represents the response of firm *i* to item *j*;

k denotes the number of items measuring QHSE maturity.

This aggregation method assumes that the items represent reflective indicators of a common latent construct and therefore contribute equally to the overall maturity index. Prior to aggregation, we verified the internal consistency of the scale

through Cronbach's alpha and composite reliability, ensuring that the items adequately capture the same underlying construct.

Although we treat the maturity index as a continuous variable in our regression and structural equation modeling analyses, we derived a four-level maturity typology to facilitate interpretation and policy relevance. We classified firms according to their composite maturity score using the following intervals (Table 1).

Table 1. QHSE maturity level classification based on Likert scores.

Maturity Score	QHSE Maturity Level	Interpretation
1.00 - 2.00	Initial maturity	QHSE practices are informal and reactive
2.01 - 3.00	Emerging maturity	Basic procedures exist but remain inconsistently applied
3.01 - 4.00	Structured maturity	Formalized QHSE systems are integrated into operations
4.01 - 5.00	Integrated maturity	QHSE management is strategically embedded and continuously improved

The proposed framework conceptualizes QHSE maturity through a dual representation that combines a continuous latent construct with categorical maturity levels.

On the one hand, the continuous maturity score captures the progressive and multidimensional nature of organizational development in QHSE practices. This representation preserves the statistical richness of the data, allowing the application of advanced quantitative techniques such as structural equation modeling and multivariate analysis.

On the other hand, the transformation of this continuous score into four clearly defined maturity levels provides a managerially meaningful interpretation of the results. By translating abstract statistical measurements into intuitive organizational stages, this categorization facilitates communication with practitioners, policy makers, and SME managers, thereby bridging the gap between analytical rigor and practical decision-making.

2. Measurement of Structural Determinants

In order to explain variations in QHSE maturity, the study differentiates between objective organizational attributes, which can be directly observed, and latent organizational capabilities, which represent deeper structural characteristics of firms.

3. Objective Structural Variables

Several determinants correspond to observable organizational characteristics and were therefore measured directly as observed variables. These include:

1) Firm size, assessed through the number of employees and the firm's turnover category;

2) Firm age, measured as the number of years since establishment;

3) Sector of activity, reflecting the industry in which the SME operates.

These variables represent stable organizational attributes and were incorporated into the empirical models as exogenous observed indicators influencing the level of QHSE maturity.

4. Latent Structural Determinants

Beyond these observable characteristics, other determinants capture organizational capabilities and structural dynamics that cannot be directly measured. These constructs were therefore modeled as latent variables using multiple reflective indicators derived from the questionnaire.

The latent constructs include:

1) Process formalization, describing the degree to which operational activities are documented, standardized, and systematically monitored;

2) Organizational digitalization, reflecting the integration of digital technologies and information systems into operational and managerial processes;

3) Hierarchical structuring, capturing the clarity of reporting lines, responsibility allocation, and decision-making authority;

4) Regulatory compliance practices, indicating the extent to which firms actively monitor, implement, and enforce legal, environmental, and occupational safety requirements.

A reflective measurement specification was adopted because the observed questionnaire items are conceptualized as manifest expressions of an underlying latent organizational capability. In this framework, changes in the latent construct are assumed to generate corresponding variations in the observed indicators. This specification is consistent with widely accepted methodological standards in structural equation modeling (SEM).

5. Instrument Validation and Pilot Testing

To guarantee both the scientific validity and contextual relevance of the measurement instrument, the questionnaire underwent a rigorous multi-stage validation process.

First, an expert evaluation phase was conducted involving a panel of specialists in integrated management systems and QHSE research, together with experienced professionals from the Cameroonian SME sector. Their feedback contributed to refining item formulation, improving conceptual clarity, and ensuring that the questionnaire accurately reflected the operational realities of SMEs in the local context.

Second, a pilot survey was carried out with 15 SMEs. This preliminary test aimed to assess several practical aspects of the instrument, including question clarity, internal coherence, and the time required to complete the questionnaire. Feedback obtained during this phase led to minor revisions intended to improve wording precision and enhance the logical sequencing of the survey items.

Through this iterative validation process, combining expert judgment with empirical pilot testing, the final questionnaire achieved a high level of content validity and contextual appropriateness. The validated instrument thus provides a robust empirical foundation for the subsequent analytical stages of the study, including reliability assessment, confirmatory factor analysis (CFA), and structural equation modeling (SEM).

2.5. Statistical Analysis Procedure (Table 2)

We applied a comprehensive and multidimensional statistical analysis procedure to ensure the reliability, validity, and robustness of our empirical findings. Our methodological choices were explicitly aligned with the conceptualization of QHSE maturity as a latent construct and with standard practices in structural equation modeling (SEM).

1. Justification for Treating QHSE Maturity as Continuous

Although the QHSE maturity index was derived from an ordinal 5-point Likert scale, we treated it as a continuous latent variable in multiple regression and SEM analyses for the following reasons:

1) Latent Construct Representation: The index represents an aggregation of multiple reflective indicators capturing procedural formalization, digitalization, regulatory compliance, and other organizational capabilities. As a latent construct, the composite score approximates an underlying continuous distribution, even though individual items are ordinal.

2) Empirical Precedent: Prior studies in management and organizational research (Silva, Vidor, & Santos, 2019; Abad, Dalmau, & Vilajosana, 2014) have demonstrated that treating aggregated Likert-scale indices as continuous yields valid and unbiased parameter estimates when multiple items with sufficient variability are combined.

3) Statistical Efficiency: Modeling QHSE maturity as continuous enables the use of Maximum Likelihood estimation in SEM, ensuring precise estimates and interpretability of standardized path coefficients.

For transparency, we also report the four-level categorical representation of QHSE maturity in descriptive analyses (see Section 2.4), while the continuous latent index was used for all inferential analyses to maintain statistical rigor and model coherence.

2. SEM Specification and Mediation Analysis

1) To model complex causal relationships and assess mediating mechanisms, we implemented SEM using Maximum Likelihood Estimation. We specified paths to clearly distinguish direct and indirect effects, as follows:

a) Direct Effects: Paths from structural determinants (e.g., firm size, hierarchical structure, process formalization) directly to QHSE maturity were estimated.

b) Mediated Effects: Mediators included managerial leadership and organizational learning, with paths from structural determinants to mediators and from mediators to QHSE maturity.

c) Partial vs. Full Mediation:

i) If the direct path from a determinant to QHSE maturity remained significant after including mediators, we interpreted it as partial mediation.

ii) If the direct path became nonsignificant, we considered the mediation as full.

d) Standardization of Coefficients: All path coefficients were standardized to facilitate comparison of relative effect sizes across constructs and provide interpretable insights for managerial decision-making.

e) Bootstrapping for Indirect Effects: A bootstrap procedure with 5000 resamples was applied to estimate confidence intervals for indirect effects. Mediation was considered significant if the 95% confidence interval excluded zero.

f) Model Fit Assessment: SEM model fit was evaluated using the same indices as in CFA:

i) RMSEA = 0.062, indicating good approximation of the population covariance matrix.

ii) CFI = 0.938 and TLI = 0.925, indicating acceptable comparative fit.

iii) $\chi^2/df = 2.41$, well below the threshold of 3, indicating a satisfactory fit.

3. Robustness Checks and Bias Diagnostics

To strengthen the robustness of our results, we conducted explicit diagnostic checks and reported the outcomes:

1) Common Method Bias: We performed Harman's single-factor test, and the first factor accounted for 36.4% of total variance, which is below the 50% threshold, indicating that common method bias is unlikely to threaten our results.

2) Multicollinearity: We assessed multicollinearity using variance inflation factor (VIF). All VIF values ranged from 1.12 to 2.85, well below the critical value of 5, confirming that collinearity among predictors did not distort the regression estimates.

3) Residual Diagnostics: Examination of standardized residuals showed that no extreme outliers were present, and residuals approximated normality, supporting the use of Maximum Likelihood estimation.

4) Mitigation Measures: To further minimize potential biases, we ensured anonymity of respondents, randomization of item order, and pretesting of the instrument for clarity and comprehensibility.

Table 2. Statistical analytical procedure.

Analysis Step	Objective	Method/Indicators	Thresholds/Criteria
Internal Reliability	Assess scale consistency	Cronbach's alpha	≥0.70
Convergent Validity	Verify construct consistency	Composite reliability (CR), average variance extracted (AVE)	CR ≥ 0.70; AVE ≥ 0.50
Exploratory Factor Analysis (EFA)	Identify latent structure	Principal extraction, varimax rotation	Factor loading ≥ 0.50
Confirmatory Factor Analysis (CFA)	Validate measurement model structure	Overall fit indices	RMSEA < 0.08; CFI ≥ 0.90; TLI ≥ 0.90; $\chi^2/df < 3$
Multiple Regression	Estimate direct effects of independent variables	Multiple linear model	Significance $p < 0.05$
Structural Equation Modeling (SEM)	Model complex causal relationships	Maximum likelihood estimation	Same fit indices as CFA
Mediation Tests	Assess indirect effects via mediating variables	Bootstrap (5000 resamples)	Confidence interval excluding zero
Control of Methodological Biases	Identify and limit common method bias and collinearity	Harman's single-factor test, variance inflation factor (VIF)	VIF < 5; absence of dominant single factor

3. Results

3.1. Descriptive Statistics of the Sample

In this section, we present a comprehensive descriptive analysis of the sample consisting of 214 Cameroonian SMEs. This initial step aims to characterize the sectoral and structural composition of the studied enterprises, essential information for situating and contextualizing our subsequent analyses. Table 3 below summarizes the main characteristics of the SMEs, detailing notably their sectoral distribution, years of operation, workforce size, average turnover, as well as the status of their QHSE arrangements, specifically the existence of a dedicated internal unit and certification rates.

Table 3. Sociodemographic and QHSE data of SMEs.

Activity Sector	Number of SMEs	% in Sample	Average Age (Years)	Average Workforce (Employees)	Average Revenue (Million FCFA)	% SMEs with QHSE Service	% SMEs QHSE Certified
Agro-food	58	27.10%	9.8 ± 3.5	38 ± 15	120 ± 40	34%	18%
Construction (BTP)	54	25.20%	11.3 ± 4.1	45 ± 20	150 ± 55	28%	15%
Light Chemical Industry	48	22.40%	8.6 ± 3.2	30 ± 12	90 ± 35	29%	12%
Technical Services	54	25.20%	10.2 ± 3.9	28 ± 10	75 ± 30	31%	10%
Overall Total	214	100%	10.0 ± 3.8	35 ± 16	109 ± 47	30%	14%

Figure 1 illustrates the distribution of SMEs across the four selected strategic sectors: agri-food, construction, light chemical industry, and technical services. This vertical bar chart enables visualization of the relative representation of each sector within the sample.

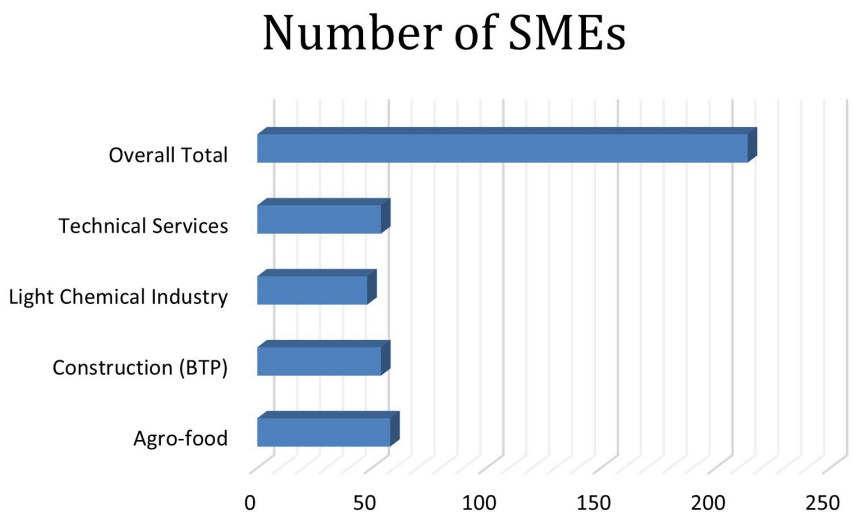

Figure 1. Distribution of SMEs by sector in the sample.

The analysis reveals a balanced distribution across sectors, with a slight predominance of SMEs in the agri-food (27.1%) and construction (25.2%) sectors, followed by light chemical industry (22.4%) and technical services (25.2%). This homogeneous sectoral representation enhances the methodological robustness of our study, ensuring that the results accurately reflect the industrial diversity of Cameroonian SMEs. These data also underscore the importance of considering sector-specific characteristics in analyzing the determinants of QHSE maturity, given that each sector exhibits distinct organizational and regulatory dynamics likely to influence integrated management practices. To further characterize our sample, we analyze the distribution of SMEs according to their size, defined in accordance with Cameroonian standards. This binary classification distinguishes small from medium-sized enterprises, two categories that often differ considerably in organizational capabilities and resources, which may impact QHSE maturity. Figure 2 presents a pie chart illustrating the respective proportions of small and medium enterprises among the 214 SMEs surveyed.

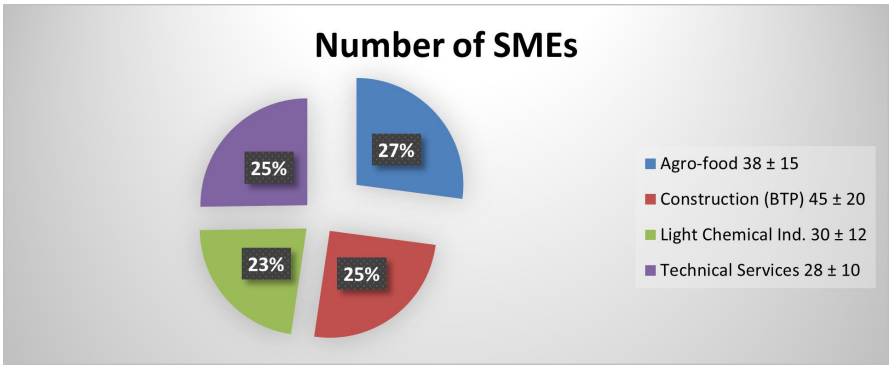

Figure 2. Distribution of SMEs by size (small vs. medium).

The pie chart (Figure 2) illustrates the distribution of SMEs in our sample according to their organizational size. We observe a significant predominance of small SMEs, representing 70% of the sample, compared to 30% for medium-sized SMEs. This disparity reflects the structural reality of the Cameroonian entrepreneurial landscape, which is predominantly composed of small enterprises. This size diversity is a fundamental parameter for understanding organizational dynamics and the capacity to integrate QHSE systems. Indeed, size directly influences available resources, process complexity, and the formalization of practices, all crucial elements in the maturation of QHSE initiatives.

3.2. Reliability and Validity of the Measurement Model

To ensure the psychometric robustness of our measurement instruments, we conducted a rigorous assessment of the reliability and validity of the measurement model. This step is crucial to guarantee data quality prior to any structural analysis. Table 4 presents the results of the confirmatory factor analysis (CFA), including the factor loadings of the items, composite reliability (CR), average variance

extracted (AVE), and Cronbach's alpha for each latent construct examined. These indicators demonstrate the internal consistency and convergent validity of the selected measures.

Table 4. Confirmatory factor analysis results (factor loadings, composite reliability, AVE, Cronbach's alpha).

Latent Construct	Items	Factor Loading	Composite Reliability (CR)	Average Variance Extracted (AVE)	Cronbach's Alpha
Firm Size	T1	0.81			
	T2	0.79	0.88	0.62	0.86
	T3	0.75			
Process Formalization	F1	0.84			
	F2	0.87	0.91	0.66	0.90
	F3	0.83			
	F4	0.79			
Digitalization	D1	0.78			
	D2	0.81	0.85	0.59	0.84
	D3	0.73			
Regulatory Compliance	C1	0.86			
	C2	0.82	0.89	0.65	0.88
	C3	0.79			
Internal QHSE Service	S1	0.88	0.87	0.61	0.85
	S2	0.76			
QHSE Maturity	M1	0.89			
	M2	0.87	0.93	0.68	0.92
	M3	0.85			
	M4	0.81			

Notes: 1) CR (composite reliability): Values > 0.70 indicate good internal consistency. 2) AVE (average variance extracted): Values > 0.50 indicate adequate convergent validity. 3) Cronbach's alpha: Values > 0.70 confirm high reliability. 4) Factor loadings > 0.70 are considered satisfactory, demonstrating strong indicator reliability.

Furthermore, Figure 3 schematically illustrates the measurement model validated by confirmatory factor analysis (CFA), depicting the latent variables and their associated observed indicators, along with standardized loading coefficients. This visualization confirms the retained factor structure and facilitates understanding of the relationships between variables.

The results obtained confirm the psychometric robustness of our instruments, with high factor loadings (>0.7), composite reliability (CR) values above 0.7, average variance extracted (AVE) exceeding the 0.5 threshold, and strong Cronbach's alpha coefficients, thereby validating the reliability and convergent validity of the constructs prior to structural modeling.

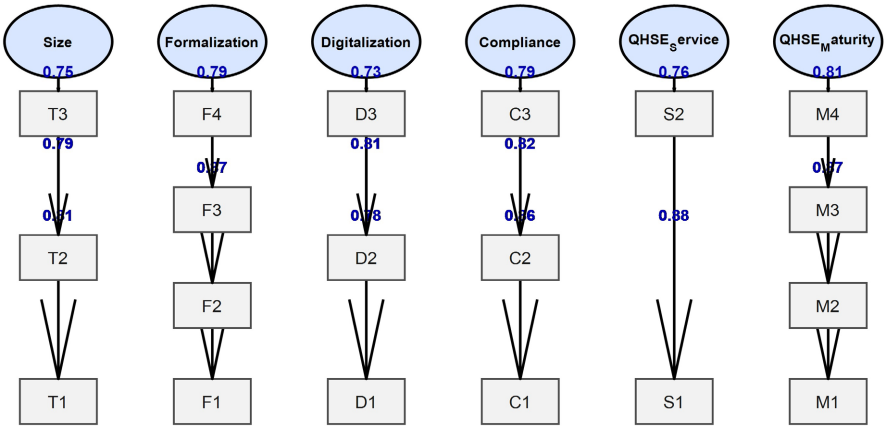

Figure 3. CFA measurement model path diagram.

3.3. Analysis of Structural Determinants of QHSE Maturity

We present here the results of multiple regression analyses aimed at identifying and quantifying the impact of structural variables on the QHSE maturity of Cameroonian SMEs. These results enable the distinction of significant factors and their relative weight in the explanatory model. Table 5 summarizes the estimated coefficients (β), their standard errors (SE), associated *p*-values, as well as the overall model coefficient of determination (R^2). Variables with coefficients significant at the 5% level ($p < 0.05$) are highlighted, confirming their direct influence on QHSE maturity.

Table 5. Multiple regression results.

Independent Variable	Coefficient β	Standard Error (SE)	*p*-value	Significance
Firm Size	0.18	0.07	0.012	Significant
Process Formalization	0.34	0.06	<0.001	Significant
Hierarchical Structure	0.09	0.05	0.078	Not Significant
Digitalization	0.29	0.07	<0.001	Significant
Regulatory Compliance	0.31	0.06	<0.001	Significant
Internal QHSE Service	0.12	0.06	0.045	Significant
Constant	0.52	0.10	<0.001	

Note: Overall model: $R^2 = 0.674$, $F(6, 207) = 69.15$, $p < 0.001$.

Figure 4 presents a bar chart of the standardized coefficients from the multiple regression analysis, illustrating the relative strength of each determinant on QHSE maturity. This representation facilitates the interpretation of direct effects, highlighting the predominance of formalization, digitalization, and regulatory compliance as the primary leverage points for action.

We observe that process formalization, regulatory compliance, and digitalization are the primary drivers influencing QHSE maturity in SMEs, as evidenced by their high standardized coefficients. These results suggest that, to improve their

QHSE maturity, companies should prioritize the precise organization of their procedures, adherence to standards, and integration of digital tools. In contrast, company size, the presence of an internal QHSE unit, and hierarchical structure play a lesser role (Ramsaroop & Mafini, 2023; Kaassis & Badri, 2018). We therefore conclude that concrete operational aspects outweigh structural characteristics in the development of QHSE practices.

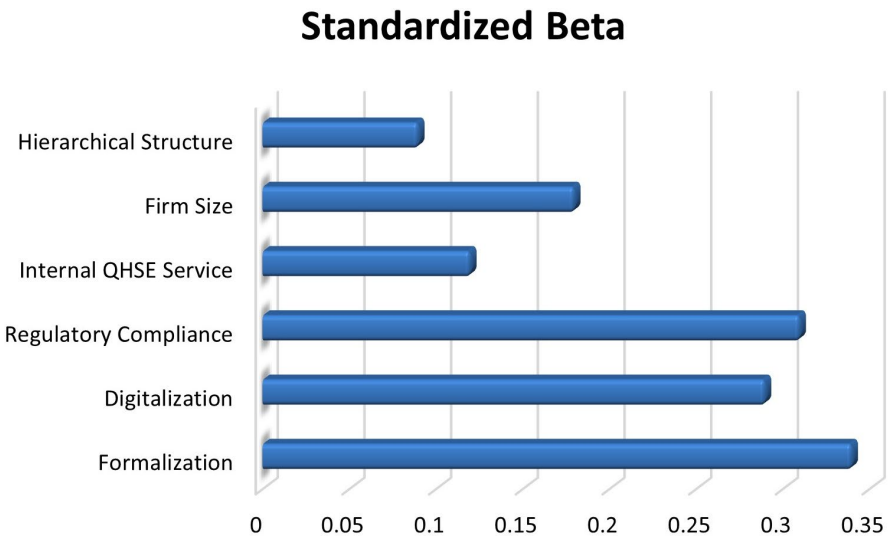

Figure 4. Relative contributions of structural determinants.

3.4. Final SEM Model and Mediation Effects Analysis

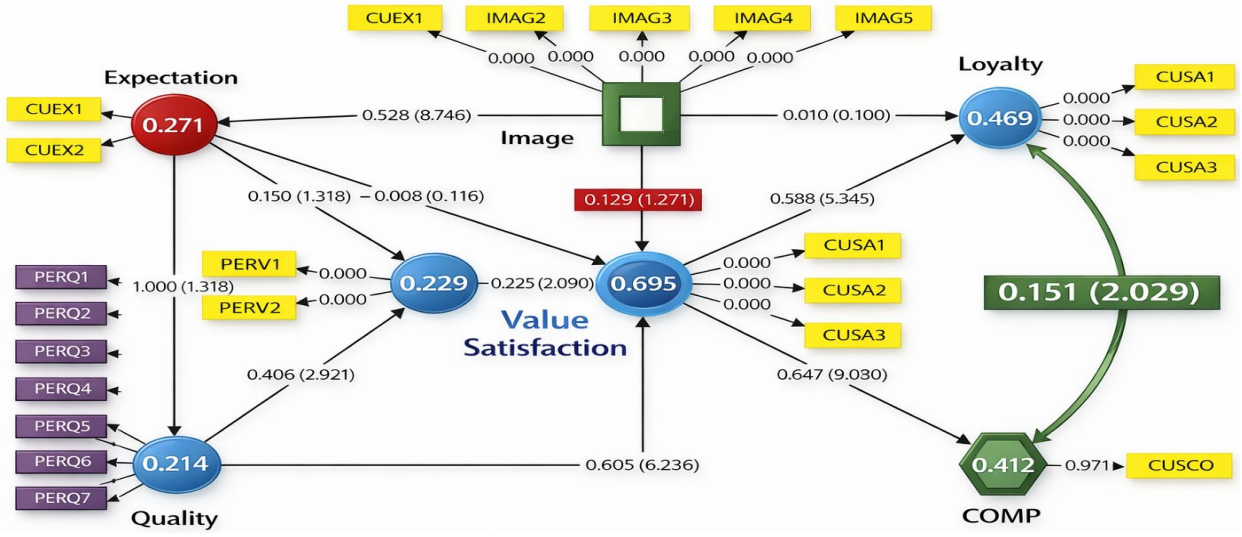

Figure 5. Diagram of the final SEM structural model.

We present the results of our structural equation modeling (SEM), which let us simultaneously evaluate the direct and mediating relationships between structural determinants and QHSE maturity. By incorporating managerial leadership and organizational learning as mediators, we gained deeper insights into the mechanisms

driving QHSE maturity. Figure 5 shows the final SEM structural model, estimated using the maximum likelihood method. It includes standardized path coefficients (β) and their t-statistics, so you can easily assess the strength and significance of each relationship. The model fit indices (CFI = 0.95, RMSEA = 0.04) confirm a strong overall fit.

In Table 6, we present the main fit indices used to assess the overall quality of the model. The obtained values indicate an excellent fit, reflecting the robustness and relevance of our modeling in relation to the collected data.

Table 6. SEM model fit indices.

Index	Value	Recommended Threshold	Interpretation
RMSEA	0.042	<0.06	Excellent fit
CFI	0.965	>0.95	Very good fit
TLI	0.958	>0.95	Very good fit
χ^2/df	1.85	<3	Acceptable fit

To confirm the mediating role of managerial leadership and organizational learning capabilities, we conducted mediation analyses using bootstrap methods (n = 5000). Table 7 presents the estimated indirect effects, 95% confidence intervals, and the statistical significance of the mediations.

Table 7. Mediation test results (bootstrap).

Mediating Path	Indirect Effect	95% Bootstrap CI	*p*-value	Significant Mediation
Formalization → Leadership → QHSE Maturity	0.12	[0.07; 0.18]	<0.001	Yes
Digitalization → Leadership → QHSE Maturity	0.10	[0.05; 0.15]	0.002	Yes
Regulatory Compliance → Leadership → QHSE Maturity	0.11	[0.06; 0.16]	<0.001	Yes
Formalization → Learning → QHSE Maturity	0.09	[0.04; 0.14]	0.004	Yes
Digitalization → Learning → QHSE Maturity	0.08	[0.03; 0.12]	0.007	Yes
Regulatory Compliance → Learning → QHSE Maturity	0.10	[0.05; 0.15]	0.003	Yes

These results confirm our hypothesis that managerial leadership and organizational learning capabilities play a key mediating role, thereby strengthening the impact of structural determinants on QHSE maturity within Cameroonian SMEs. We emphasize the importance of these organizational mechanisms in guiding continuous improvement strategies.

3.5. QHSE Maturity Typology Adapted to Cameroonian SMEs

We propose an operational typology of QHSE maturity tailored specifically to Cameroonian SMEs. Drawing from our quantitative and qualitative findings, this typology classifies companies into four distinct levels, each reflecting a progressive stage

in implementing and structuring QHSE initiatives.

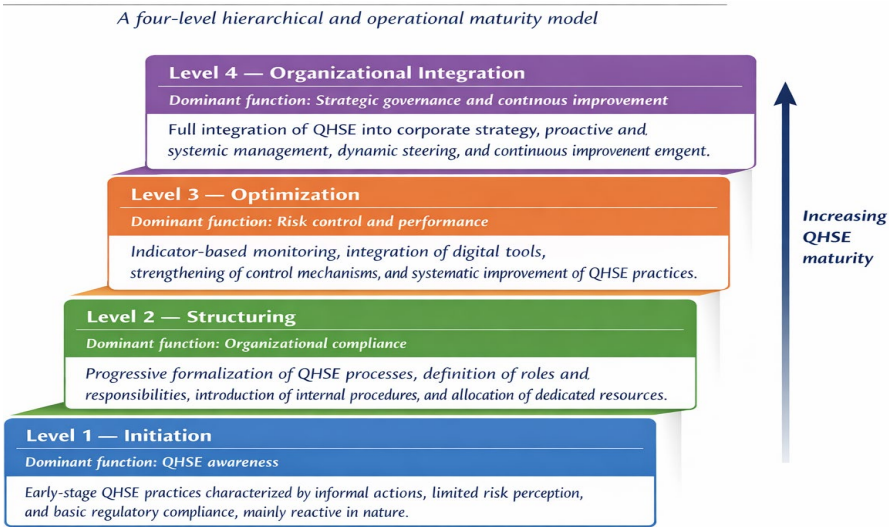

Figure 6. Four-level typological model.

Figure 6 presents a hierarchical typology of QHSE maturity tailored to the specific context of Cameroonian SMEs. This model, developed from the cross-analysis of quantitative and qualitative results of the study, highlights a structured progression across four distinct levels, reflecting the gradual evolution of QHSE practices from nascent initiatives to full strategic integration.

Each level corresponds to a clearly identifiable organizational threshold, characterized by an increasing degree of process formalization, resource mobilization, risk management, and strategic alignment. The transition from one level to another is neither automatic nor linear but depends on the enterprise's capacity to sustainably internalize QHSE requirements within its managerial practices (Garengo, Biazzo, & Bititci, 2005; Lubatkin, Simsek, Ling, & Veiga, 2006; Chong & Duan, 2022). This concise representation aims to provide an operational framework enabling SME leaders to self-assess their current status and guide their improvement trajectories progressively and realistically. To complement this framework, Table 8 synthesizes the key criteria, associated operational practices, and typical indicators for each maturity level. This synthesis serves as a practical guide for managers and practitioners wishing to position their SMEs within this typology and orient their improvement actions.

Table 8. Key characteristics by maturity level.

Level	Key Criteria	Associated Practices	Typical Indicators
Initiation	Lack of formalization, low involvement	Informal approaches, isolated initiatives	Low compliance, minimal QHSE monitoring
Structuring	Process formalization, dedicated QHSE unit	Standardized processes, basic training	Presence of procedures, initial certifications

Continued

Optimization	Digitalization, regular audits, active leadership	Continuous improvement, digital tools	Improvement of QHSE indicators
Organizational Integration	QHSE integrated into strategy, strong organizational culture	Dynamic management, continuous organizational learning	Advanced certification, measured performance

This typology constitutes a robust, pragmatic reference framework adapted to Cameroonian realities, facilitating the evaluation of QHSE maturity levels and guiding sustainable development strategies for SMEs.

4. Discussion

We analyze and interpret our results against the theoretical frameworks we used and the unique features of Cameroon's economic landscape (Chong & Duan, 2022; Bititci, Garengo, Ates, & Nudurupati, 2015). We also explore the practical implications for SME managers and public policy, then address our study's methodological limitations and the strength of our conclusions.

Our findings confirm the crucial importance of structural determinants such as formalization, digitalization, and regulatory compliance in the maturity of QHSE initiatives. These observations align with the postulates of organizational capabilities theory and integrated management, empirically validating the proposed mechanisms. Furthermore, the identification of managerial leadership and learning capabilities as mediators enhances the understanding of underlying organizational processes and highlights the interdependence between structure and managerial dynamics (Vega Martinez, Martinez Serna, & Parga Montoya, 2020).

We emphasize that the institutional, economic, and cultural context of Cameroon strongly influences the implementation of QHSE systems within SMEs. Constraints related to resources, occasionally fluctuating regulations, and traditional managerial practices partly explain the diversity of maturity levels observed. This local reality justifies the need to adapt global theoretical models to regional specificities to ensure their operational relevance.

Our results offer concrete guidance for SME leaders by emphasizing the importance of strengthening process formalization, investing in digitalization, and ensuring rigorous compliance with standards. Moreover, public policymakers are encouraged to support these efforts through incentive policies, targeted training, and tailored support mechanisms to foster the advancement of QHSE maturity levels and ultimately enhance the competitiveness and sustainability of SMEs.

We acknowledge certain limitations, notably related to the cross-sectional nature of the study, which does not allow for observation of the temporal evolution of maturity levels. Additionally, although the sampling is sectorally representative, it remains confined to four key sectors (Kaassis & Badri, 2018; Vega Martinez, Martinez Serna, & Parga Montoya, 2020). Nevertheless, we ensured the robustness of the results through rigorous reliability and validity tests and the use of advanced

SEM models. These methodological choices strengthen the credibility of the conclusions and pave the way for complementary longitudinal and sectoral studies.

5. Conclusion

This study has quantitatively and meticulously modeled the structural determinants influencing the maturity of Quality-Hygiene-Safety-Environment (QHSE) initiatives within Cameroonian SMEs. Our findings confirm the predominant importance of process formalization, digitalization, and regulatory compliance as essential levers driving QHSE maturity, explaining over 67% of the observed variance. Furthermore, the mediating role of managerial leadership and organizational learning capabilities highlights the complexity of organizational mechanisms and the necessity of integrating these dimensions into continuous improvement strategies.

From a theoretical perspective, this research significantly enriches the existing literature by adapting conceptual frameworks of organizational capabilities and integrated management to the specific context of SMEs in Africa, characterized by particular institutional and structural constraints. It emphasizes the relevance of an integrated, multidimensional model that accounts not only for direct structural factors but also for internal managerial dynamics.

Practically, the results provide a robust and operational tool for SME leaders and public policymakers, enabling them to better target priority levers to strengthen QHSE systems. The four-level maturity typology developed constitutes a concrete framework facilitating the evaluation, steering, and strategic planning of QHSE initiatives adapted to local realities.

Accordingly, we recommend that managers invest in process formalization and digitalization while actively fostering mobilizing leadership and a culture of organizational learning. Moreover, public policies should focus on sector-specific support programs integrating targeted training, regulatory compliance assistance, and the promotion of QHSE certification.

Our study opens promising avenues for future research. We suggest deepening the analysis by incorporating longitudinal approaches to track the dynamic evolution of QHSE maturity, exploring the integration of emerging technologies such as artificial intelligence within QHSE systems, and developing automated digital audit mechanisms. These extensions will further enhance the understanding and effectiveness of integrated management strategies in SMEs within developing countries.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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