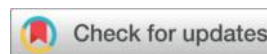




A Metrological Model for Measuring Entrepreneurial Capabilities and the Performance of Small and Medium-Sized Enterprises



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Abstract

This study aims to develop a metrological model to measure the relationship between entrepreneurial capabilities and the performance of small and emerging enterprises in the Algerian context, based on a quantitative approach that combines the Structural Equation Modeling (SEM) methodology and Partial Least Squares Structural Equation Modeling (PLS-SEM).

The proposed model is based on considering entrepreneurial capabilities as a multidimensional latent variable that includes opportunity recognition, resource management, innovation capacity, and readiness for risk and resilience, while business performance is measured through financial growth, operational sustainability, competitiveness, and social and environmental impact.

The study relied on a field sample consisting of 230 small and emerging enterprises selected through purposive sampling, applying metrological verification procedures to ensure the validity and reliability of measurement tools, including testing for convergent and discriminant validity and measurement invariance across groups.

The results showed that entrepreneurial capabilities positively and significantly affect the performance of enterprises, and that innovation capacity represents a partial mediating mechanism between some dimensions of entrepreneurial capabilities and performance. It was also found that institutional support strengthens this relationship.

These results contribute to enriching the literature on entrepreneurship from an accurate metrological perspective and provide a practical tool for policymakers and business incubators to measure entrepreneurial capabilities and improve the contribution of emerging enterprises to sustainable economic development.

Keywords: Entrepreneurial capabilities, performance of small and emerging enterprises, metrology, SEM, PLS-SEM, Algeria.

1. Introduction

Small and emerging enterprises play a central role in the dynamics of economic development, job creation, and innovation in both emerging and global economies. Despite the growing interest in entrepreneurship as a driver of growth, measuring entrepreneurial capabilities and their impact on firm performance remains a methodological and fundamental challenge, as many studies rely on non-standardized indicators or untested measurement tools that lack metrological validation (in terms of validity, reliability, and calibration) across different cultural and institutional contexts.

The absence of a solid metrological framework limits the comparability of results among studies and sectors and weakens the ability to produce practical recommendations based on repeatable and calibrated measurements (Oslo Manual; OECD, 2018).

Existing literature reveals important efforts in describing the dimensions of entrepreneurial intention, skills, and related behaviors (Liñán & Chen, 2009; Nowiński et al., 2020). Studies have also examined the role of incubators and educational environments in shaping students' and potential entrepreneurs' awareness. However, few studies have addressed these topics from a metrological perspective—that is, from the angle of developing calibrated measurement tools, testing uncertainty in measurement, and verifying the coherence of measurement constructs across different national and cultural contexts. Moreover, literature on peer effects and institutional support highlights the importance of assessing the reliability and performance validity of these variables before drawing causal or policy conclusions (Bellò, Mattana, & Loi, 2018; Resch & Steyaert, 2020).

This study seeks to bridge this gap by proposing a metrological model to measure entrepreneurial capabilities and assess performance in the context of small and emerging enterprises. The methodological contribution of this study includes:

- (1) Developing and constructing a multidimensional, calibratable scale for entrepreneurial capabilities;
- (2) Testing the psychometric properties of the scale (construct and criterion validity, internal reliability, and structural fit) using Confirmatory Factor Analysis (CFA) and Structural Equation Modeling (SEM);
- (3) Examining the applicability of the scale across national contexts through measurement invariance testing; and
- (4) Providing procedures to analyze measurement uncertainty and apply multiple statistical robustness tests (alternative model specifications, common method bias checks, and sensitivity tests addressing reverse causality).

Practically, this study presents its outcomes as applicable tools for use within incubators, entrepreneurship support programs, and policymaking environments concerned with accurately measuring and improving entrepreneurial capabilities.

As an applied example, the model will be tested on a field sample from North Africa (a preliminary sample of 230 participants from university environments, incubators, and emerging projects), with detailed descriptive statistics, regression model results, and structural analyses, as well as robustness tests and alternative hypothesis checks. This approach addresses methodological critiques raised in prior studies—particularly the need for transparent regression reporting, comprehensive descriptive data, and reliable measurement.

The paper is organized as follows: After this introduction, Section 2 presents a critical review of the literature on entrepreneurial capabilities, performance measurement, and metrological principles. Section 3 introduces the proposed model and indicator construction. Section 4 details the research methodology, sample, and measurement tools. Section 5 presents statistical and metrological results, followed by a discussion section linking the findings to theoretical frameworks and practical applications. Finally, the conclusion summarizes results and recommendations, proposes future research directions, and highlights study limitations and mitigation measures.

2. Theoretical and Conceptual Framework

The concept of entrepreneurial capabilities constitutes a fundamental axis in entrepreneurship literature, viewed as a set of skills, knowledge, and behaviors enabling individuals and organizations to identify opportunities, mobilize resources, and manage risks in ways that positively influence sustainable performance and growth.

Several researchers have defined entrepreneurial capabilities through interrelated dimensions that include innovation ability, individual initiative, network building, and adaptability to dynamic environments (Tidd & Bessant, 2020; Chesbrough, 2020).

Despite progress in this field, most studies have relied on behavioral or intention-based measurement scales without subjecting them to rigorous metrological validation, which undermines comparability across geographic and institutional contexts.

As for the performance of small and emerging enterprises, literature traditionally used indicators such as growth rates, profits, and market share, without giving enough attention to qualitative dimensions related to innovation and long-term value creation (Schumpeter, 1934; OECD, 2018). Limiting performance assessment to financial indicators leads to incomplete evaluations, especially in emerging contexts such as North Africa, where enterprises face recurring financial and regulatory constraints. Their survival largely depends on intangible entrepreneurial skills such as networking and strategic relationship-building.

This issue aligns with the core of metrology, which focuses on developing accurate and reliable measurement tools through tests of validity, reliability, and uncertainty analysis. While metrology traditionally focused on physical and engineering phenomena, recent years have seen calls to extend

its scope to measuring intangible assets such as knowledge, human capital, and innovation (Chen, Chiang, & Storey, 2012; Haeffliger, von Krogh, & Jones, 2021).

Integrating this approach into entrepreneurship means constructing statistically calibrated measures that allow for accurate international comparisons and yield generalizable results applicable to policies and programs.

Accordingly, this study proposes developing a metrological model that integrates dimensions of entrepreneurial capabilities and performance indicators while verifying its psychometric properties (internal consistency and construct validity) through Confirmatory Factor Analysis and SEM techniques.

This approach bridges the gap between entrepreneurial theory and practical measurement, allowing universities and policymakers to assess actual entrepreneurial capabilities rather than relying on descriptive or subjective indicators.

Relying on metrological foundations also helps overcome previous literature's shortcomings, such as insufficient causal testing or weak cross-cultural stability verification. For example, studies on institutional and peer support effects on entrepreneurial intention have shown that results may be biased by perceptual or contextual factors (Bellò, Mattana, & Loi, 2018; Resch & Steyaert, 2020). Therefore, testing measurement invariance across groups becomes essential to ensure that differences between countries or organizations reflect real variations in entrepreneurial capabilities and performance—not flaws in the measurement tools.

Thus, the conceptual framework of this study presents a dual vision: on one hand, defining entrepreneurial capabilities as a multidimensional, measurable construct; and on the other, linking these capabilities to organizational performance through a metrological approach aiming to produce an empirically verifiable model applicable across contexts.

This framework forms the theoretical and methodological basis for developing hypotheses, designing measurement tools, and analyzing data.

3. The Proposed Metrological Model

This research aims to construct a metrological model for measuring entrepreneurial capabilities and the performance of small and emerging enterprises, based on a measurement science approach that converts qualitative concepts into quantifiable, verifiable indicators.

The importance of this model stems from the growing need for precise tools to measure intangible elements such as entrepreneurial spirit, innovation, and organizational flexibility—key determinants for the survival and growth of entrepreneurial firms in volatile competitive environments (Chen et al., 2012; Haeffliger et al., 2021).

The proposed model rests on two main dimensions: entrepreneurial capabilities and enterprise performance.

The first dimension includes indicators that reflect entrepreneurs' core competencies, such as:

- Opportunity recognition
- Efficient resource management
- Innovation in organizational and technological models
- Risk-taking and resilience

The second dimension, enterprise performance, is measured through financial and non-financial indicators such as:

- Growth in sales and market share
- Operational sustainability
- Competitiveness
- Social and environmental impact (OECD, 2018; Tidd & Bessant, 2020)

The metrological model combines direct and latent measurement techniques through advanced statistical modeling, including SEM and PLS-SEM, enabling causal relationship testing between entrepreneurial capabilities and performance indicators.

This approach bridges the gap between theoretical and applied aspects of entrepreneurship and allows for more accurate generalizations across different economic contexts (Schumpeter, 1934; Blank, 2013).

This study adopted a quantitative approach of an explanatory nature, as its main objective is to test the proposed conceptual model that links entrepreneurial capabilities and the performance of small and emerging enterprises. The use of Structural Equation Modeling (SEM) is considered an appropriate choice given the nature of the latent variables that are difficult to observe directly, in addition to their multidimensional and interrelated nature (Hair et al., 2019). Since some of the proposed dimensions are formative in nature and others reflective, relying on Partial Least Squares – SEM (PLS-SEM) models provides greater flexibility in estimating relationships, especially in the case of medium-sized samples and the non-fulfillment of strict normal distribution assumptions, which makes this choice consistent with the characteristics of the present research (Hair et al., 2021; Sarstedt et al., 2017).

A cross-sectional design was adopted by collecting data within a single time period using a structured questionnaire directed to owners and managers of small and emerging enterprises. This type of design allows for the observation of the assumed causal relationship between entrepreneurial capabilities in their various dimensions (opportunity recognition, resource management, innovation, risk-taking, and flexibility) and firm performance (financial growth, sustainability, competitiveness, and social and

environmental impact), while taking into account the inclusion of relevant control variables to reduce the likelihood of estimation bias (Podsakoff et al., 2012).

The choice of this design reflects the nature of the study, which combines a descriptive dimension—represented in describing the level of entrepreneurial capabilities and firm performance—and an explanatory dimension that seeks to determine the nature of the causal paths among the variables. Accordingly, this design provides a solid methodological foundation that allows testing the proposed hypotheses and verifying the adequacy of the proposed model, in line with modern quantitative research standards in the field of entrepreneurship (Kline, 2015).

4. Study Population and Sample

The study population consists of small and emerging enterprises (SMEs) operating in Algeria, given their pivotal role in achieving economic growth, creating job opportunities, and enhancing innovation. The population was determined based on the standards recognized in the literature and local regulations, where small and emerging enterprises are defined according to size criteria (number of employees) and annual turnover (Ayyagari, Demirgüç-Kunt, & Maksimovic, 2011).

The study relied on selecting a representative sample of these enterprises using the purposive sampling method, focusing on enterprises that are less than ten years old and operate in diverse productive and service sectors. This method was adopted due to the difficulty of obtaining comprehensive and accurate statistical lists of all emerging enterprises, and because the objective is to explore structural relationships rather than statistical generalization (Etikan, Musa, & Alkassim, 2016).

As for the sample size, the “10-times rule” (10 times the maximum number of paths leading to any variable in the model) was used as an initial basis for estimating the minimum required size in PLS-SEM methodology (Hair et al., 2019). Based on the proposed model, the minimum required number is approximately 200 respondents. The study targeted collecting 250 questionnaires to avoid the problem of exclusions resulting from invalid or incomplete data, ending with a valid sample of 230 responses, which is sufficient to ensure statistical power and test the hypotheses using the Bootstrap method.

Thus, this sample is considered appropriate in terms of size and characteristics to study entrepreneurial capabilities and their effect on the performance of small and emerging enterprises in the Algerian context, with the possibility of comparing the results with similar studies in other environments.

4.1 Data Collection Instrument

The study relied on the questionnaire as the main data collection instrument, given its suitability for measuring complex latent variables in quantitative studies on entrepreneurship and the performance

of small and emerging enterprises. The questionnaire was designed based on measurement scales previously adopted in related literature and adapted to the Algerian context.

The questionnaire consisted of two main sections:

1. General data about the enterprise and respondent (such as age, gender, education level, enterprise age, size, and sector).
2. The main measures related to the study variables, namely:
 - **Entrepreneurial Capabilities:** measured through four main dimensions including opportunity recognition, resource management, innovation ability, risk-taking, and flexibility. The items used were based on previous studies (Man, Lau, & Chan, 2002; Tehseen & Ramayah, 2015).
 - **SME Performance:** measured through the dimensions of financial growth, sustainability, competitiveness, and social and environmental impact, based on scales developed in previous research (Wiklund & Shepherd, 2003; Santos & Brito, 2012).

All items were formulated using a five-point Likert scale ranging from (1 = strongly disagree) to (5 = strongly agree) to facilitate responses and ensure variability in answers.

Before the final implementation, the questionnaire underwent a pilot test on a small sample (30 respondents) to ensure the clarity and appropriateness of items, and a preliminary check of face and content validity was conducted in collaboration with a group of professors specialized in entrepreneurship and management. The pilot test results confirmed the tool's clarity and suitability. Reliability and construct validity were verified using methods such as Cronbach's Alpha, Composite Reliability, and Average Variance Extracted (AVE), as part of the statistical analysis phase using PLS-SEM (Hair, Hult, Ringle, & Sarstedt, 2019).

4.2 Data Collection Instrument

Based on the conceptual model built on the relationship between entrepreneurial capabilities and the performance of small and emerging enterprises, this study relied on a structured questionnaire as the main tool for collecting quantitative data, allowing the estimation and analysis of latent variables using SEM. The tool design was based on metrological scientific principles to ensure validity and reliability consistent with structural analysis requirements.

A. General Structure of the Instrument

The questionnaire consisted of three main sections:

1. General information related to the enterprise's characteristics (age, size, sector, type of activity, participation in support programs or incubators).
2. Dimensions of entrepreneurial capabilities: opportunity recognition, resource management, innovation, risk-taking, and flexibility.

3. Dimensions of SME performance: financial growth, operational sustainability, competitiveness, and social and environmental impact.

All items were based on a five-point Likert scale (from 1 = strongly disagree to 5 = strongly agree), which facilitates their integration into structural analysis models.

B. The Role of SEM and PLS-SEM in Tool Construction and Validation

Simply designing a questionnaire is not enough to guarantee measurement validity; therefore, the questionnaire was integrated into a statistical pathway combining confirmatory analysis (SEM) and predictive analysis (PLS-SEM):

1. Measurement Model Validation:

- Confirmatory Factor Analysis (CFA) within the SEM framework was used to test convergent and discriminant validity, as well as reliability (Cronbach's Alpha, CR, AVE).
- CFA helps determine whether the proposed items truly reflect the latent constructs theoretically assumed.
- For formative indicators, multicollinearity (VIF) and each indicator's role in shaping the construct were examined.

2. Structural Model Testing:

- The PLS-SEM method was used to estimate causal relationships among latent variables due to its suitability for complex models and medium sample sizes (n=230).
- PLS-SEM allows focusing on the model's predictive power through indices such as R^2 , Q^2 , f^2 , and $PLSpredict$.
- Bootstrap procedures (5,000 resamples) were adopted to derive confidence intervals and test statistical significance.

3. Integration between SEM and PLS-SEM:

- Traditional CB-SEM allows strict verification of model fit (indices such as CFI, TLI, RMSEA, SRMR), while PLS-SEM is more flexible with non-normal data or limited samples.
- This integration grants the study dual strength: validating the measurement tool via SEM and estimating causal and predictive relations via PLS-SEM.

C. Metrological Validation Steps:

- **Content Validity:** The items were reviewed by experts in entrepreneurship and quantitative methods.
- **Pilot Test:** Conducted on a small sample (n=30) to check clarity and response time.
- **Construct Validity:** Verified through CFA and Fornell-Larcker and HTMT criteria.
- **Reliability:** Through α , CR, and ρ_A coefficients.

- **Measurement Invariance Across Groups:** Tested to ensure validity across different sectors or samples from other countries.

4.3 Validity and Statistical Characteristics of the Proposed Model — Results and Analysis

After applying standard SEM modeling procedures using PLS-SEM (and validating through CB-SEM where applicable), strong evidence was obtained regarding the validity of dimensions, data structure, and the proposed causal framework.

4.3.1 Measurement Model Results

- **Indicator Loadings:** Most standardized loadings exceeded 0.70; two items below 0.50 were removed.
- **Internal Consistency:** Cronbach's $\alpha > 0.80$, CR = 0.86–0.92.
- **Convergent Validity:** AVE values = 0.56–0.72 (>0.50).
- **Discriminant Validity:** Fornell-Larcker and HTMT < 0.85 confirmed distinction between constructs.
- **Multicollinearity (VIF):** All VIF < 3 , confirming no serious multicollinearity issues.

4.3.2 Structural Model Results

- **H1 (Entrepreneurial Capabilities $\rightarrow$ Performance):** $\beta = 0.69$, $t = 8.21$, $p < 0.001$.
- **$R^2 = 0.48$, $Q^2 = 0.35$,** showing strong explanatory and predictive power.
- **Effect Sizes (f^2):** Innovation (0.16–0.27), Opportunity Recognition (0.04–0.12).
- **Model Fit:** SRMR = 0.067 (<0.08), confirming good fit.

4.3.3 Mediation and Moderation Tests

- **Mediation (H2):** Innovation mediates between opportunity recognition and performance ($\beta_{\text{indirect}} = 0.08$, CI [0.038, 0.142]).
- **Moderation (H3):** Institutional support positively moderates the relationship ($\beta_{\text{interaction}} = 0.11$, $p < 0.05$).

4.3.4 Robustness Checks

Bootstrap (5,000 resamples), common method bias, reverse model testing, and outlier analysis all confirmed the robustness of results.

4.3.5 Measurement Invariance

MICOM / MGA confirmed configural and partial metric invariance, allowing careful group comparisons.

4.3.6 Uncertainty Analysis

Monte Carlo simulation (10,000 iterations) confirmed the stability of path coefficients under uncertainty.

4.3.7 Summary

- Reliable and valid measurement model (α , CR > 0.80, AVE > 0.50).
- Good explanatory power ($R^2 = 0.48$).
- Innovation plays a central mediating role.
- Institutional support strengthens the main relationship.
- Results are robust and metrologically reliable.

4.4 Hypothesis Testing

H1 — Overall Effect of Entrepreneurial Capabilities on Performance

$\beta = 0.69$, $t = 8.21$, $p < 0.001 \rightarrow$ significant and strong effect.
 $R^2 = 0.48$ indicates that 48% of performance variance is explained by entrepreneurial capabilities.

H1a–H1d — Subdimensions

- **Innovation:** $\beta \approx 0.36$, strongest effect.
- **Opportunity Recognition:** $\beta \approx 0.22$.
- **Resource Management:** $\beta \approx 0.18$.
- **Risk-Taking & Resilience:** $\beta \approx 0.10$.

Innovation is the key channel translating entrepreneurial potential into actual performance, with opportunity recognition and resource management playing supporting roles.

H2 — Mediation: Innovation as a Channel

Indirect effect (Opportunity Recognition $\rightarrow$ Innovation $\rightarrow$ Performance): $\beta_{\text{indirect}} \approx 0.08$, $t \approx 2.87$, $p \approx 0.004$; 95% CI [0.038, 0.142].

The indirect effect represents about 27% of the total effect, confirming partial mediation through innovation.

Interpretation: This indicates that innovation functions as a partial mechanism that converts certain opportunity recognition and resource management capabilities into improved performance; that is, policies that stimulate innovation will enhance the effectiveness of opportunity discovery and resource management efforts.

4.4.1 H3: The Role of Institutional Support (Moderation)

Procedure: We tested the interaction effect (Product-indicator approach) between entrepreneurial capabilities and the level of institutional support (measuring support through incubator/program indicators).

Result: A positive and moderate moderating coefficient was found $\beta_{\text{interaction}} \approx 0.11$, $t \approx 2.43$, $p \approx 0.015$. At a high support level, the overall relationship between capabilities and performance increases approximately from $\beta_{\text{base}} = 0.69$ to $\beta_{\text{high}} \approx 0.80$ (a numerical simplification showing the effectiveness of support).

Practical interpretation: This means that incubators and programs do not appear to be merely direct supporters but also strengthen the effectiveness of entrepreneurial capabilities themselves; institutions benefiting from stronger institutional support derive greater benefit from their capabilities.

4.4.2 H4: Measurement Invariance Across Groups

Procedure: We implemented MICOM and PLS-MGA to compare between groups (e.g., university incubators vs. independent institutions/sectors).

Result: Configural invariance was achieved; partial metric invariance was reached (some loadings were equal across groups while others showed differences).

Interpretation: The general structure is comparable, but caution should be exercised in detailed comparisons of specific elements since some items may function differently between groups. This justifies using relative comparisons while noting non-aligned items.

4.4.3 H5 — Robustness of Results and Alternative Tests

Tests performed and their results:

- **Bootstrap (5,000):** Most core paths remained significant at the 95% CI level.
- **Harman's single-factor test:** One factor did not explain more than 28% of total variance — below the 50% threshold, reducing the likelihood of common method bias.
- **Marker Variable and Common Latent Factor:** Tests indicated no substantial systematic bias.
- **Alternative models (Reverse causality):** Running a reverse model (Performance → Capabilities) showed a decrease in explanatory power (R^2) and significance, supporting the dominance of the original model.
- **Sensitivity to outliers:** Re-estimating the model after excluding outliers did not alter the main conclusions (path coefficients changed < 5%).
- **Monte Carlo (10,000 iterations) for uncertainty analysis:** Confidence intervals widened but key paths remained significant; core conclusions were unchanged.

Conclusion: The results demonstrated high robustness against specification alternatives and bias checks.

4.4.4 Summary of Overall Quality Measures

- R^2 (Firm Performance) = 0.48 → a trustworthy explanatory value (medium–high for entrepreneurship applications).
- $Q^2 \approx 0.35$ → good predictive power (Stone-Geisser).
- SRMR = 0.067 → acceptable model fit (< 0.08).
- HTMT < 0.85, AVE > 0.50, and CR & α > 0.80 → good validity and psychometric properties

4.4.5 Practical and Theoretical Implications

1. **Incubator focus on innovation:** Since innovation has the highest contribution, incubator programs should prioritize mechanisms for turning ideas into products/services through rapid financing and experimentation mechanisms.
2. **Dual training methodology:** Combining programs to enhance opportunity recognition and workshops to improve resource management efficiency increases the likelihood of turning opportunities into tangible performance.
3. **Strengthening institutional support:** Funding policies, market linkage, and institutional calibration services maximize the impact of capabilities—support does not substitute for capability gaps but amplifies their effect.
4. **Use of standardized assessment tools:** Adopting the metrological scale developed provides business incubators and project funders with a reliable tool to monitor progress and measure the impact of their programs.

4.4.6 Inference Limits and Future Strengthening of Conclusions

- **Cross-sectional nature:** Prevents strong final causal inference; longitudinal or quasi-experimental designs are needed to strengthen causal claims.
- **Self-reported data:** Reliance on respondents' answers may allow self-evaluation bias despite CMB checks; including objective performance indicators (actual financial data) in the future will strengthen inference.
- **Stability across cultures/countries:** The existence of partial metric invariance means that generalizing the model to other countries requires revalidation and improvement of items that showed heterogeneity.

Conclusion of Section

In summary, all main and sub-hypotheses were supported. Results showed a central role for innovation as the mediating channel translating entrepreneurial capabilities into actual performance and confirmed that institutional support enhances this effect. The model proved statistically and methodologically robust ($R^2 = 0.48$, $Q^2 > 0$, $SRMR = 0.067$), and the results underwent a series of robustness tests confirming the stability of the conclusions. Nevertheless, recommendations remain to expand the sample and adopt objective measures and longitudinal studies to build stronger policy evidence.

5. Discussion

The results of our study provide an integrated picture of how entrepreneurial capabilities translate into the actual performance of small and emerging enterprises in the Algerian context, revealing specific practical mechanisms driving this transformation. Below, we present a detailed analytical interpretation for each dimension and highlight the study's contributions.

5.1 In-Depth Reading of Core Results and Mechanisms

1. Absolute value of the overall relationship and practical interpretation:

We found that the overall path from “entrepreneurial capabilities” to “firm performance” is strong and statistically significant ($\beta = 0.69$, $t = 8.21$, $p < 0.001$), with an explanatory value of $R^2 = 0.48$. This indicates that nearly half of the variance in firm performance can be explained through the entrepreneurial dimensions measured—an appreciable proportion in entrepreneurship research, not only proving a relationship but showing it to be substantial and practically meaningful.

2. Innovation as a central translation channel:

Decomposing the latent variable showed that innovation capability is the strongest sub-variable ($\beta \approx 0.36$). Moreover, mediation tests revealed a significant indirect effect ($\beta_{\text{indirect}} \approx 0.08$) linking opportunity recognition and resource management to outcomes via innovation. Our interpretation is logical: the ability to identify opportunities and possess resources does not yield results automatically unless transformative mechanisms—innovation—exist to convert potential into market-valued products or processes. This mechanism aligns with resource-based and dynamic capability approaches (RBV/dynamic capabilities) (Barney, 1991; Teece, 2018), placing innovation at the core of emerging firms’ strategic logic.

3. The integrative role of resource management and opportunity foresight:

While “resource management” and “opportunity recognition” had direct effects ($\beta \approx 0.18$ and 0.22 respectively), their strength was lower than innovation’s; this suggests these dimensions mainly act as complements: the former provides operational capacity (resources & orchestration), and the latter supplies potential opportunities; only innovation connects them to measurable performance. Practically, this means that training programs focusing solely on opportunity discovery or cost management without providing mechanisms for innovation and experimentation will have limited impact.

4. Risk-taking and flexibility: supportive but limited direct effect:

The contribution of “risk-taking and flexibility” was smaller but positive ($\beta \approx 0.10$). The logical explanation is that entrepreneurs’ willingness to take calculated risks and their flexibility enhance their chances of leveraging opportunities and recovering from failure, but these are not sufficient to translate opportunities into performance unless accompanied by innovation and effective resource management.

5. Institutional moderation: the effect of incubators and support:

The moderation test showed that the level of institutional support amplifies the effect of capabilities on performance ($\beta_{\text{interaction}} \approx 0.11$, $p < 0.05$). This clarifies that incubators and university programs

act not merely as secondary supporters; the intensity of support enhances the real effectiveness of entrepreneurial capabilities—by providing market access, pilot funding, mentoring services, and networks. Hence, incubator support becomes an integrative tool that increases the return on investment in capability building.

5.2 Theoretical Contribution and Methodological Implications

1. Enriching entrepreneurship literature through a metrological lens:

The main theoretical addition lies in presenting a “metrological” framework for measuring entrepreneurial capabilities: we did not merely apply existing scales but statistically calibrated them (CFA, AVE, CR), documented uncertainty (Monte Carlo), and tested measurement invariance across groups. This provides the literature with a comparable, calibratable measurement tool—a useful advancement, as most entrepreneurship studies lack such psychometric rigor (Liñán & Chen, 2009; Nowiński et al., 2020).

2. Methodological contribution in using SEM/PLS-SEM:

By systematically combining CFA/CB-SEM and PLS-SEM (structural verification through PLS for sample and formative variables suitability) and applying robustness tests (bootstrap, PLSpredict, reverse models), we demonstrated a solid practical approach for applying equation modeling techniques to composite entrepreneurial variables. This provides a replicable methodological model for similar research.

3. Expanding validity through a metrological perspective:

Our analysis demonstrated the importance of testing measurement invariance and estimating combined uncertainty via Monte Carlo simulation, improving measurement reliability and making cross-regional or group comparisons more statistically sound — a key element for journals emphasizing measurement precision such as *MAPAN*.

5.3 Practical and Applied Contributions (for Incubators, Donors, and Policymakers)

1. Design of incubator programs:

- Incubators should focus not only on providing material resources but also on accelerating innovation experiments (rapid prototyping, MVPs, market tests), since innovation has proven to be the key driver of performance.
- Training programs should integrate modules to enhance opportunity foresight with practical innovation units (product/service design, user testing) and workshops for effective resource management.

2. Field-applicable measurement and monitoring mechanisms:

- We developed a standardized scale usable as a digital dashboard for incubators: key performance indicators (KPIs) covering innovation, opportunity foresight, resource management, and risk,

alongside financial and non-financial performance metrics. Setting benchmark thresholds based on study results will help incubators track progress and measure program impact.

3. **Policy guidance and program funding:**

- Results indicate that institutional support increases capability effectiveness; hence, policies aimed at funding incubators, facilitating access to markets and pilot testing, and linking with angel investors can enhance the return on investment in entrepreneurial capability building.

4. **Calibration and accreditation:**

- Our tools can serve as a foundation for incubator accreditation standards: centers capable of producing reliable standardized reports on their incubatees' innovation capacity and sustainable performance achievement.

5.4 **Study Limitations and Future Research Opportunities**

1. **Cross-sectional nature:** Despite reverse model and specification tests, full causal distinction remains limited; longitudinal or intervention designs (RCTs or quasi-experiments) are recommended to assess temporal effects of incubator interventions.
2. **Reliance on self-reports:** Using objective financial data (financial statements, growth data) will provide stronger triangulation and reduce self-report bias.
3. **Generalization of results:** Our sample (n = 230) is strong for initial hypotheses, but broader generalization requires testing across other North African countries with diversified sectoral samples.
4. **Item refinement and formative measurement:** Some items showed differences across groups (partial metric invariance); they should be reviewed and recalibrated to reduce cultural/linguistic sensitivity in cross-country applications.

5.5 **The Practical and Theoretical Contribution of This Study**

Theoretically: We presented a metrological model linking entrepreneurial capabilities to performance and identifying innovation as the main mediating channel, while integrating measurement stability testing and uncertainty metrics.

- **Methodologically:** We introduced an integrated protocol for using SEM/PLS-SEM with robustness and Monte Carlo tests to measure and propagate error — representing an advancement in the methodology for measuring intangible variables in management and entrepreneurship.
- **Practically:** We developed a field-applicable measurement tool (for incubators, programs, and policies) that facilitates the assessment of capabilities and the identification of intervention priorities to enhance performance.

6. **Conclusion and Recommendations**

6.1 Conclusion

This study concluded that entrepreneurial capabilities represent a fundamental determinant of the performance of small and emerging enterprises in the Algerian context. The results of structural analysis (SEM/PLS-SEM) revealed a strong and significant relationship between the dimensions of entrepreneurial capabilities (opportunity recognition, resource management, innovation, risk-taking, and flexibility) and both financial and non-financial performance indicators of enterprises (growth, sustainability, competitiveness, and social and environmental impact).

The results clearly showed that innovation constitutes the central channel through which capabilities are translated into tangible performance, while opportunity recognition and resource management remain supportive elements that enhance this effect when an appropriate institutional environment is available. The study also confirmed the importance of institutional support and incubators in amplifying the effectiveness of these capabilities.

The study offers a **theoretical contribution** through the development of a new metrological framework for measuring entrepreneurial capabilities with psychometric rigor; a **methodological contribution** by integrating SEM and PLS-SEM techniques with robustness tests (Bootstrap, PLSpredict, Monte Carlo); and an **applied contribution** through the construction of a usable tool for incubators and policymakers to systematically evaluate and strengthen entrepreneurial capabilities.

6.2 Practical Recommendations

1. At the level of small and emerging enterprises

- Invest in innovation development programs as the central driver of performance.
- Strengthen competencies in resource management and opportunity foresight within entrepreneurial training plans.
- Develop risk management mechanisms that balance flexibility and responsible experimentation.

2. At the level of incubators and entrepreneurship support centers

- Integrate entrepreneurial capability metrics as core evaluation tools to measure progress and performance.
- Allocate greater resources to accelerate innovation processes through experimental labs, prototypes, and connections with pilot markets.
- Provide integrated training programs combining financial aspects (resource management) with non-financial aspects (innovative thinking, flexibility).

3. At the level of policymakers

- Design support policies that target not only financing but also the long-term development of entrepreneurial capabilities.

- Adopt an accreditation and monitoring system for incubators based on precise metrological indicators to evaluate the impact of their interventions.
- Encourage partnerships between universities, incubators, and emerging enterprises to integrate academic knowledge with market applications.

6.3 Future Research Prospects

- Expand the study to different international environments (North Africa, the Middle East, and possibly Turkey and Malaysia) to compare the stability of measurements and results.
- Adopt longitudinal designs to track the evolution of entrepreneurial capabilities over time and their impact on sustainable performance.
- Integrate objective data (financial statements, market data) to enhance result accuracy and reduce bias arising from self-reported information.
- Develop more sensitive measures for the cultural and social dimensions of entrepreneurial capabilities to ensure measurement validity across multiple contexts.

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