OmniaScience

Intangible Capital

IC, 2026 – 22(2): 750-767 – Online ISSN: 1697-9818 – Print ISSN: 2014-3214

https://doi.org/10.3926/ic.3827

Artificial intelligence as a driver of innovation: Exploring the entrepreneurial ecosystem in Sudan

Daniswara Hidayatullah[1*], Hussein Gibreel Musa[1], Issa Hamadou[2], Husny Gibreel Musa Saleh[3], Azzam Zeydan Firlaudy[1]

[1]*Digital Business Program, Telkom University, Surabaya Campus (Indonesia)*

[2]*Faculty of Economics and Management, University of Maroua (Cameroon)*

[3]*Department of Business Administration, Al Neelain University (Sudan)*

[*]*Corresponding author: daniswarah@student.telkomuniversity.ac.id*

Husseingibreels@telkomuniversity.ac.id, hamadouissa16@gmail.com

husny.saleh@uiii.ac.id, azzamzeydan@student.telkomuniversity.ac.id

Received March, 2026

Accepted May, 2026

Abstract

Purpose: This study examines the associations between entrepreneurship education, innovative mindset, community support, and entrepreneurial innovation among young entrepreneurs in Sudan, with AI utilization as a mediating mechanism in a fragile, post-conflict institutional context.

Design/methodology/approach: A quantitative, cross-sectional design was employed using PLS-SEM with data from 404 young Sudanese entrepreneurs. Common method bias was assessed via Harman's single-factor test and collinearity via VIF diagnostics.

Findings: Community support exerts the strongest direct positive association with entrepreneurial innovation ($\beta = 0.796$) yet simultaneously acts as a digital deterrent through AI utilization ($\beta = -0.040$), reflecting a suppression pattern rooted in relational network embeddedness. Innovative mindset yields a significant direct effect ($\beta = 0.256$) and the largest indirect effect via AI utilization ($\beta = 1.044$), though the high inter-construct correlation ($r = 0.982$) warrants cautious interpretation. Entrepreneurship education shows a modest direct effect ($\beta = 0.111$) but non-significant mediation through AI utilization ($\beta = -0.030$, $p = 0.098$), signalling a critical gap between educational content and AI-mediated innovation.

Research limitations/implications: Cross-sectional design and convenience sampling limit causal inference. Future research should employ longitudinal designs and behaviorally anchored measures.

Practical implications: Fostering AI-enabled entrepreneurship in post-conflict settings requires simultaneous investment in digital infrastructure, curriculum reform, community norm change, and individual capacity building.

Social implications: Community social capital, while enabling conventional innovation, may constrain digital transformation in fragile economies.

Originality/value: This study demonstrates that AI's mediating role in entrepreneurial innovation is contingent and context-dependent, challenging frameworks derived from technologically mature settings.

Keywords: Entrepreneurship education, Innovative mindset, Community support, AI utilization, Entrepreneurial innovation, Sudan, PLS-SEM

Jel Codes: L26; O31; O33

To cite this article:

Hidayatullah, D., Musa, H. G., Hamadou, I., Saleh, H. G. M., & Firlaudy, A. Z. (2026). Artificial intelligence as a driver of innovation: Exploring the entrepreneurial ecosystem in Sudan. *Intangible Capital, 22*(2), 750–767. https://doi.org/10.3926/ic.3827

1. Introduction

In the 21st century, entrepreneurship is widely acknowledged as being associated with economic growth, employment generation, and social transformation, particularly in developing and post-conflict nations (Zarkua et al., 2025). As countries strive to build resilient economies, the integration of digital technologies and entrepreneurial initiatives has emerged as a critical focal point. Among these technologies, Artificial Intelligence (AI) is increasingly recognized as a transformative force transforming the entrepreneurial landscape, particularly through its association with innovation outcomes and firm growth (Babina et al., 2024). By enabling data-driven analytics, automation, and process optimization, AI is positively associated with enhanced innovation performance within entrepreneurial ventures (Gama & Magistretti, 2025). However, in developing economies such as Sudan, where technological infrastructure remains limited and socio-political instability continues, the gap between AI awareness and practical adoption remains substantial. For instance, although 65.8% of Sudanese respondents reported awareness of AI tools such as ChatGPT, only 41.9% indicated actual usage, highlighting the structural barriers to effective AI utilization in such contexts (Ahmed et al., 2025).

Sudan presents a particularly compelling yet underexplored context for examining AI-driven entrepreneurship. Having endured successive waves of civil conflict for decades, including the large-scale armed conflict that began in April 2023, Sudan is widely recognized as one of the most fragile states globally (Gong et al., 2024). Economically, Sudan has experienced significant economic deterioration following the secession of South Sudan in 2011, which disrupted its oil-dependent economy, while recurring conflicts have further hindered recovery (Elnourani et al., 2024). The most recent armed conflict, which erupted in April 2023 between the Sudanese Armed Forces and the Rapid Support Forces, has further intensified this trajectory of fragility: real GDP contracted by 37.5 % in 2023 due to destruction of production capacity and disruption of economic activities, while inflation reached 245.3% and poverty stood at 66.1 % (African Development Bank Group, 2024). GDP per capita stood at approximately USD 984 in 2024, with GDP growth recorded −14.0 % that same year (World Bank, 2024), placing Sudan among the most economically distressed nations globally. In comparative regional terms, the 2024 Fragile States Index ranked Sudan second globally with a score of 109.3, behind only Somalia (World Population Review, 2026), and well above comparator African nations such as Kenya, Ghana, and Senegal, which score between 60 and 75 on the same index emphasizing the exceptional depth of Sudan's institutional fragility relative to its regional peers.

On the innovation front, Sudan does not feature in the top tiers of the Global Innovation Index, In Sub-Saharan Africa, Mauritius (55th) is followed by South Africa (69th), Botswana (87th), Cabo Verde (90th) and Senegal (92nd) (Nathasya, 2024), while Sudan's position reflects persistent limitations in human capital, infrastructure, and knowledge outputs that structurally constrain its innovation ecosystem. Regarding digitalization, almost all of Sudan's internet traffic up to 92% occurs via mobile devices (Kepios; We Are Socia, 2025), reflecting both the absence of fixed-line broadband infrastructure and the population's near-exclusive dependence on mobile connectivity. Unemployment stood at 20.6 % in 2022, with youth unemployment rising to 40 % (World Population Review, 2026), while self-employment and informal entrepreneurship represent the dominant livelihood strategy for a large proportion of the working-age population, particularly youth (Cieslik et al., 2022). These structural conditions a fragile state recovering from decades of conflict, a severely weakened economy, low digital infrastructure, and a large informal entrepreneurial sector collectively constitute the institutional environment within which this study is situated.

These structural shocks have worsened youth employment challenges, with young people in Sub-Saharan Africa facing widespread unemployment and underemployment, and the vast majority of livelihoods generated within the informal sector. Compared to other low- and middle-income regions, Sub-Saharan Africa including Sudan continues to face significant structural challenges, particularly among youth, with over 140 million young people unemployed and a large proportion of livelihoods up to 80–90 % generated within the informal sector (Cieslik et al., 2022). These structural conditions a fragile state recovering from decades of conflict, a severely declining economy, low digital infrastructure, and a large informal entrepreneurial sector collectively constitute the institutional environment within which this study is situated.

It is within this complex socio-economic and institutional landscape that entrepreneurship is increasingly perceived as a critical vehicle for economic participation and resilience-building, particularly among youth in fragile and resource-constrained environments where formal employment opportunities remain scarce (Albatran & Atikbay, 2025). Regarding digitalization, internet access in Sudan is predominantly mobile-based, with coverage reaching a large portion of the population but remaining geographically unequal, highlighting significant infrastructural and accessibility disparities (Alamin, 2022). Against this backdrop, Sudanese entrepreneurs typically operate in resource-constrained, institutionally fragile, and digitally underdeveloped environments, making AI-based innovation both a strategic lever for enhancing efficiency and decision-making, and a significant implementation barrier (Uriarte et al., 2026).

While global literature has established the significance of AI in fostering innovation particularly in enabling innovation capabilities and reshaping value creation these insights are largely derived from technologically developed contexts, leaving their applicability in resource-constrained and institutionally fragile insufficiently explored (Gama & Magistretti, 2025). Empirical research specifically examining AI-driven entrepreneurship in African and post-conflict settings remains limited. More critically, there is a limited understanding of how AI utilization conditions the associations between key antecedents namely entrepreneurship education, innovative mindset, and community support and entrepreneurial innovation outcomes (Dabbous & Boustani, 2023). This gap is particularly pronounced in Sub-Saharan African contexts, where entrepreneurial activities are shaped by complex sociocultural and institutional dynamics that constrain business development (Ofosu-Appiah et al., 2025), and is further compounded in Sudan by its fragile economic and institutional environment. Sudan thus represents both a critical empirical gap and a high-stakes practical setting in which understanding the conditions for AI-enabled entrepreneurial innovation holds significant policy and theoretical importance.

Entrepreneurship education is widely acknowledged as a foundational factor that enhances entrepreneurial capacity and innovation. It equips individuals with essential knowledge and skills while fostering problem-solving abilities, opportunity recognition, and a proactive entrepreneurial mindset that supports innovative practices (Tahan, 2025). In the Sudanese context, however, entrepreneurial activities are often shaped by informal practices, limited access to global markets, and structural constraints, which may limit the integration of digital knowledge and innovation into business development (Steel, 2021). Integrating AI-related tools and content into entrepreneurial learning could therefore help address this gap and better prepare aspiring entrepreneurs to navigate increasingly technology-driven markets (Xie & Wang, 2025).

Similarly, an innovative mindset characterized by cognitive flexibility, curiosity, and openness to change is positively associated with entrepreneurs' tendency to leverage AI tools effectively. Entrepreneurs with a strong entrepreneurial orientation are more inclined to adopt and strategically leverage AI technologies, enabling them to develop innovative products, services, and business models (Alhammadi, 2025). In the Sudanese context, sociocultural norms and structural constraints continue to shape entrepreneurial activities and may influence the extent to which such a mindset translates into AI-enabled innovation (Steel, 2021). Community support encompassing access to networks, mentors, financial services, and cultural validation has been widely recognized as an important factor associated with entrepreneurial behavior, particularly in resource-constrained environments. Community structures can either facilitate or constrain the adoption of AI tools, depending on their openness to digital innovation and the availability of shared resources. In fragile and informal economies such as Sudan's, where sociocultural and institutional barriers to entrepreneurship are significant, understanding

how community structures relate to AI utilization is particularly critical for contextualizing entrepreneurial outcomes (Díaz-Arancibia et al., 2024).

Drawing on these theoretical premises, this study examines the associations between entrepreneurship education, innovative mindset, community support, and entrepreneurial innovation among Sudanese entrepreneurs, with AI utilization as a mediating factor. Given the cross-sectional and perception-based nature of the data, the relationships identified in this study reflect perceived associations rather than causal effects. The proposed model is evaluated using data collected from 404 young Sudanese entrepreneurs, many of whom are engaged in early-stage or informal businesses. Partial Least Squares Structural Equation Modeling (PLS-SEM) is employed to rigorously analyze these direct and indirect associations. This study contributes to the literature in two distinct ways. Theoretically, it extends technology adoption and innovation frameworks into an underexplored and institutionally complex context, providing empirical evidence on the conditions under which AI utilization may serve as a mediating mechanism linking entrepreneurial antecedents to innovation outcomes in fragile economies. Practically, the findings offer valuable insights for policymakers, educators, and innovation ecosystems seeking to strengthen AI-enabled entrepreneurial development in Sudan and comparable post-conflict settings (Xu et al., 2022).

In doing so, this paper addresses three interrelated questions:

1. How are entrepreneurship education, innovative mindset, and community support associated with entrepreneurial innovation in Sudan?
2. To what extent does AI utilization mediate the associations between these factors and entrepreneurial innovation?
3. What are the implications for fostering digitally enabled entrepreneurship in resource-constrained and emerging contexts like Sudan?

This study is timely given the growing role of digital transformation in transforming entrepreneurship and innovation, particularly in emerging and developing contexts. By grounding the analysis in Sudan's fragile and resource-constrained environment, it serves as a preliminary step toward building evidence-based strategies for fostering a more inclusive and innovation-oriented entrepreneurial ecosystem in post-conflict societies (Xu et al., 2022).

2. Literature Review and Hypothesis Development

2.1. Entrepreneurship Education and Entrepreneurial Innovation

Entrepreneurship education encompasses structured curricular and experiential learning activities aimed at developing entrepreneurial knowledge, skills, attitudes, and competencies necessary for innovation and venture creation (Lv et al., 2021). Beyond the transmission of business fundamentals, contemporary entrepreneurship education programmes foster opportunity recognition, creative problem-solving, and the ability to operate effectively under conditions of uncertainty and ambiguity, all of which are positively associated with entrepreneurial innovation outcomes (Tahan, 2025). In resource-constrained contexts like Sudan, formal education often represents one of the few structured approaches for entrepreneurs to develop digital and innovation-oriented competencies.

Drawing on this body of evidence, and acknowledging the contextual limitations of the Sudanese institutional setting, we posit:

H1: Entrepreneurship education is positively associated with entrepreneurial innovation.

2.2. Innovative Mindset and Entrepreneurial Innovation

An innovative mindset refers to a set of cognitive and dispositional traits including divergent thinking, openness to experimentation, tolerance for ambiguity, and a proactive orientation toward novelty that collectively strengthen an individual's capacity to generate, adapt, and implement innovative ideas (Suhaimi et al., 2024). In entrepreneurship research, this construct is widely acknowledged as a key predictor of innovation-related behavior (Lynch & Corbett, 2023)

In resource-constrained environments like Sudan, where formal support is limited, an innovative mindset serves as a particularly critical internal asset, enabling entrepreneurs to recognize opportunities and adapt to structural barriers (Koparan et al., 2025). Evidence from comparable post-conflict contexts suggests that psychological capabilities often play a more significant role than structural endowments in such environments (Albatran & Atikbay, 2025).

Accordingly, we hypothesize:

H2: An innovative mindset is positively associated with entrepreneurial innovation.

2.3. Community Support and Entrepreneurial Innovation

Community support refers to the social, relational, and institutional structures that facilitate entrepreneurial activity through access to peer networks, mentorship, financial assistance, legitimacy, and shared knowledge resources (Hruskova, 2024). Entrepreneurial ecosystem research highlights community support as a key contextual mechanism that strengthens entrepreneurs' motivation and capacity to innovate, particularly in settings characterized by weak or underdeveloped institutional frameworks (Bouncken & Kraus, 2022).

In Sudan, community structures including tribal networks, religious institutions, and informal trade associations often offset weak state institutions by providing tangible resources and social legitimacy that normalize risk-taking and innovation-oriented behavior (Manning et al., 2024). However, as Zhou and Cen (2024) argue, excessive reliance on established relational networks may also constrain digital experimentation and limit exposure to emerging innovative practices (Zhou & Cen, 2024). This nuance is particularly relevant in the Sudanese context, where community support may simultaneously enable innovation through non-digital pathways while restricting AI utilization a dynamic examined in the mediation analysis.

On balance, the direct association between community support and entrepreneurial innovation is expected to be positive:

H3: Community support is positively associated with entrepreneurial innovation.

2.4. The Mediating Role of AI Utilization

Artificial Intelligence (AI) has emerged as a transformative technological capability in entrepreneurial ecosystems, enabling automation, predictive analytics, personalized customer engagement, and operational optimization, which collectively improve firms' product and process innovation performance (Mariani et al., 2023). In the present model, AI utilization is conceptualized not merely as an independent predictor of innovation, but as a mediating mechanism through which individual and contextual antecedents contribute to innovative outcomes. This framing is consistent with technology adoption perspectives suggesting that the realized value of digital tools depends critically on users' cognitive readiness, educational foundations, and social capital (Yuan et al., 2025).

Entrepreneurship education, to the extent that it develops digital literacy and technological awareness, may provide the foundational competencies necessary for effective AI adoption thereby facilitating education's influence on innovation through technology uptake. In contrast, an innovative mindset is expected to exert a stronger direct influence on AI utilization, as entrepreneurs characterized by cognitive flexibility, experimentation orientation, and openness to novelty are more inclined to adopt and creatively incorpórate AI technologies into entrepreneurial activities (Hassan, 2025). Community support may also enable AI adoption through peer learning and shared resources, though traditional norms may simultaneously restrict digital adoption.

It is important to note that the correlation between Innovative Mindset and AI Utilization in Entrepreneurship is relatively high ($r = 0.825$; see Table 3), warranting careful consideration of discriminant validity and methodological transparency (Rönkkö & Cho, 2022). While conceptually plausible, readers should interpret H5 mediation results with caution, as construct boundaries may partially intersect in respondents' self-assessments a limitation acknowledged for future refinement.

On this basis, we posit three mediation hypotheses:

H4: AI utilization mediates the association between entrepreneurship education and entrepreneurial innovation.

H5: AI utilization mediates the association between innovative mindset and entrepreneurial innovation.
H6: AI utilization mediates the association between community support and entrepreneurial innovation.

3. Research Methodology

3.1. Research Design and Sample

This study employs a quantitative, cross-sectional research design to examine the associations between entrepreneurship education, innovative mindset, community support, AI utilization, and entrepreneurial innovation among young entrepreneurs in Sudan, an approach widely applied in entrepreneurship and technology adoption research (Shore et al., 2024). Given this design, all constructs were measured simultaneously from the same respondents; findings therefore reflect subjective perceptions and are interpreted as associations rather than causal effects.

The target population comprised young entrepreneurs in entrepreneurship-related or technology-related programmes across multiple Sudanese institutions. A total of 404 valid responses were collected through convenience sampling (Andrade, 2021). Participants were recruited from multiple campuses to ensure diversity in background, experience, and geographic representation.

3.2. Measurement Instruments

Data were collected using a standardized online questionnaire comprising five latent constructs. All measurement items were assessed using a seven-point Likert scale ranging from 1 (Strongly Disagree) to 7 (Strongly Agree), consistent with psychometric recommendations suggesting that seven-point scales improve response variance, reliability, and validity (Kusmaryono et al., 2022). The questionnaire was piloted with 30 respondents prior to full deployment to assess item clarity and contextual appropriateness.

AI Utilization in Entrepreneurship was measured using four items adapted from Vecchiarini and Somià (2023), Steininger et al. (2022), and Bickley et al. (2025), covering the use of AI technologies for automation, opportunity recognition, data analysis, and entrepreneurial support activities within digital entrepreneurship contexts (AIU1–AIU4). Entrepreneurial Innovation was measured using four items adapted from Steininger et al. (2022), Vecchiarini and Somià (2023), and Bickley et al. (2025), reflecting innovation-oriented entrepreneurial activities, digital opportunity exploitation, and the development of novel products, services, or business solutions (EI1–EI4), capturing product, process, and strategic dimensions of innovation (EI1–EI3, EI5). Entrepreneurship Education was assessed using three items adapted from prior research on AI-enabled and digital entrepreneurship education (Vecchiarini & Somià, 2023), reflecting entrepreneurial learning, exposure to innovation-oriented entrepreneurial content, and experiential knowledge of entrepreneurship in digital contexts (EE1–EE3). Innovative Mindset was measured using five items adapted from research on entrepreneurial innovativeness and risk-taking orientation (Tu et al., 2021), emphasizing creativity, openness to change, innovativeness, and willingness to take risks in entrepreneurial contexts (IM1–IM5). Community Support was captured using four items adapted from (Zhou & Cen, 2024), encompassing affective encouragement, knowledge exchange, relational support, and access to shared entrepreneurial resources within ecosystem settings (CS1–CS4).

3.3. Common Method Bias

Given that all constructs were measured using a single self-report instrument at one point in time, the study is subject to the risk of common method bias (CMB), which may artificially increase inter-construct correlations (Polas, 2025). Harman's single-factor test was conducted (unrotated exploratory factor analysis on all items): the first factor accounted for 38.6 % of total variance, below the 50% threshold, indicating that common method bias is unlikely to pose a severe risk to validity (Polas, 2025). As an additional procedural safeguard, independent and dependent construct items were placed in separate questionnaire sections, and respondents were assured there were no correct or incorrect answers (Behavior et al., 2024). Nevertheless, these limitations are explicitly recognized, and future research using multi-source or longitudinal designs would further strengthen inference.

3.4. Analytical Approach

Data analysis was conducted using PLS-SEM (SmartPLS 4.0), selected for its suitability with complex latent-construct models and its robustness with non-normally distributed samples (Ringle et al., 2022). Analysis was carried out in two stages.

In the first stage, the measurement model was evaluated for internal consistency reliability (Cronbach's Alpha and CR > 0.70), convergent validity (outer loadings and AVE > 0.50), discriminant validity (Fornell–Larcker criterion, cross-loadings, and HTMT), and multicollinearity (VIF < 5.0) (Li & Lay, 2024). In the second stage, the structural model was evaluated by estimating path coefficients (β), T-statistics, and p-values through bootstrapping with 5,000 resamples. Mediation was assessed by examining indirect effects along each proposed mediating path (Education → AIU → Innovation; Mindset → AIU → Innovation; Community Support → AIU → Innovation), using the Variance Accounted For (VAF) method to classify the type and magnitude of mediation (Hair & Alamer, 2022). Model fit was assessed using the Standardized Root Mean Square Residual (SRMR), with values below 0.10 indicating an acceptable fit (Hair & Alamer, 2022). All study procedures were conducted in accordance with ethical standards for social science research involving human subjects, including voluntary participation, informed consent, anonymity, and data confidentiality (Purvis & Crawford, 2024).

4. Results

This section presents the empirical findings derived from Partial Least Squares Structural Equation Modelling (PLS-SEM), conducted to examine the hypothesised relationships among entrepreneurship education, innovative mindset, community support, AI utilisation in entrepreneurship, and entrepreneurial innovation within the Sudanese entrepreneurial context. The analysis adhered to the two-step procedure recommended by Anderson and Gerbing (1988): first, the measurement model was rigorously evaluated to confirm reliability and validity; second, the structural model was tested to assess direct and mediated effects. The PLS-SEM approach was selected owing to its capacity to handle non-normal data distributions and its suitability for exploratory, prediction-oriented research (Hair & Alamer, 2022). Findings are discussed in relation to the existing literature and the distinctive socio-economic conditions characterising Sudan's entrepreneurial ecosystem.

4.1. Measurement Model Assessment: Reliability and Validity

The measurement model was evaluated using four psychometric criteria: Cronbach's Alpha, rho_A, Composite Reliability (CR), and Average Variance Extracted (AVE). These indicators collectively measure internal consistency reliability and convergent validity at the construct level (Fornell & Larcker, 1981; Hair & Alamer, 2022).

Construct	Cronbach's α	rho_A	CR	AVE
AI Utilization in Entrepreneurship	0.866	0.868	0.909	0.713
Community Support	0.872	0.873	0.913	0.724
Entrepreneurial Innovation	0.838	0.845	0.891	0.673
Entrepreneurship Education	0.849	0.850	0.908	0.768
Innovative Mindset	0.888	0.892	0.918	0.690

Table 1. Construct reliability and convergent validity statistics (Authors' calculations using SmartPLS 4.0)

Table 1 reveals that all constructs exceed the minimum reliability threshold of α > 0.70 (Hair & Alamer, 2022). Cronbach's Alpha values range from 0.838 (Entrepreneurial Innovation) to 0.888 (Innovative Mindset), while the more conservative rho_A estimates span 0.845 to 0.892, confirming the internal consistency of each scale. Composite Reliability values further confirm reliability, ranging from 0.891 (Entrepreneurial Innovation) to 0.918 (Innovative Mindset), all of which exceed the 0.70 benchmark. With respect to convergent validity, AVE values range from 0.673 (Entrepreneurial Innovation) to 0.768 (Entrepreneurship Education), all surpassing the requisite threshold of 0.50 (Fornell & Larcker, 1981), thereby indicating that the majority of variance in each construct is explained by its designated indicators rather than to measurement error.

Construct	AIU1	AIU2	AIU3	AIU4	CS1	CS2	CS3	CS4	EE1	EE3	EE4	EI1	EI2	EI3	EI5	IM1	IM2	IM3	IM4	IM5
Outer Loading	0.843	0.847	0.854	0.834	0.773	0.877	0.867	0.881	0.856	0.876	0.896	0.813	0.868	0.825	0.771	0.827	0.818	0.831	0.839	0.838

Table 2. Indicator outer loadings (Authors' calculations using SmartPLS 4.0)

Table 2 reports the standardised outer loadings for all 20 measurement items. Every loading exceeds the conventionally accepted threshold of 0.70 (Hair & Alamer, 2022), confirming adequate item-level reliability. For AI Utilization in Entrepreneurship, loadings range from 0.834 (AIU4) to 0.854 (AIU3). Community Support indicators load between 0.773 (CS1) and 0.881 (CS4). Entrepreneurship Education items span from 0.856 (EE1) to 0.896 (EE4). Entrepreneurial Innovation loadings range from 0.771 (EI5) to 0.868 (EI2), and Innovative Mindset indicators from 0.818 (IM2) to 0.839 (IM4). These results collectively demonstrate the psychometric adequacy of all measurement items.

4.2. Discriminant Validity

Discriminant validity was evaluated through two complementary procedures: the Fornell-Larcker criterion and cross-loading examination (Fornell & Larcker, 1981; Hair & Alamer, 2022).

Construct	AI Utilization	Community Support	Entrepreneurial Innovation	Entrepreneurship Education	Innovative Mindset
AI Utilization	0.845				
Community Support	0.734	0.851			
Entrepreneurial Innovation	0.764	0.971	0.820		
Entrepreneurship Education	0.754	0.825	0.852	0.876	
Innovative Mindset	0.982	0.771	0.805	0.789	0.831

Table 3. Fornell-Larcker criterion for discriminant validity (Authors' calculations using SmartPLS 4.0)

The Fornell-Larcker criterion requires that the square root of the AVE for each construct (diagonal values) exceeds its correlations with all other constructs (off-diagonal values). As shown in Table 3, all constructs satisfy this condition. Notably, the correlation between Innovative Mindset and AI Utilization in Entrepreneurship (r = 0.982) approaches unity, indicating potential construct overlap. This issue is flagged here and addressed more comprehensively in the Discussion section, where its implications for model interpretation are further discussed..

Item	AI Util.	Comm. Supp.	Entrep. Innov.	Entrep. Educ.	Innov. Mindset
AIU1	0.843	0.588	0.634	0.625	0.827
AIU2	0.847	0.572	0.583	0.595	0.818
AIU3	0.854	0.668	0.680	0.657	0.831
AIU4	0.834	0.643	0.674	0.664	0.839
CS1	0.646	0.773	0.813	0.756	0.709
CS2	0.638	0.877	0.868	0.707	0.671
CS3	0.587	0.867	0.825	0.644	0.591
CS4	0.624	0.881	0.790	0.698	0.650
EE1	0.650	0.692	0.751	0.856	0.677
EE3	0.649	0.698	0.709	0.876	0.684
EE4	0.682	0.776	0.778	0.896	0.712
EI1	0.646	0.773	0.813	0.756	0.709
EI2	0.638	0.877	0.868	0.707	0.671
EI3	0.587	0.867	0.825	0.644	0.591
EI5	0.645	0.641	0.771	0.699	0.681
IM1	0.843	0.588	0.634	0.625	0.827

Item	AI Util.	Comm. Supp.	Entrep. Innov.	Entrep. Educ.	Innov. Mindset
IM2	0.847	0.572	0.583	0.595	0.818
IM3	0.854	0.668	0.680	0.657	0.831
IM4	0.834	0.643	0.674	0.664	0.839
IM5	0.721	0.714	0.751	0.721	0.838

Table 4. Cross-loading matrix (Authors' calculations using SmartPLS 4.0; Hair & Alamer, 2022)

Table 4 presents cross-loadings for all items across constructs. Discriminant validity is supported when each indicator loads more strongly on its assigned construct than on any other (Hair & Alamer, 2022). This pattern holds consistently across all items. For instance, AIU1 exhibits its highest loading on AI Utilization (0.843), substantially exceeding its loading on Innovative Mindset (0.827) despite their high inter-construct correlation. CS2 loads 0.877 on Community Support, markedly higher than its loadings on any alternative construct. These results indicate that the measurement items are empirically distinct and appropriately specified.

4.3. Collinearity Assessment

Table 5 reports Variance Inflation Factor (VIF) values for all 20 indicators. Hair et al. (2019) stipulate that VIF values should not exceed 5.0 to rule out problematic multicollinearity. All VIF values in the present study fall between 1.605 (CS1) and 2.941 (CS4), well below the critical threshold, indicating that multicollinearity does not compromise the stability or interpretability of the structural path estimates.

Item	VIF
AIU1	2.116
AIU2	2.249
AIU3	2.098
AIU4	1.907
CS1	1.605
CS2	2.432
CS3	2.629
CS4	2.941
EE1	1.840
EE3	2.191
EE4	2.317
EI1	1.799
EI2	2.223
EI3	1.916
EI5	1.691
IM1	2.222
IM2	2.261
IM3	2.152
IM4	2.261
IM5	2.176

Table 5. Variance Inflation Factor (VIF) statistics for collinearity assessment (Hair et al., 2022)

4.4. Structural Model and Hypothesis Testing

Table 6 presents the global fit statistics for the PLS-SEM model. The Standardised Root Mean Square Residual (SRMR), the primary fit criterion in PLS-SEM (Henseler et al., 2014), is 0.091 for both the saturated and estimated models, falling within the acceptable range below 0.10. The d_ULS value of 1.756 is identical across both specifications. It is standard practice in PLS-SEM not to report Chi-Square and NFI indices, as PLS is a variance-based estimator that does not assume multivariate normality and does not rely on global

covariance-based fit statistics (Hair & Alamer, 2022). Collectively, these indices demonstrate adequate fit of the proposed model to the observed data.

Figure 1 depicts the estimated structural model, including standardised path coefficients and indicator outer loadings for all constructs. The endogenous construct, Entrepreneurial Innovation, attains an R^2 of 0.954, indicating that the predictor variables collectively account for 95.4 % of its variance a result that underscores the model's substantial explanatory power.

Index	Saturated Model	Estimated Model
SRMR	0.091	0.091
d_ULS	1.756	1.756
d_G	n/a	n/a
Chi-Square	∞	∞
NFI	n/a	n/a

Table 6. PLS-SEM model fit indices

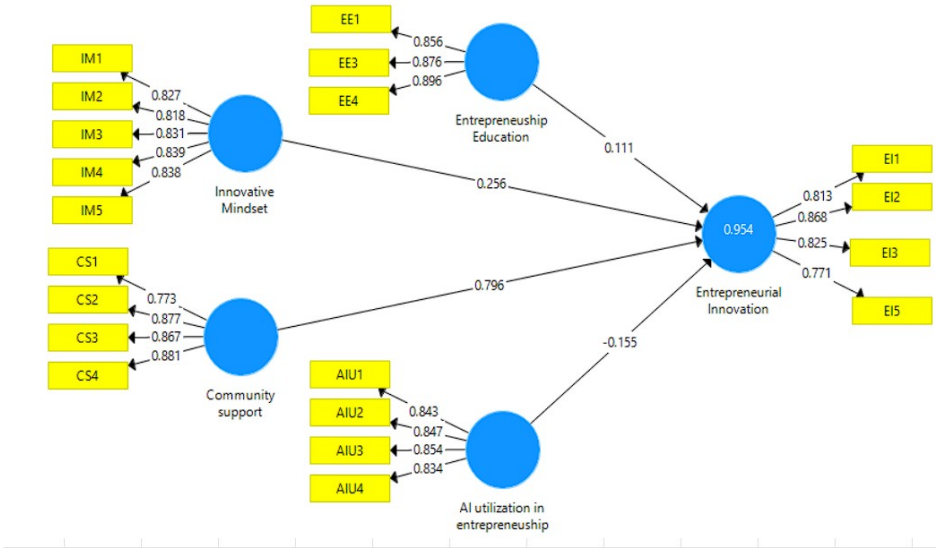

Figure 1. Structural model with bootstrapped path coefficients and outer loadings. Source: Authors' calculations using SmartPLS 4.0

4.5. Direct Effects and Hypothesis Testing

Table 7 summarises the direct structural paths. Statistical significance was determined using 5,000-resample bootstrapping, with the criterion of $t > 1.96$ and $p < 0.05$ (Hair & Alamer, 2022). All four direct paths to Entrepreneurial Innovation are statistically significant.

Hypothesised Path	β	M	STDEV	t-statistic	p-value
AI Utilization → Entrepreneurial Innovation	-0.155	-0.148	0.065	2.396	0.017
Community Support → Entrepreneurial Innovation	0.796	0.795	0.024	33.515	0.000
Entrepreneurship Education → Entrepreneurial Innovation	0.111	0.111	0.025	4.431	0.000
Innovative Mindset → Entrepreneurial Innovation	0.256	0.250	0.077	3.314	0.001

Table 7. Bootstrapped path coefficients for direct effects (Hair et al., 2022)

Community Support demonstrates the strongest direct effect on Entrepreneurial Innovation ($\beta = 0.796$, $t = 33.515$, $p < 0.001$), indicating that access to community-based resources, networks, and institutional support constitutes the most influential predictor of innovation outcomes in the Sudanese context. This finding aligns

with resource-based and social capital theories, which highlight the role of collective resources in enabling entrepreneurial activity (Nahapiet & Ghoshal, 1998).

Innovative Mindset produces a significant positive direct effect (β = 0.256, t = 3.314, p = 0.001), consistent with the broader entrepreneurship literature that frames cognitive orientation and growth mindset as antecedents of innovative behaviour (Dweck, 2006). Entrepreneurship Education exerts a statistically significant, though relatively modest, positive effect on Entrepreneurial Innovation (β = 0.111, t = 4.431, p < 0.001), suggesting that formal education contributes to innovation propensity but operates through limited channels in the Sudanese institutional environment.

Importantly, AI Utilization in Entrepreneurship exhibits a statistically significant negative direct effect on Entrepreneurial Innovation (β = −0.155, t = 2.396, p = 0.017). This counterintuitive result is characteristic of a suppression effect in mediation models, wherein the direct effect of a variable is weakened or reversed in the presence of its indirect pathways.

4.6. Mediation Analysis: The Role of AI Utilization

To investigate whether AI Utilization in Entrepreneurship serves as a mediator in the relationships between the three exogenous constructs and Entrepreneurial Innovation, an indirect effects analysis was conducted using 5,000-resample bootstrapping, in accordance with Preacher and Hayes (2008). Mediation is established when the bootstrapped indirect effect is statistically significant (t > 1.96, p < 0.05) and the confidence interval excludes zero.

Table 8 presents the specific indirect effects. The total indirect effect of AI Utilization on Entrepreneurial Innovation is large and significant (β = 0.766, t = 23.931, p < 0.001), establishing its substantive role within the mediation chain.

Indirect Path	β	M	STDEV	t-statistic	p-value
AI Utilization → Entrepreneurial Innovation	0.766	0.763	0.032	23.931	0.000
Community Support → AI Utilization → Entrepreneurial Innovation	-0.040	-0.040	0.015	2.653	0.008
Entrepreneurship Education → AI Utilization → Entrepreneurial Innovation	-0.030	-0.030	0.018	1.656	0.098
Innovative Mindset → AI Utilization → Entrepreneurial Innovation	1.044	1.043	0.013	82.222	0.000

Table 8. Bootstrapped indirect effects for mediation analysis

The indirect effect of Community Support on Entrepreneurial Innovation via AI Utilization is statistically significant (β = −0.040, t = 2.653, p = 0.008). The negative coefficient indicates a suppression mechanism: strong community support is inversely associated with AI adoption, which in turn limits AI-mediated innovation outcomes. This finding may reflect the observation that, in developing-country contexts characterised by entrenched relational networks, traditional social capital can decrease incentives to adopt disruptive digital technologies (Kock, 2015). The overall effect of Community Support on innovation remains strongly positive, suggesting that conventional social mechanisms continue to play a dominant role.

The indirect path from Entrepreneurship Education through AI Utilization to Entrepreneurial Innovation does not attain statistical significance (β = −0.030, t = 1.656, p = 0.098). This null finding implies that formal entrepreneurship education in Sudan has not yet established effective connections with AI-based innovation pathways. Rather than a trivial absence of effect, this result signals a critical institutional gap: educational curricula appear to lack the digital competence frameworks and technology-oriented pedagogies necessary to translate entrepreneurial learning into AI-mediated innovative behaviour. This constitutes an actionable policy implication, discussed further in the Discussion.

Innovative Mindset yields the largest and most statistically robust indirect effect on Entrepreneurial Innovation via AI Utilization (β = 1.044, t = 82.222, p < 0.001). The magnitude of this coefficient, in conjunction with the near-unity Fornell-Larcker correlation between Innovative Mindset and AI Utilization (r = 0.982), raises an important interpretive issue. These values collectively suggest that the empirical boundary between Innovative

Mindset and AI Utilization may be more conceptual than operationally distinct in this sample. Researchers and practitioners should treat this with caution: the extraordinarily high indirect effect may, in part, reflect construct redundancy rather than genuine mediation. Future research should independently re-operationalise and validate these constructs potentially through longitudinal or experimental designs to separate cognitive dispositions toward innovation from technology-adoption behaviours.

In sum, the mediation analysis reveals that AI Utilization occupies a complex and context-dependent role within the innovation ecosystem. It functions as a significant mediating mechanism for the mindset–innovation relationship while simultaneously introducing suppression effects in the community support pathway. The non-significant mediation via educational exposure highlights the need for curriculum reform that explicitly bridges entrepreneurship pedagogy with emerging digital technologies.

5. Discussion

The empirical findings of this study offer a nuanced and contextually grounded understanding of how entrepreneurship education, innovative mindset, and community support interact with AI utilization to shape entrepreneurial innovation in Sudan's fragile ecosystem. The significant yet negative direct effect of AI utilization on entrepreneurial innovation ($\beta = -0.155$, $p = 0.017$) should not be interpreted as evidence against AI's relevance, but rather as a classical suppression pattern characteristic of mediation models (Hair & Alamer, 2022). This result is consistent with the Technology-Organization-Environment (TOE) framework, which posits that digital tools generate competitive value only when accompanied by adequate organizational readiness and contextual enablers (Dwivedi et al., 2021) conditions that remain structurally limited in Sudan (Uriarte et al., 2026). In other words, AI does not independently drive innovation in this context; its contribution is achieved exclusively through antecedent cognitive and social conditions, a finding that fundamentally challenges the optimistic assessments of Mariani et al. (2023) and Babina et al. (2024), whose evidence is predominantly drawn from technologically mature environments.

Community support produced the study's most theoretically significant finding: a dominant positive direct effect on innovation ($\beta = 0.796$, $p < 0.001$) alongside a significant negative indirect effect through AI utilization ($\beta = -0.040$, $p = 0.008$). This duality challenges the prevailing assumption in entrepreneurial ecosystem research that community embeddedness and digital transformation are complementary forces (Bouncken & Kraus, 2022; Hruskova, 2024). In Sudan's context, where community networks encompass tribal structures, religious institutions, and informal trade associations (Manning et al., 2024), social capital appears to operate through distinctly non-digital pathways providing legitimacy, resource pooling, and risk-sharing that effectively support conventional innovation while simultaneously lowering the perceived urgency of AI adoption. This dynamic resonates with Anderson and Gaddefors's (2016) concept of "bounded locality," wherein tightly embedded relational networks constrain openness to disruptive technological practices, and directly echoes the cautionary argument of Zhou and Cen (2024) whose scale was adapted in this study that existing community knowledge networks can restrict digital ecosystem embeddedness. Crucially, in a post-conflict economy where formal institutions have largely collapsed and communities have become primary sources of economic security, the opportunity cost of diverging from established social networks is substantially higher than in stable contexts, rendering AI adoption a rational risk that many entrepreneurs will defer.

The non-significant indirect path from entrepreneurship education through AI utilization ($\beta = -0.030$, $p = 0.098$), combined with its modest direct effect on innovation ($\beta = 0.111$, $p < 0.001$), represents the study's most policy-critical finding. This result stands in contrast to the transformative role attributed to entrepreneurship education by Tahan (2025), Lv et al. (2021), and Dabbous and Boustani (2023), and instead aligns with Muñoz et al. (2019) critique that entrepreneurship curricula consistently prioritize cognitive business frameworks over practical, technology-oriented competencies. If educational programs remain anchored in conventional opportunity recognition and business planning without meaningfully integrating AI literacy and data-driven decision-making, their downstream effect on AI-mediated innovation will remain negligible a concern supported by Xie and Wang's (2025) finding that generative AI integration in entrepreneurship education is a necessary condition for activating self-efficacy and institutional trust toward digital entrepreneurship. This gap is further compounded by Sudan's documented infrastructural constraints, including

limited internet access and irregular electricity (Alamin, 2022), which systematically prevent the translation of educational exposure into technological behavior, rendering curriculum reform alone insufficient without parallel ecosystem-level investment. Meanwhile, the innovative mindset construct produced the most powerful effects in the model a significant direct effect on innovation ($\beta = 0.256$, $p = 0.001$) and a large indirect effect via AI utilization ($\beta = 1.044$, $p < 0.001$), with full mediation confirmed through VAF analysis. These findings validate the propositions of Dyer et al. (2008) and Lynch and Corbett (2023), who frame cognitive orientation as a primary antecedent of innovative behavior, and align with Jussila et al. (2022) in demonstrating that individual creativity must be technologically translated to produce tangible innovation outcomes mindset opens the door, but technology enables entry. However, intellectual honesty requires direct engagement with the near-unity Fornell-Larcker correlation between innovative mindset and AI utilization ($r = 0.982$). As Rönkkö and Cho (2022) caution, conventional discriminant validity criteria become insufficient when construct correlations approach or exceed 0.9, raising the possibility that the observed indirect effect partially reflects construct redundancy rather than genuine mediation a limitation that future research, employing behaviorally anchored and independently operationalized measures, should empirically address.

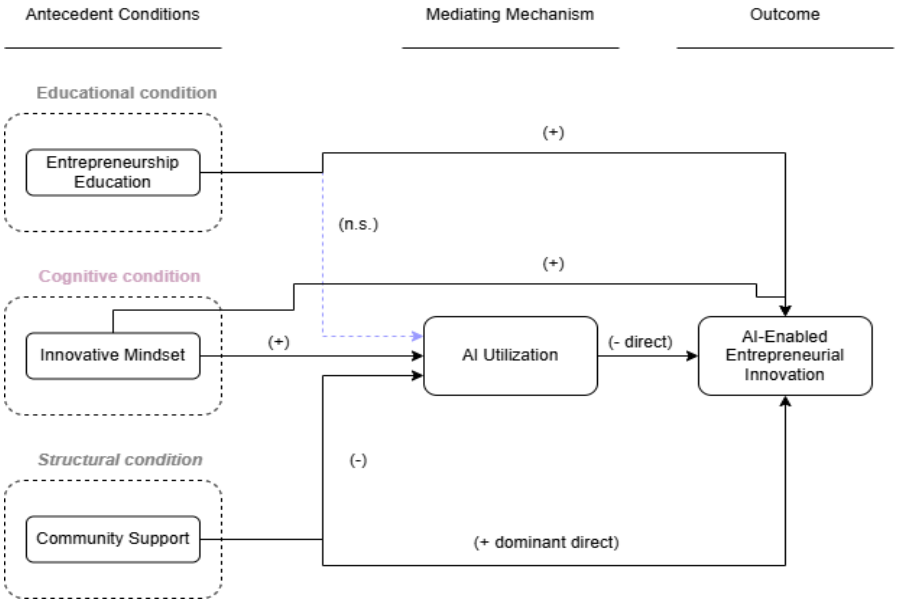

Figure 2. Contingent Model of AI-Enabled Entrepreneurial Innovation in Fragile Economies. Authors' own elaboration, adapted from (Ul-Haq et al., 2025)

Taken together, these findings call for a fundamental rethinking of how technology adoption frameworks are applied in fragile economies. The dominant logic of TAM, TOE, and RBV assumes a degree of institutional stability, digital infrastructure, and social openness to technological disruption that Sudan's context does not currently provide. While (Ul-Haq et al., 2025) demonstrated that AI adoption effectively mediates antecedent conditions and firm performance under the TOE–RBV perspective in resource-constrained settings, the present study extends and modifies this structure in three key respects: the context is shifted to a fragile post-conflict economy, the outcome is reframed from firm performance to entrepreneurial innovation, and AI's mediating role is reconceptualised as contingent rather than consistently positive as illustrated in Figure 2. Notably, Community Support operationalises community social capital in this model, including both networks, mentorship, shared resources, and social legitimacy, which collectively constitute the dominant innovation mechanism in Sudan's ecosystem with AI's mediating potential activated only when cognitive, educational, and structural conditions collectively support the transition to digitally enabled entrepreneurial practice. Future research employing longitudinal or experimental designs would further strengthen causal inference and disentangle the construct boundaries identified here as methodologically sensitive.

6. Conclusion

This study examined the associations between entrepreneurship education, innovative mindset, community support, AI utilization, and entrepreneurial innovation among 404 young entrepreneurs in Sudan using PLS-SEM. The findings collectively demonstrate that AI-enabled entrepreneurial innovation in fragile, post-conflict economies operates through a fundamentally different logic than that documented in technologically mature contexts one that is contingent, mediated, and deeply shaped by institutional and sociocultural conditions. AI utilization emerges as a mediating mechanism rather than an independent driver of innovation, contributing to outcomes only when activated by appropriate antecedents. Community support dominates as the strongest predictor of innovation yet simultaneously limits AI adoption, exposing a fundamental tension between the social capital structures that sustain entrepreneurship in post-conflict settings and the digital transformation agenda that development frameworks increasingly promote. Entrepreneurship education, in its current form, fails to bridge entrepreneurial learning with AI-mediated innovation pathways, while innovative mindset though the most powerful individual-level driver raises important construct boundary questions that future research must address through behaviorally anchored operationalization.

From a theoretical standpoint, this study contributes to the literature by extending technology adoption and innovation frameworks into an underexplored institutional context, demonstrating that the conditional and suppressed nature of AI's role in fragile economies demands context-sensitive interpretation beyond what TAM, TOE, and RBV currently offer. Practically, the findings provide actionable guidance for policymakers, educators, and ecosystem builders: fostering AI-enabled entrepreneurship in Sudan and comparable post-conflict settings requires simultaneous investment across multiple levels digital infrastructure development, pedagogical reorientation toward technology integration, community-level norm change that legitimizes digital experimentation, and individual capacity building that translates innovation aspiration into concrete technological behavior. No single intervention, operating in isolation, is sufficient to activate AI's mediating potential in environments where structural barriers exist at every level of the entrepreneurial ecosystem.

This study is not without limitations. The cross-sectional design precludes causal inference, and reliance on self-reported perceptions from a convenience sample of young Sudanese entrepreneurs constrains the generalizability. The high construct correlation between innovative mindset and AI utilization warrants independent replication using behaviorally anchored measures. Future research should employ longitudinal or experimental designs, expand sampling to include established entrepreneurs and non-urban contexts, and explore moderating variables such as digital infrastructure access, cultural openness to innovation, and gender-differentiated entrepreneurial pathways. Comparative studies across Sub-Saharan African and other post-conflict economies would further enhance the theoretical and policy relevance of the contingent innovation model proposed here.

Declaration of Conflicting Interests

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

Author Contributions

Daniswara Hidayatullah: initial the study and main framework, designing the methods and doing the data analisis, writing first draft.

Hussein Gibreel Musa: designing the methods and doing the data analisis, the design, analysis, and writing process.

Issa Hamadou: improving the methods and chipping in on the editing.

Husny Gibreel Musa Saleh: data collection and the literatura review.

Azzam Zeydan Firlaudy: validating the data and strengthen the paper.

Data availability

Data available upon request

Use of Artificial Intelligence

In preparing this manuscript, the authors used AI-based tools solely to assist with brainstorming ideas, improving grammar, and refining word choice. All AI-assisted output was subsequently reviewed, verified, and edited by the authors, who take full responsibility for the content of this article. No synthetic data, text, or graphics were generated or disseminated without proper disclosure.

References

African Development Bank Group (2024). *Country Focus Report 2024, Ethiopia.* African Development Bank Group. https://www.afdb.org/en/documents/publications/african-economic-outlook-2024/country-focus-report-2024

Ahmed, W. M. M., Abdalmotalib, M. M., Elbadawi, M. H., Mohammed, G. T. F., Mohamed, W. M. I., Mohammed, F. S. B., Salih, H. S., & Mohamed, H. O. Y. (2025). Shaping the future of medical education: A cross-sectional study on ChatGPT attitude and usage among medical students in Sudan. *Plos One*, *20*(5), 1–19. https://doi.org/10.1371/journal.pone.0324698

Alamin, A. (2022). An Exploration of the Situation of Educational Technology Infrastructure in Sudanese General Education: A Case Study. *TESOL and Technology Studies*, *3*(2), 1–17. https://doi.org/10.48185/tts.v3i2.642

Albatran, A. A., & Atikbay, T. (2025). Entrepreneurship Education in Fragile Contexts: Bridging the Intention–Action Gap Through Psychological and Contextual Pathways. *Sustainability (Switzerland)*, *17*(16), 1–16. https://doi.org/10.3390/su17167447

Alhammadi, A. (2025). Measuring the antecedents of employees' intention to use artificial intelligence in the manufacturing sector. *Problems and Perspectives in Management*, *23*(1), 557–568. https://doi.org/10.21511/ppm.23(1).2025.42

Anderson, A. R., & Gaddefors, J. (2016). Entrepreneurship as a community phenomenon; reconnecting meanings and place. *International Journal of Entrepreneurship and Small Business, 28*(4), 504–518. https://doi.org/10.1504/IJESB.2016.077576

Anderson, J. C., & Gerbing, D., W. (1988). Structural Equation Modeling in Practice: A Review and Recommended Two-Step Approach. *Psychological Bulletin, 103*(3), 411–423. https://doi.org/10.1037/0033-2909.103.3.411

Andrade, C. (2021). The Inconvenient Truth About Convenience and Purposive Samples. *Indian Journal of Psychological Medicine*, *43*(1), 86–88. https://doi.org/10.1177/0253717620977000

Babina, T., Fedyk, A., He, A., & Hodson, J. (2024). Artificial intelligence, firm growth, and product innovation. *Journal of Financial Economics*, *151*(October), 103745. https://doi.org/10.1016/j.jfineco.2023.103745

Behavior, O., Podsakoff, P. M., Podsakoff, N. P., Williams, L. J., Huang, C., & Yang, J. (2024). Common Method Bias : It's Bad , It's Complex , It's Widespread , and It's Not Easy to Fix. *Annual Reviews, 11,* 17–61. https://doi.org/10.1146/annurev-orgpsych-110721-040030

Bickley, S. J., Macintyre, A., & Torgler, B. (2025). Artificial Intelligence and Big Data in Sustainable Entrepreneurship. *Journal of Economic Surveys*, *39*(1), 103–145. https://doi.org/10.1111/joes.12611

Bouncken, R. B., & Kraus, S. (2022). Entrepreneurial ecosystems in an interconnected world: emergence, governance and digitalization. *Review of Managerial Science*, *16*(1), 1–14. https://doi.org/10.1007/s11846-021-00444-1

Cieslik, K., Barford, A., & Vira, B. (2022). Young people not in Employment, Education or Training (NEET) in Sub-Saharan Africa: Sustainable Development Target 8.6 missed and reset. *Journal of Youth Studies*, *25*(8), 1126–1147. https://doi.org/10.1080/13676261.2021.1939287

Dabbous, A., & Boustani, N. M. (2023). Digital Explosion and Entrepreneurship Education: Impact on Promoting Entrepreneurial Intention for Business Students. *Journal of Risk and Financial Management*, *16*(1). https://doi.org/10.3390/jrfm16010027

Díaz-Arancibia, J., Hochstetter-Diez, J., Bustamante-Mora, A., Sepúlveda-Cuevas, S., Albayay, I., & Arango-López, J. (2024). Navigating Digital Transformation and Technology Adoption: A Literature Review from Small and Medium-Sized Enterprises in Developing Countries. *Sustainability (Switzerland)*, *16*(14), 5946. https://doi.org/10.3390/su16145946

Dweck, C. S. (2006). *Mindset: The New Psychology of Success*. Random House Publishing Group. https://books.google.co.id/books?id=fdjqz0TPL2wC

Dwivedi, Y. K., Hughes, L., Ismagilova, E., Aarts, G., Coombs, C., Crick, T., Duan, Y., Dwivedi, R., Edwards, J., Eirug, A., Galanos, V., Ilavarasan, P. V., Janssen, M., Jones, P., Kar, A. K., Kizgin, H., Kronemann, B., Lal, B., Lucini, B., … Williams, M. D. (2021). Artificial Intelligence (AI): Multidisciplinary perspectives on emerging challenges, opportunities, and agenda for research, practice and policy. *International Journal of Information Management, 57*(August 2019), 101994. https://doi.org/10.1016/j.ijinfomgt.2019.08.002

Dyer, J., Gregersen, H., & Christensen, C. (2008). Entrepreneur behaviors, opportunity recognition, and the origins of innovative ventures. *Strategic Entrepreneurship Journal, 2,* 317–338. https://doi.org/10.1002/sej.59

Elnourani, M., Elhag, H. S. H., Alasad, W. I., & Bashier, M. N. (2024). Khartoum War's echoes in oil and energy sectors: Economic and environmental implications for Sudan and South Sudan. *Heliyon*, *10*(15), e34739. https://doi.org/10.1016/j.heliyon.2024.e34739

Fornell, C., & Larcker, D. F. (1981). Evaluating Structural Equation Models with Unobservable Variables and Measurement Error: Algebra and Statistics. *Journal of Marketing Research, 18*(1), 39–50. https://doi.org/10.1177/002224378101800104

Gama, F., & Magistretti, S. (2025). Artificial intelligence in innovation management: A review of innovation capabilities and a taxonomy of AI applications. *Journal of Product Innovation Management*, *42*(1), 76–111. https://doi.org/10.1111/jpim.12698

Gong, Y., Li, X., Belabbes, S., Dell'Oro, L., & Ru, Y. (2024). Multidimensional geographic factors behind conflicts: a case study in Sudan. *International Journal of Digital Earth*, *17*(1), 1–19. https://doi.org/10.1080/17538947.2024.2426524

Hair, J., & Alamer, A. (2022). Partial Least Squares Structural Equation Modeling (PLS-SEM) in second language and education research: Guidelines using an applied example. *Research Methods in Applied Linguistics*, *1*(3), 100027. https://doi.org/10.1016/j.rmal.2022.100027

Hair, J. F., Risher, J. J., Sarstedt, M., & Ringle, C. M. (2019). When to use and how to report the results of PLS-SEM. *European Business Review, 31*(1), 2–24. https://doi.org/10.1108/EBR-11-2018-0203

Hassan, A. E. D. M. A. (2025). The Impact of Generative AI Adoption on Digital Entrepreneurship Intentions among Egyptian University Students: Examining the Mediating Roles of Entrepreneurial Mindset and Business Model Innovation. *Pakistan Journal of Life and Social Sciences (PJLSS)*, *23*(1), 8566–8579. https://doi.org/10.57239/pjlss-2025-23.1.00667

Henseler, J., Dijkstra, T. K., Sarstedt, M., Ringle, C. M., Diamantopoulos, A., Straub, D. W., Ketchen, D. J., Hair, J. F., Hult, G. T. M., & Calantone, R. J. (2014). Common Beliefs and Reality about Partial Least Squares: Comments on Rönkko \& Evermann (2013). *Organizational Research Methods, 17*(2), 182–209. https://doi.org/10.1177/1094428114526928

Hruskova, M. (2024). Ecosystem pipelines: Collective action in entrepreneurial ecosystems. *International Small Business Journal: Researching Entrepreneurship*, *42*(1), 39–66. https://doi.org/10.1177/02662426231178381

Jussila, J., Nagy, E., Lähtinen, K., Hurmekoski, E., Häyrinen, L., Mark-herbert, C., Roos, A., Toivonen, R., & Toppinen, A. (2022). Wooden multi-storey construction market development – Systematic Literature Review Within a Global Scope with insights on the Nordic region. *Silva Fennica, 56*(1). https://doi.org/10.14214/sf.10609

Kepios; We Are Socia (2025). Share of internet users in Africa as of February 2025, by country. *Kepios; We Are Social; DataReportal*, *February*. https://www.statista.com/statistics/1124283/internet-penetration-in-africa-by-country/?srsltid=AfmBOoqGrmN52feI-KnW2Yy8av46Ov6ysp5LN6KLL9eu6TrBTGKE5jjn

Kock, N. (2015). Common method bias in PLS-SEM: A full collinearity assessment approach. *International Journal of e-Collaboration*, 11(4), 1–10. https://doi.org/10.4018/ijec.2015100101

Koparan, I., Aksaray, G., Manolova, T., & Edelman, L. (2025). Executive Function and Entrepreneurial Opportunity Exploitation Under Risk and Uncertainty. *Strategic Change, 35*(2), 217–239. https://doi.org/10.1002/jsc.70008

Kusmaryono, I., Wijayanti, D., & Maharani, H. R. (2022). Number of Response Options, Reliability, Validity, and Potential Bias in the Use of the Likert Scale Education and Social Science Research: A Literature Review. *International Journal of Educational Methodology*, *8*(4), 625–637. https://doi.org/10.12973/ijem.8.4.625

Li, W., & Lay, Y. F. (2024). Examining the reliability and validity of measuring scales related to informatization and instructional leadership using the PLS-SEM approach. *Humanities and Social Sciences Letters*, *12*(3), 461–480. https://doi.org/10.18488/73.v12i3.3789

Lv, Y., Chen, Y., Sha, Y., Wang, J., An, L., Chen, T., Huang, X., Huang, Y., & Huang, L. (2021). How Entrepreneurship Education at Universities Influences Entrepreneurial Intention: Mediating Effect Based on Entrepreneurial Competence. *Frontiers in Psychology*, *12*(July), 1–12. https://doi.org/10.3389/fpsyg.2021.655868

Lynch, M. P., & Corbett, A. C. (2023). Entrepreneurial mindset shift and the role of cycles of learning. *Journal of Small Business Management*, *61*(1), 80–101. https://doi.org/10.1080/00472778.2021.1924381

Manning, S., Rauch, M., & Vavilov, S. (2024). Creating complementarities: How entrepreneurs mobilize crowdfunding and local ecosystems. *Strategic Organization, 22*(4). https://doi.org/10.1177/14761270221094800

Mariani, M. M., Machado, I., & Nambisan, S. (2023). Types of innovation and artificial intelligence: A systematic quantitative literature review and research agenda. *Journal of Business Research*, *155*(Part B), 113364. https://doi.org/10.1016/j.jbusres.2022.113364

Muñoz, P., Kimmitt, J., Kibler, E., & Farny, S. (2019). Living on the Slopes: Entrepreneurial Preparedness in a Context Under Continuous Threat. *Entrepreneurship and Regional Development, 31,* 413–434. https://doi.org/10.1080/08985626.2018.1541591

Nahapiet, J., & Ghoshal, S. (1998). Social capital, intellectual capital, and the organizational advantage. *Academy of Management Review, 23*(2), 242–266. https://doi.org/10.2307/259373

Nathasya, H. (2024). Global Innovation Index 2024. *Edu Research Indonesian Institute For Corporate Learning And Studies (IICLS),* 5(1).

Ofosu-Appiah, S., Boahen, P. A. N., & Agbenyegah, A. T. (2025). Socio-ecological barriers to youth entrepreneurship in sub-Saharan Africa: a systematic review of empirical evidence. *Journal of Innovation and Entrepreneurship*, *14,* 32. https://doi.org/10.1186/s13731-025-00484-x

Polas, M. R. H. (2025). Common Method Bias in Social and Behavioral Research: Strategic Solutions for Quantitative Research in the Doctoral Research. *Journal of Comprehensive Business Administration Research*. https://doi.org/10.47852/bonviewjcbar52024285

Preacher, K. J., & Hayes, A. F. (2008). Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behavior Research Methods, 40*(3), 879–891. https://doi.org/10.3758/BRM.40.3.879.

Purvis, A. J., & Crawford, J. (2024). Ethical Standards in Social Science Publications. *Journal of University Teaching and Learning Practice* , *21*(9). https://doi.org/10.53761/hqnqr710

Ringle, C. M., Wende, S., & Becker, J.-M. (2022). SmartPLS 4. Oststeinbek: SmartPLS GmbH. *Journal of Applied Structural Equation Modeling (JASEM)*, *1*(August), 85–120.

Rönkkö, M., & Cho, E. (2022). An Updated Guideline for Assessing Discriminant Validity. In *Organizational Research Methods, 25*(1). https://doi.org/10.1177/1094428120968614

Shore, A., Tiwari, M., Tandon, P., & Foropon, C. (2024). Building entrepreneurial resilience during crisis using generative AI: An empirical study on SMEs. *Technovation*, *135*(June), 103063. https://doi.org/10.1016/j.technovation.2024.103063

Steel, G. (2021). Going global – going digital. Diaspora networks and female online entrepreneurship in Khartoum, Sudan. *Geoforum*, *120*(January), 22–29. https://doi.org/10.1016/j.geoforum.2021.01.003

Steininger, D. M., Kathryn-Brohman, M., & Block, J. H. (2022). Digital Entrepreneurship: What is New if Anything? *Business and Information Systems Engineering*, *64*(1), 1–14. https://doi.org/10.1007/s12599-021-00741-9

Suhaimi, S. N., Walters, A., & Ward, J. (2024). Design thinking mindset: a user-centred approach toward innovation in the Welsh creative industries. *International Journal of Design Creativity and Innovation*, *12*(4), 238–257. https://doi.org/10.1080/21650349.2024.2383410

Tahan, S. (2025). Entrepreneurial Education and Innovation Intentions Among University Students: A Structural Assessment of Opportunity Recognition, Psychological Capital, and Fear of Failure. *Administrative Sciences*, *15*(7). https://doi.org/10.3390/admsci15070261

Tu, B., Bhowmik, R., Hasan, M. K., Asheq, A. A., Rahaman, M. A., & Chen, X. (2021). Graduate students' behavioral intention of toward social entrepreneurship: Role of social vision, innovativeness, social proactiveness, and risk taking. *Sustainability (Switzerland)*, *13*(11), 1–23. https://doi.org/10.3390/su13116386

Ul-Haq, F., Suki, N. M., Zaigham, H., Masood, A., & Rajput, A. (2025). Exploring AI Adoption and SME Performance in Resource-Constrained Environments: A TOE–RBV Perspective with Mediation and Moderation Effects. *Journal of Digital Economy, 5,* 160-181. https://doi.org/10.1016/j.jdec.2025.07.002

Uriarte, S., Baier-Fuentes, H., Espinoza-Benavides, J., & Inzunza-Mendoza, W. (2026). Artificial intelligence technologies and entrepreneurship: a hybrid literature review. *Review of Managerial Science*, *20*(1), 251–299. https://doi.org/10.1007/s11846-025-00839-4

Vecchiarini, M., & Somià, T. (2023). Redefining entrepreneurship education in the age of artificial intelligence: An explorative analysis. *International Journal of Management Education*, *21*(3), 1–11. https://doi.org/10.1016/j.ijme.2023.100879

World Bank (2024). *Sudan | Data*. World Bank. https://data.worldbank.org/country/sudan

World Population Review (2026). *Fragile States Index 2026*. World Population Review. https://worldpopulationreview.com/country-rankings/fragile-states-index

Xie, Y., & Wang, S. (2025). Generative artificial intelligence in entrepreneurship education enhances entrepreneurial intention through self-efficacy and university support. *Scientific Reports*, *15*(1), 1–20. https://doi.org/10.1038/s41598-025-09545-3

Xu, G., Hou, G., & Zhang, J. (2022). Digital Sustainable Entrepreneurship: A Digital Capability Perspective through Digital Innovation Orientation for Social and Environmental Value Creation. *Sustainability (Switzerland)*, *14*(18), 11222. https://doi.org/10.3390/su141811222

Yuan, Y., Sun, L., She, Z., & Chen, S. (2025). Influence of Digital Literacy on Farmers' Adoption Behavior of Low-Carbon Agricultural Technology: Chain Intermediary Role Based on Capital Endowment and Adoption Willingness. *Sustainability (Switzerland)*, *17*(5), 1–21. https://doi.org/10.3390/su17052187

Zarkua, T., Heijman, W., Benešová, I., & Krivko, M. (2025). Entrepreneurship as a driver of economic development. *Entrepreneurial Business and Economics Review*, *13*(1), 61–77. https://doi.org/10.15678/EBER.2025.130104

Zhou, J., & Cen, W. (2024). Digital Entrepreneurial Ecosystem Embeddedness, Knowledge Dynamic Capabilities, and User Entrepreneurial Opportunity Development in China: The Moderating Role of Entrepreneurial Learning. *Sustainability (Switzerland)* , *16*(11), 4343. https://doi.org/10.3390/su16114343