Journal of Commerce and Accounting Research
14 (1) 2025, 133-146
http://publishingindia.com/jcar/
doi: https://doi.org/10.21863/jcar/2025.14.1.011

Submitted: 24 January, 2024
Accepted: 26 March, 2024

TURNING LEMONS INTO LEMONADE: MEDIATING COLLABORATIVE INNOVATION THROUGH DIGITAL TRANSFORMATION FOR SUSTAINABLE ENTREPRENEURSHIP

Sadananda Sahoo*, Saumendra Das, A. Chiranjibi Rambabu Achary***, Rohit Bansal******

Abstract *This study employs structural equation modelling and a 5-point Likert scale to examine the relationship among Digital Transformation, Collaborative Innovation, and Sustainable Entrepreneurship. Utilising Variance Inflation Factors (VIF) for collinearity assessment, the inner model demonstrates stable construct relationships despite moderate VIF values. When collinearity is evaluated using Variance Inflation Factors (VIF), the inner model shows robust construct correlations even with moderate VIF values. The results of path coefficient analysis show that collaborative innovation and digital transformation have a major, beneficial impact on sustainable entrepreneurship. The psychometric assessments ensure the reliability and validity of the constructs in the measurement model. The model selection of the study based upon Bayesian Information Criterion (BIC), sustains the efficacy of models, incorporating Collaborative Innovation and Sustainable Development by accentuating their critical charities to accomplish a frugal and effective model fit, vibrant for understanding multifarious phenomena. Specifically, f-square values highlight the practical significance of effect size measurements. Overall, this study offers a clear knowledge of the connections between these important concepts, which will be helpful for practitioners and policymakers as they promote sustainable entrepreneurship through collaborative innovation and digital transformation.*

Keywords: *Digital Transformation, Collaborative Innovation, Sustainable Entrepreneurship, Structural Equation Modelling, 5-Point Likert Scale*

JEL Classification: *O31, O33, L26*

INTRODUCTION

The contemporary business landscape is shaped by the relentless march of technological progress, with digital transformation at its forefront. In this era, entrepreneurs are not only steering traditional business challenges but also harnessing the transformative potential of digital technologies to foster sustainable entrepreneurship. Entrepreneurship, as a small-scale ventures, plays an important role in sustaining economies by reducing unemployment, producing jobs, and nurturing innovation and creativity, accordingly confirming economic sustainability and fortune (Upadhaya & Chadha, 2019). This paper gets on a journey to explore the intricate interplay between digital transformation, collaborative innovation, and the imperative of sustainable entrepreneurship. In a world where lemons are aplenty, we seek to elucidate how they can be turned into lemonade through a mediating force of collaborative innovation in the digital age.

Context and Significance of the Study

The onset of the digital era has unleashed waves of innovation and disruption across industries. Traditional

* Associate Professor of Economics, Department of Economics, GIET University, Gunupur, Rayagada, Odisha, India. Email: sadananda@giet.edu
** Associate Professor, School of Management Studies, GIET University, Gunupur, Rayagada, Odisha, India. Email: saumendra@giet.edu
*** Assistant Professor in Management, GIET University, Gunupur, Rayagada, Odisha, India. Email: chiranjibi@giet.edu
**** Department of Management Studies, Vaish College of Engineering, Rohtak, Haryana, India. Email: rohitbansal.mba@gmail.com

business models are being reshaped, and entrepreneurs are continually pressed to adapt to the evolving landscape. Technology expansion leads to systems development and is thrived by technology acceptance, as it expedites enriched information management and productivity, fuelling organisational synergy and client offerings (Changati & Kansal, 2019). Digital transformation, marked by the integration of digital technologies into all aspects of business, offers unprecedented opportunities for entrepreneurs to streamline operations, expand markets, and enhance customer experiences. Yet, it also presents formidable challenges as entrepreneurs steer a landscape of rapid technological change, cybersecurity threats, and the need to balance profit-seeking with environmental and societal responsibility. One of the prominent consequences of digital transformation is its capacity to facilitate and amplify collaborative innovation. Enterprises no longer operate in silos; they engage in open collaborations, co-creation, and knowledge sharing. This phenomenon is not merely a choice but a strategic necessity for thriving in an interconnected world.

At the heart of this research lies the question of how digital transformation acts as a catalyst for collaborative innovation and, in turn, mediates the path to sustainable entrepreneurship. The significance of this study lies in its potential to offer entrepreneurs, policymakers, and business leaders understandings into harnessing digital technologies to navigate challenges and convert adversity into advantage. It provides a roadmap for leveraging collaborative innovation as a bridge to sustainable entrepreneurship, addressing not only financial viability but also societal and environmental impact. The journey ahead takes us through a nuanced exploration of the digital transformation phenomenon, the dynamics of collaborative innovation, and the dimensions of sustainable entrepreneurship. We will investigate the links, synergies, and mediating effects that underpin this triad, offering a comprehensive understanding of how, in a world teeming with lemons, lemonade can be the result.

LITERATURE REVIEW

Digital Transformation in Entrepreneurship

The surge of digital technologies has undeniably transformed the business landscape. Scholars such as Westerman et al. (2014) emphasise that digital transformation entails more than just adopting the latest technology; it necessitates a holistic reshaping of business models and processes to fully exploit the potential of these innovations. Digital transformation, as described by Iansiti and Lakhani (2020), fundamentally alters the way firms create and capture value, making it a pivotal force in contemporary entrepreneurship. The impact of digital transformation transcends industries, affecting sectors from traditional manufacturing to service-based domains (Bharadwaj et al., 2013).

Collaborative Innovation in the Digital Age

Digital transformation has brought about a paradigm shift in innovation. Collaborative innovation has emerged as a key driver of success in this landscape. Chesbrough (2003) introduced the concept of open innovation, highlighting the value of external collaboration. Recent research by Bauer and Prado (2020) further underscores the role of digital platforms in facilitating open innovation and breaking down silos. As firms increasingly engage with ecosystems of partners, including startups, customers, and suppliers, the process of innovation becomes distributed, rapid, and responsive to market needs (Marcon, 2021).

Sustainable Entrepreneurship in the Modern Era

Sustainable entrepreneurship is not merely a trendy buzzword but a critical approach to business. Literature reveals the intersection of sustainability and entrepreneurship as a complex yet rewarding endeavour. Schaltegger et al. (2017) define sustainable entrepreneurship as the pursuit of opportunities to create value through novel solutions that address environmental and social challenges. Halme et al. (2020) argue that sustainable entrepreneurship goes beyond corporate social responsibility, encompassing practices that enhance economic, environmental, and social dimensions. Small and Medium-sized Enterprises (SMEs) play a decisive role by spawning employment, accumulating value, and contributing to innovation, particularly in developing countries (Hendieh, 2023). Notably, social and environmental objectives do not compete with profitability but complement it, a concept often referred to as the triple bottom line (Elkington, 1997). MSMEs produce extensive employment and afford entrepreneurial opportunities to the people in both rural and urban areas (Sulthana, Subrahmanyam & Habibullah, 2022).

Digital Transformation as a Catalyst for Collaborative Innovation and Sustainable Entrepreneurship

Digital transformation has demonstrated its potential as a mediator between innovation and sustainable entrepreneurship. This transformative power lies in its ability to break down geographical and organisational boundaries (Boudreau & Lakhani, 2009). As enterprises become digitally connected ecosystems, collaborative innovation flourishes. These alliances, driven by digital tools and platforms, serve as conduits for co-creating solutions that are both innovative and sustainable. Rogers (1995) accentuated four key aspects affecting technology acceptance: the innovation itself, communication channels, timing of implementation, and societal attitudes towards adoption (Changati & Kansal, 2019).

The literature paints a picture of a dynamic and interrelated triad, where digital transformation plays the role of an enabler, collaborative innovation is the intermediary force, and sustainable entrepreneurship represents the ultimate goal. However, to navigate this landscape successfully, it is essential to understand the nuances, synergies, and challenges that underpin these concepts.

STATEMENT OF THE PROBLEM

In an era marked by unprecedented digital transformation, entrepreneurs are increasingly embracing collaborative innovation to foster sustainable entrepreneurship. However, despite substantial research in individual domains (digital transformation, collaborative innovation, and sustainable entrepreneurship), there exists a gap in our understanding of the interconnected dynamics of these concepts, particularly the mediating role of digital transformation in the collaborative innovation process. This research aims to address this gap by investigating how digital transformation mediates and influences collaborative innovation within the context of sustainable entrepreneurship, ultimately contributing to a more holistic understanding of the contemporary entrepreneurial landscape. We formulate a series of succinct research questions (RQs) to direct our investigation and serve as the foundation for our empirical analysis.

RQ1: Is there a positive and significant relationship between the level of digital transformation and sustainable entrepreneurship?

RQ2: Does collaborative innovation mediate the relationship between digital transformation and sustainable entrepreneurship?

RQ3: Does collaborative innovation have a positive and significant impact on sustainable entrepreneurship?

THEORETICAL UNDERPINNINGS AND ORIGINATION OF HYPOTHESES

The theoretical framework for this research is founded on several key concepts and models that underpin the study. These frameworks provide a structured lens through which we analyse the interplay of digital transformation, collaborative innovation, and sustainable entrepreneurship. This theoretical framework provides a comprehensive basis for investigating the complex relationships and processes at the intersection of digital transformation, collaborative innovation, and sustainable entrepreneurship.

Digital Transformation and Sustainable Entrepreneurship

As technology spreads, the Indian government lifts focus on the digital infrastructure of enterprises where innovation is a variable which has an affirmative influence on entrepreneurs. (Arora & Kaur, 2018). Digital transformation stands out as a major force in the evolution and advancement of entrepreneurial endeavours. It involves the incorporation of digital technologies and procedures to enhance effectiveness, enhance customer interactions, and boost competitiveness within diverse industries and domains. Entrepreneurs have the opportunity to harness digital transformation to devise novel business models, products, services, and innovations tailored to market demands and standards. Digital transformation encompasses e-commerce, cloud computing, artificial intelligence, block chain, and the internet of things.

The theoretical foundation for the intersection of "Digital Transformation" and "Sustainable Entrepreneurship" draws from well-established theories. The Resource-Based View (RBV) theory, as articulated by Barney (1991), emphasises the pivotal role of digital transformation in enhancing an organisation's resource base and adaptability. The Open Innovation Framework, a concept introduced by Chesbrough (2003), offers a valuable understandings of how digital technologies can foster open collaborations and align with institutional pressures for sustainability**.**

H1: There is a positive and significant relationship between digital transformation and sustainable entrepreneurship.

Digital Transformation and Collaborative Innovation

Digital Transformation and Collaborative Innovation are grounded in theories such as the Resource-Based View and Open Innovation. The former emphasises digital capabilities as resources, while the latter underscores the value of external collaborations. Dynamic Capabilities theory contributes to understanding adaptability in a changing environment, with digital transformation enhancing these capabilities. In parallel, Collaborative Innovation theory elucidates the process of collaborating with external partners for innovation. All of these theories play a vital role in shaping Sustainable Entrepreneurship, where digital transformation and collaborative innovation can foster economic, environmental, and social sustainability (Schaltegger & Wagner, 2011).

H2: There is a positive and significant relationship between digital transformation and Collaborative innovation.

Collaborative Innovation and Sustainable Entrepreneurship

A current and notable trend in the sphere of entrepreneurship development and innovation revolves around the surging prominence of collaborative innovation. Collaborative innovation is a multifaceted process that encompasses the collaborative co-creation, co-development, and co-delivery of solutions in tandem with a diverse spectrum of stakeholders. These stakeholders can include customers, suppliers, strategic partners, competitors, and local communities. The essence of collaborative innovation empowers entrepreneurs to tap into a rich mosaic of perspectives, a reservoir of diverse skill sets, access to varied resources, and an intricate web of interconnected networks.

The Open Innovation Theory suggests that Innovation Ecosystems facilitate collaborative innovation by promoting knowledge sharing and co-creation among diverse ecosystem actors (Chesbrough, 2003). This collaboration, in turn, can enhance Sustainable Entrepreneurship by providing access to external knowledge, resources, and complementary capabilities. The Triple Helix Model highlights the interaction between universities, industries, and governments within innovation ecosystems, fostering collaborative innovation that can drive sustainability-focused entrepreneurial activities (Etzkowitz & Leydesdorff, 2000).

H3: Collaborative Innovation has a positive and significant impact on sustainable entrepreneurship.

Mediating Role of Collaborative Innovation

The examination of the mediating role of Collaborative Innovation between Digital Transformation and Sustainable Development draws from established literature. According to Chesbrough (2003), the Open Innovation Framework sheds light on the value of external collaboration and highlights how digital transformation can facilitate open collaborations. Therefore, it becomes essential to explore the interplay and mediating effects of Collaborative Innovation within the context of digital transformation and sustainable development, keeping in mind the nuances, synergies, and challenges that underpin these concepts.

H4: Collaborative innovation mediates the relationship between digital transformation and sustainable entrepreneurship.

Building upon the theoretical foundations discussed above, we have illustrated the study's proposed conceptual model in Fig. 1.

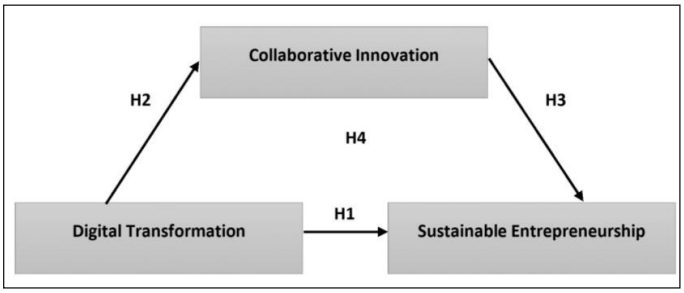

Fig. 1: Hypothesised Model

METHODS

This research examines the complex dynamics of digital transformation, collaborative innovation, and sustainable entrepreneurship by employing a quantitative approach.

Data Collection

The study collected data from 106 active participants who took part in an entrepreneurship conclave titled "MSME CONCLAVE-INDUSTRY ACADEMIA MEET" hosted through a collaborative effort by MSME-DFO, Cuttack, DIC Rayagada, and Atal Community Innovation Centre (ACIC)-GIETU University on August 31, 2023. Data collection was facilitated through a Google Form e-questionnaire that incorporated a 5-point Likert scale for participants to express

their opinions and perceptions. Following meticulous scrutiny and examination of the collected data, responses from 97 participants were deemed suitable for inclusion in the study.

Data Analysis

The research employed two software tools, SPSS 26 and Smart PLS, to conduct data analysis. These tools allowed for systematic data processing and robust statistical examination of the research constructs. Various statistical techniques were applied to measure variables, explore relationships, and test hypotheses. The quantitative analysis approach was chosen for its ability to provide a comprehensive view of the phenomenon under investigation.

Measurement Instruments

During the scale-development process, a comprehensive eighteen item scale was created to measure the three dimensions of entrepreneurship. The survey instruments featured a 5-point Likert scale, where participants were asked to express their opinions and perceptions by selecting a response that ranged from "1 - Strongly Disagree" to "5 - Strongly Agree." 1 (strongly disagree), 2 (disagree), 3 (neutral), 4 (agree), and 5 (strongly agree)." This scale was chosen to allow participants to provide nuanced feedback on various aspects of entrepreneurship.

Collaborative Innovation

The Collaborative Innovation scale utilised in this research is specifically designed to assess individuals' proclivity for engaging in collaborative innovative behaviours and practices. This measurement tool employs a six-item scale. Higher scores on this scale denote a heightened level of engagement and alignment with collaborative innovation initiatives, whereas lower scores indicate a reduced degree of involvement in such activities. The sample items included from the scale were, to what extent has collaborative innovation positively mediated the relationship between digital transformation and sustainable entrepreneurship within your organisation? To what extent does your organisation involve customers and end-users in the innovation process through digital channels, contributing to sustainable entrepreneurship? And so on. The scale confirmed good internal consistency, yielding a Cronbach's alpha value of 0.916.

Digital Transformation

The study developed a seven-item scale based on research using a 5-point scale, spanning from "1: strongly disagree" to "5: strongly agree". Elevated scores indicate greater levels of digital entrepreneurship, whereas lower scores indicate lesser levels of digital entrepreneurship. Sample items included, like, to what extent has digital transformation facilitated collaborative innovation in your organisation? Has digital transformation significantly impacted the sustainability of your entrepreneurial venture? How well does your organisation leverage digital transformation to foster collaborative innovation with external partners and stakeholders? The scale has been validated in multiple studies with Cronbach's alpha values fluctuating from 0.6 to 0.8 (Hirschi, 2009). A Cronbach alpha of 0.894 is achieved for this scale, indicating good internal consistency.

Sustainable Entrepreneurship

The sustainable entrepreneurship scale consists of a collection of six items, which have been derived and modified from existing literature (Nhemachena & Murimbika, 2018). Respondents are provided with these items and are asked to rate their agreement using a 5-point Likert scale. Participants evaluate their degree of concordance with the statements for each of these items. Sample items included, like: How important is environmental sustainability to your organisation's overall mission and business strategy? How well does your organisation integrate sustainability criteria into its product and service development processes? To what extent does your organisation engage in responsible sourcing and ethical supply chain management for sustainability?. However, 0.932 is the Cronbach's alpha for the scale, indicating even higher internal consistency.

Hypothesis Testing

Hypotheses derived from the theoretical framework are tested using appropriate statistical tests. The analysis seeks to establish whether digital transformation significantly influences collaborative innovation, whether collaborative innovation mediates the relationship between digital transformation and sustainable entrepreneurship, and the extent of these effects.

Data Validation and Reliability

To ensure the validity and reliability of the research findings, statistical techniques such as factor analysis and Cronbach's

alpha are applied to assess the internal consistency of the measurement scales.

DATA ANALYSIS: RESULTS AND DISCUSSION

The data gathered from the questionnaires underwent analysis through Smart PLS4 software. All the construct values set the satisfactory cut-off value of 0.7, as suggested by Nunnally (1978). The seven-item Digital Transformation (DIGT), six-item Collaboration Innovation (COLB), and five-item sustainable entrepreneurship (SUST) produce the *Cronbach's alpha values* for scale as 0.894, 0.916, and 0.932, respectively (shown in Fig. 2). The scale was prepared to commence the acquisition of comprehensive empirical data for the research investigation.

The primary goal of this research was to predict the dependent variable sustainable entrepreneurship (SUST), widely used in SEM research (Hussain & Li, 2022). This was achieved using a two-stage SEM approach, following the model proposed by Hair, Ringle, and Sarstedt (2013). In the first stage, a thorough measurement model assessment was performed to evaluate construct validity and goodness of fit. After confirming a satisfactory measurement model, the study proceeded to the second stage, employing Structural Equation Modelling (SEM) to empirically represent the structural relationships between different constructs through path estimates.

Before validating the measurement model, an exploratory factor analysis (EFA) was conducted as a preliminary step to ensure meaningful factor loadings for measured variables and to reveal the underlying relationships between measured variables and their respective constructs.

Exploratory Factor Analysis

Kaiser-Meyer-Olkin (KMO) and Bartlett's Sphericity tests are applied to assess sample adequacy for factor analysis, and the obtained values were deemed adequate. The approximate chi-square value was 1246.663 with 153 degrees of freedom, significant at the 5 percent level of significance. The Kaiser-Meyer-Olkin (KMO) statistic yielded a value of 0.856, which exceeds the suggested threshold of 0.50 (Hair et al., 2013) as presented in Table 1.

Table 1: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.856
Bartlett's Test of Sphericity	Approx. Chi-Square	1246.663
	df	153
	Sig.	.000

Source: Author's estimation.

Measurement Model Assessment

The measurement model in the factor analysis displays the relationship between constructs and indicators, incorporating Composite Reliability (CR) to assess internal consistency and reliability, and Average Variance Extracted (AVE) to evaluate convergent validity (Sarstedt et al., 2014).

Table 2: Convergent Validity Test of Measurement Mode-Cronbach's Alpha, Composite Reliability, and Average Variance Extracted (AVE)

Constructs	Cronbach's Alpha	Composite Reliability (Rho_A)	Composite Reliability (Rho_c)	Average Variance Extracted (AVE)
Collaborative Innovation	0.916	0.939	0.933	0.700
Digital Transformation	0.894	0.908	0.916	0.610
Sustainable Development	0.932	0.949	0.948	0.786

Source: Author's estimation.

According to Gaskin and Lim, 2016, the model is considered excellent if the values of AVE are greater than 0.5 and CR exceed 0.7. As observed in Table 2, the standards of CR, and AVE meet these criteria, affirming the model's reliability and validity. The convergent validity of each critical success factor was assessed using AVE, while reliability was tested using CR.

Table 3: Outer Loadings of Items of the Constructs

Items of the Constructs	Collaborative Innovation	Digital Transformation	Sustainable Development
COLB1 <- Collaborative Innovation	0.932		
COLB 2 <- Collaborative Innovation	0.956		
COLB 3 <- Collaborative Innovation	0.841		

Items of the Constructs	Collaborative Innovation	Digital Transformation	Sustainable Development
COLB 4 <- Collaborative Innovation	0.982		
COLB 5 <- Collaborative Innovation	1.055		
COLB 6 <- Collaborative Innovation	1.166		
DIGT1 <- Digital Transformation		1.000	
DIGT 2 <- Digital Transformation		0.955	
DIGT 3 <- Digital Transformation		1.052	
DIGT 4 <- Digital Transformation		1.056	
DIGT 5 <- Digital Transformation		0.842	
DIGT 6 <- Digital Transformation		0.960	
DIGT 7 <- Digital Transformation		1.062	
SUST1 <- Sustainable Development			1.041
SUST2 <- Sustainable Development			1.015
SUST3 <- Sustainable Development			0.991
SUST4 <- Sustainable Development			0.985
SUST5 <- Sustainable Development			0.969

Source: Author's estimation

The purpose of the model is to assess the appropriateness and suitability of the utilised scales. For individual item reliability, each item's outer loadings are evaluated and it is found that outer loading values are higher than 0.70 (Sarstedt et al., 2014). It is also found in Table 3 that each item's outer loadings are more than 0.70, indicating the sufficiency of standards for the item's loading. The three-factor measurement model and structural model are depicted in Figs. 2 and 3, respectively.

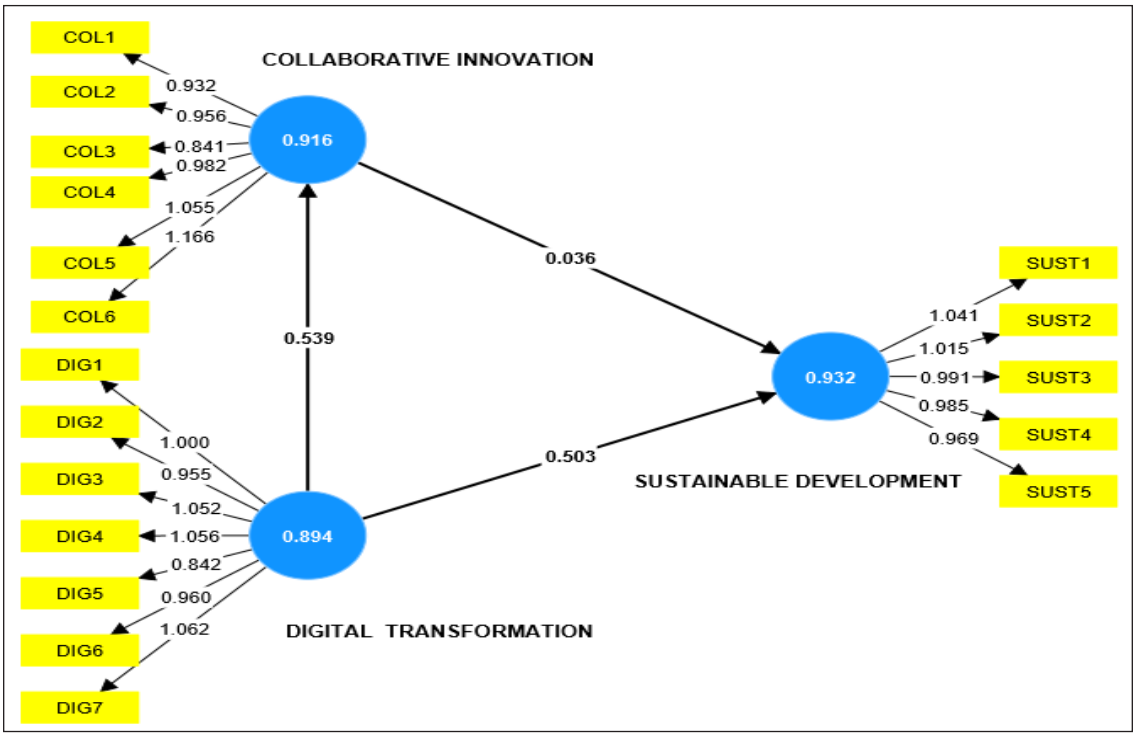

Fig. 2: Three Factor Measurement Model

Discriminant Validity

Discriminant validity is evident among all the study constructs. To validate this, the Heterotrait-Monotrait (HTMT) technique proposed by Fornell and Larcker (1981) was utilised, which evaluates discriminant validity by analysing the inter-correlations between a specific construct of interest and all other indicators in the model values below 0.85 indicate the achievement of discriminant validity (Kline, 2015). HTMT values close to 1 indicate lack of discriminant validity. Table 4 fulfils the HTMT ratio procedure, with all values in the matrix being less than 0.85 for inter-construct correlations. The HTMT Ratio-coefficients associated with each of the latent variables varied from 0.171 to 0.398, all of which are below the threshold value of 0.85, given in Table 4. There were no indications of any issues or concerns with this HTMT analysis, as specified by Gaskin and Lim (2016).

Table 4: HTMT Ratio-Coefficients

HTMT Ratio-Coefficients	**Coefficients of Heterotrait-Monotrait Ratio (HTMT)**
The Latent Variables	
Digital Transformation <-> Collaborative Innovation	0.398
Sustainable Development <-> Collaborative Innovation	0.171
Sustainable Development <-> Digital Transformation	0.379

Structural Model Assessment

The structural model describes the paths relationships between the endogenous variable and the exogenous variable in the conceptual research model. In the structural modelling, we assessed the presence of multicollinearity using Variance Inflation Factor (VIF) values, a measure that quantifies the degree of correlation among predictor variables. According to established literature, multicollinearity is considered problematic when VIF exceeds a threshold of 5 (Hair, Ringle & Sarstedt, 2013). Table 5 depicts the VIF values of the individual items, which are less than 5.

Table 5

Items	**VIF**
COLB1	3.193
COLB2	2.988
COLB3	3.197
COLB4	2.573
COBL5	2.656
COLB6	2.384
DIGT1	2.202
DIGT2	2.41
DIGT3	2.375
DIGT4	2.314
DIGT5	1.646
DIGT6	1.89
DIGT7	1.936
SUST1	4.028
SUST2	3.937
SUST3	2.906
SUST4	3.144
SUST5	2.888

Source: Author's estimation.

Variance Inflation Factors (VIF) for collinearity statistics among constructs in the inner model is examined in Table 6. The VIF values close to 1 indicate that there is little to no multicollinearity among the constructs in the inner model. This is a positive finding that the relationships between Digital Transformation, Collaborative Innovation, and Sustainable Development can be independently examined without the interference of high multicollinearity.

Table 6: Collinearity Statistics of the Structural Model

Constructs	**VIF**
Collaborative Innovation -> Sustainable Development	1.171
Digital Transformation -> Collaborative Innovation	1.000
Digital Transformation -> Sustainable Development	1.171

A standard bootstrapping technique is used to determine the implication of path coefficients, p-values, t-values, and the value of R^2. The approach involved employing 5000 bootstrap samples methodologies (Reinartz et al., 2009; Hair et al., 2014). A good model should have an SRMR (Standardized Root Mean Square Residual) value of less than 0.08 (Henseler et al., 2016; Hair et al., 2014), given in Table 7. In this study, the SRMR value is 0.079, which is lower than the threshold, signifying a good model fit. SRMR is a statistic that measures the discrepancy between the estimated model and the observed data. In this case, the SRMR value is 0.079 (Table 7). A lower SRMR value indicates a better fit to the data. An SRMR of 0.079 suggests that the estimated model provides a relatively good fit to the data, as it is a relatively small value.

The d_ULS (Unweighted Least Squares) value of 1.005 is a measure of the fit of the estimated model. It is compared to a baseline model. In this case, a value of 1.005 suggests that the estimated model is not significantly worse than the baseline model in terms of fit.

Table 7: Model Fit Indices

Model Fit Indices	Saturated Model	Estimated Model
SRMR	0.079	0.079
d_ULS	1.005	1.005
d_G	0.525	0.525
Chi-square	279.212	279.212
NFI	0.792	0.792

Source: Author's estimation.

The d_G (GFI Incremental Fit Index) of 0.525 is another measure of the incremental fit of the estimated model compared to a baseline model. A value of 0.525 suggests that the estimated model is providing a reasonable improvement over the baseline model. The chi-square value of 279.212 is a statistic used to assess how well the estimated model fits the data (Table 7). Lower chi-square values indicate better fit. In this case, the chi-square value is 279.212, which suggests that the estimated model fits the data, but it's important to note that chi-square values are often affected by sample size, so they should be interpreted in the context of the specific analysis.

NFI (Normed Fit Index) value of 0.792 is a normed fit index that measures how well the estimated model reproduces the observed data (Table 7). A value of 0.792 suggests that the model provides a reasonable fit to the data, although higher values are generally desired. The estimated model appears to provide a relatively good fit to the data. The SRMR, d_ULS, d_G, and NFI values all suggest that the model is fitting the data reasonably well.

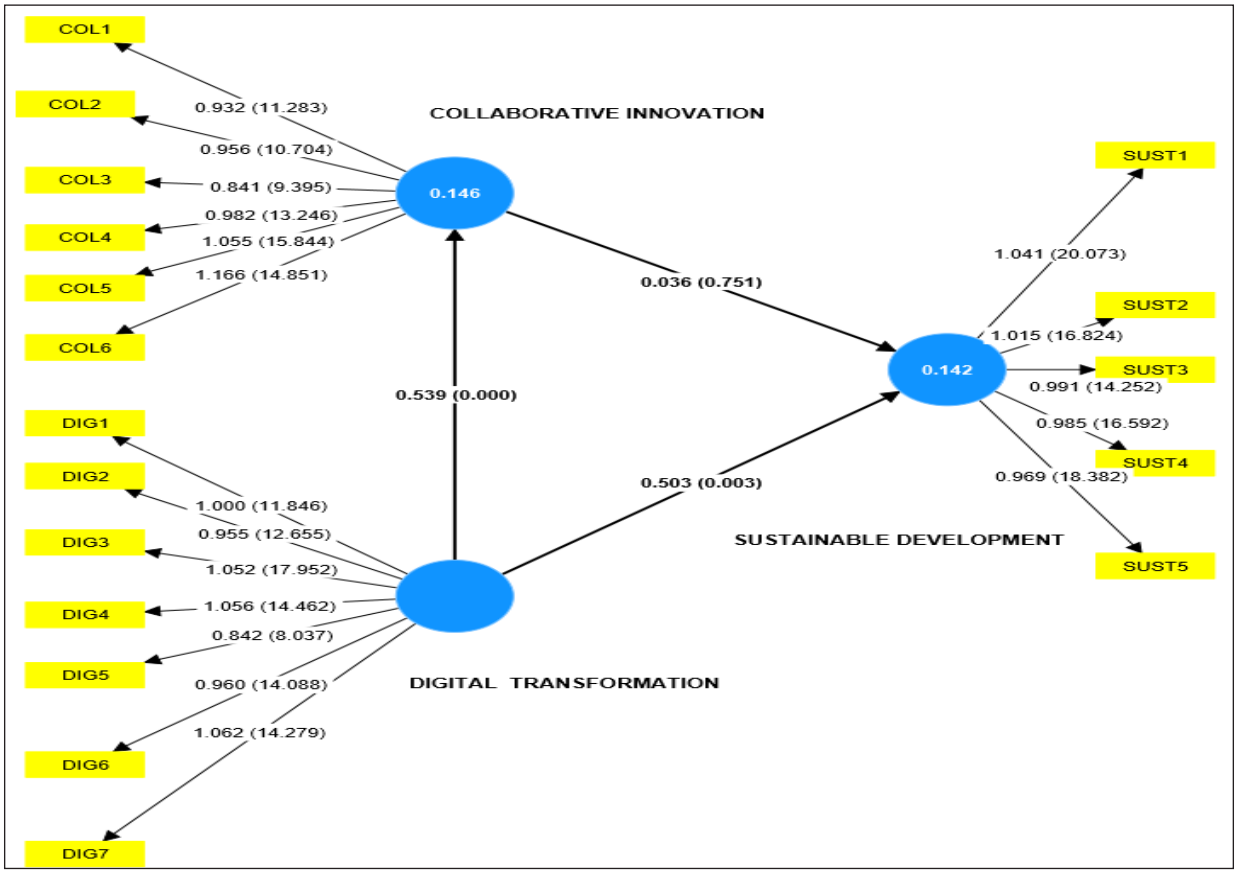

Fig. 3: Three Factor Structural Model

The loading estimates remained stable from the measurement model, showcasing the consistency of parameters across the measured items, the results further reinforce and support the validity of the measurement model (Hair et al., 2010).

Thus, the model proposes that sustainable entrepreneurship is predicted by the digital transformation, with the mediation of collaborative innovation. To ascertain the significance and relevance of the relationships in the structural model, t-values were compared to the critical t-values for a significance level of 0.05.

Model Fit with The Bayesian Information Criterion

The Bayesian Information Criterion (BIC) is a statistical criterion used for model selection. The BIC is calculated using the likelihood function and a penalty term based on the number of parameters in the model as shown in Table 7a. The model with the lower BIC is considered a better fit. A BIC less than 0 favours the hypothesised model (Bauldry, 2015).

Table 7a: The Bayesian Information Criterion

Construct	BIC (Bayesian Information Criterion)
Collaborative Innovation	-7.134
Sustainable Development	-2.081

Source: Author's estimation.

Collaborative Innovation BIC: -7.134

A more negative BIC indicates a better fit. In the context of Collaborative Innovation, the BIC value of -7.134 suggests that the model with Collaborative Innovation is favoured over alternative models for explaining the observed data. This value reflects the trade-off between model fit and complexity, with a lower BIC indicating a more parsimonious and effective model.

Sustainable Development BIC: -2.081

The BIC value of -2.081 for Sustainable Development suggests that the model including Sustainable Development is preferred over alternative models. This lower BIC indicates that the inclusion of Sustainable Development in the model provides a better fit to the data while considering the complexity of the model.

HYPOTHESIS TESTING OF THE STUDY

To ascertain the significance and relevance of the relationships in the structural model, t-values are compared to the critical t-values for a significance level of 0.05 (given in Table 8).

Table 8: Path Coefficients Details of Structural Model

Path Coefficients	Hypothesis	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P-Values
Digital Transformation -> Sustainable Development	H1	0.503	0.512	0.168	2.986	0.003
Digital Transformation -> Collaborative Innovation	H2	0.539	0.566	0.125	4.325	000
Collaborative Innovation -> Sustainable Development	H3	0.036	0.036	0.114	0.317	0.751
Digital Transformation -> Collaborative Innovation -> Sustainable Development	H4	0.019	0.021	0.067	0.290	0.772

Source: Author's estimation.

H1: There is a positive and significant relationship between digital transformation and sustainable entrepreneurship.

The path coefficient of 0.503 indicates a positive relationship between Digital Transformation and Sustainable Development. The t-value (|O/STDEV|) of 2.986 is statistically significant (p-value = 0.003), suggesting that Digital Transformation has a significant impact on Sustainable Development. In other words, digital transformation is associated with an increase in sustainable entrepreneurship.

H2: There is a positive and significant relationship between digital transformation and collaborative innovation.

The path coefficient of 0.019 represents the relationship from Digital Transformation through Collaborative Innovation to Sustainable Development. The t-value (|O/STDEV|) of 0.29 is not statistically significant (p-value = 0.772), indicating that the observed relationship may not be significant. In this case, the p-value is greater than the common significance level, so we do not have sufficient evidence to consider a statistically significant relationship between digital transformation and collaborative innovation. However, the data does not provide sufficient evidence to support a significant relationship between digital transformation and collaborative innovation (H2). Therefore, we fail to support H2.

H3: Collaborative innovation has a positive and significant impact on sustainable entrepreneurship.

The path coefficient of 0.036 indicates a positive relationship between Collaborative Innovation and Sustainable Development. However, the t-value (|O/STDEV|) of 0.317 is not statistically significant (p-value = 0.751), suggesting that the observed relationship may be due to random chance. Therefore, we nullify H2.

Mediating Effect

The mediation propositions evaluate the significant associations between the independent-dependent variable, independent - mediating variable, and mediating - dependent variable by using Baron and Kenny's (1986) technique.

H4: Collaborative Innovation mediates the relationship between Digital Transformation and Sustainable Entrepreneurship.

The path coefficient of 0.019 represents the relationship from Digital Transformation through Collaborative Innovation to Sustainable Development. The t-value (|O/STDEV|) of 0.29 is not statistically significant (p-value = 0.772), indicating that the observed relationship may not be significant. Therefore, Collaborative Innovation mediates the relationship between Digital Transformation and Sustainable Entrepreneurship ineffectively. Further analysis and additional data may be necessary to determine the strength and significance of this mediating role.

Hypotheses 1 and 2 are supported by the data, suggesting that Digital Transformation significantly influences both Collaborative Innovation and Sustainable Development. However, Hypotheses 3 and 4 do not show statistically significant relationships based on the provided t-values and p-values.

R^2 and F^2

The R-squared values provide understandings into the proportion of variance explained by the models for "Collaborative Innovation" and "Sustainable Development." The F-Square values indicate the overall model fit for specific relationships. "Digital Transformation" is a significant predictor for both "Collaborative Innovation" and "Sustainable Development," while "Collaborative Innovation" does not significantly explain the variance in "Sustainable Development."

The value of R^2 is employed to evaluate the portion of variability in the dependent variable that can be accounted for by one or multiple independent variables (Fassott et al., 2016). In this study, the value of R^2 is found to be acceptable based on the study's requirements. Falk and Miller (1992) suggest that a value above 0.10 is acceptable for R^2.

Table 9: R-Square and R-Square Adjusted

Constructs	R-Square	R-Square Adjusted
Collaborative Innovation	0.146	0.137
Sustainable Development	0.142	0.123

Source: Author's estimation.

For "Collaborative Innovation," the R-squared value is 0.146, while the adjusted R-squared is 0.137. These values suggest that the model explaining "Collaborative Innovation" accounts for about 14.6% of the variance in this variable, and the adjusted value, which accounts for the number of predictors, is 13.7% (given Table 9 and Fig. 3).

For "Sustainable Development," the R-squared value is 0.142, and the adjusted R-squared is 0.123. Similarly, this indicates that the model explaining "Sustainable Development" explains approximately 14.2% of the variance, and the adjusted value is 12.3% (given Table 9 and Fig. 3). A higher R-squared value indicates a better fit of the model to the data.

F-Square

Table 10: F-Square Effect Size

Constructs	F-Square
Collaborative Innovation -> Sustainable Development	0.001
Digital Transformation -> Collaborative Innovation	0.171
Digital Transformation -> Sustainable Development	0.129

Source: Author's estimation.

The F-square values represent the effect size of each predictor in explaining the variance in the respective outcome variable, as depicted in Table 10.

"Digital Transformation -> Collaborative Innovation" has an F-Square value of 0.171. This suggests that there is a statistically significant relationship between "Digital Transformation" and "Collaborative Innovation." The model explains a notable proportion of the variance in "Collaborative Innovation."

"Digital Transformation -> Sustainable Development" has an F-Square value of 0.129. This value indicates a statistically significant relationship between "Digital Transformation" and "Sustainable Development." The model explains a significant portion of the variance in "Sustainable Development" based on "Digital Transformation.

The F-square of 0.001 indicates a very small effect size for Collaborative Innovation in explaining the variance in Sustainable Development. This suggests that Collaborative Innovation, as a predictor, has a minimal impact on the variability observed in Sustainable Development.

IMPLICATION OF THE STUDY

Theoretical Implications

Digital Transformation and Sustainable Development (H1): The positive path coefficient (0.503) and the statistically

significant t-value (2.986, p-value = 0.003) suggest that Digital Transformation has a direct and meaningful impact on Sustainable Development. The theoretical implication involves reinforcing the understanding that strategic digital initiatives play a crucial role in fostering sustainable outcomes.

Digital Transformation and Collaborative Innovation (H2): The substantial path coefficient (0.539) and high t-value (4.325, p-value = 0.000) signify a strong positive association between Digital Transformation and Collaborative Innovation. Theoretical implications may involve exploring the mechanisms through which digital advancements stimulate collaborative practices.

Collaborative Innovation and Sustainable Development (H3): While the R-square (0.146) suggests a moderate explanatory power, the path coefficient (0.036) is statistically significant (t-value = 0.317, p-value = 0.751). Theoretical implications include further investigating the specific collaborative processes that contribute to sustainable development.

Digital Transformation -> Collaborative Innovation -> Sustainable Development (H4): The non-significant indirect effect (path coefficient = 0.019, t-value = 0.290, p-value = 0.772) highlights a theoretical gap in the assumed mediation. Theoretical discussions may explore the complexities in the relationship between digital transformation, collaborative innovation, and sustainable development.

Practical Implications

Organisations can leverage the proven positive impact of Digital Transformation on Sustainable Development for practical sustainability initiatives. This involves integrating digital technologies strategically to achieve sustainable goals, such as resource efficiency and environmental conservation.

Acknowledging the strong relationship between Digital Transformation and Collaborative Innovation, practical implications include fostering collaborative cultures within organisations. This can be achieved through digital platforms, tools, and initiatives that encourage knowledge sharing and cross-functional collaboration. While Collaborative Innovation may have a moderate impact on Sustainable Development, organisations can still benefit practically by promoting collaborative practices. Initiatives may include establishing interdisciplinary teams and platforms for collaborative ideation to enhance sustainability efforts.

Economic Implications

The positive association between Digital Transformation and Sustainable Development implies potential economic benefits. Organisations aligning digital strategies with sustainability goals may experience improved economic performance through cost savings, enhanced market reputation, and increased competitiveness.

Managerial Implications

Managers should recognise the direct positive impact of Digital Transformation on Sustainable Development and strategically align digital initiatives with sustainability objectives. Managerial efforts can focus on developing comprehensive strategies that leverage digital capabilities to achieve measurable sustainable outcomes. Given the strong link between Digital Transformation and Collaborative Innovation, managerial implications involve creating environments that support collaborative practices. This may require investment in training programs, digital infrastructure, and leadership initiatives to foster a collaborative organisational culture.

Entrepreneurial Implications

Entrepreneurs can explore opportunities in developing innovative solutions that leverage digital technologies for sustainable outcomes. Start-ups may focus on creating products or services that align with the positive impact of Digital Transformation on Sustainable Development. Recognising the significance of Digital Transformation in stimulating Collaborative Innovation, entrepreneurial ventures can explore opportunities in providing digital tools or platforms that facilitate collaboration among organisations, potentially contributing to sustainable development.

Social Implications

Social implications involve recognising the positive impact of Digital Transformation on Sustainable Development, highlighting the potential societal benefits. Digital initiatives aligned with sustainability goals can contribute to positive social change, including job creation and improved community well-being. The emphasis on Collaborative Innovation suggests social benefits arising from collaborative practices within organisations. Socially, this can contribute to knowledge-sharing, skill development, and community building.

RESEARCH LIMITATIONS AND FUTURE RESEARCH AVENUES

The study has inherent limitations that warrant consideration in interpreting its findings. The cross-sectional design poses

challenges in establishing causal relationships, underscoring the need for longitudinal studies to capture the dynamic interplay among digital transformation, collaborative innovation, and sustainable development over time. Generalisability is constrained by the specific industries and organisational contexts in the sample, cautioning against broad extrapolations. Potential common method bias, arising from reliance on self-reported data, underscores the importance of employing diverse data collection methods. The theoretical model may not comprehensively encompass all relevant factors, and ongoing technological and organisational developments could impact its applicability. Despite these limitations, the study offers valuable understandings. Future research avenues should involve longitudinal studies to explore temporal dynamics and diversify across industries for enhanced generalisability. Exploring specific collaborative mechanisms, platforms, and considering contextual factors like leadership styles and organisational culture could deepen understanding. Introducing variables interacting with digital transformation and collaborative innovation, along with cross-cultural studies, can provide richer understandings. These future research directions aim to advance comprehension and offer valuable insights for academic and practical applications in digital transformation, collaborative innovation, and sustainable development.

CONCLUSION

This study establishes a significant positive relationship between digital transformation and sustainable performance (H1), highlighting the important role of strategic digital initiatives in promoting sustainability. However, collaborative innovation does not have a significant effect on sustainability, testing the hypothesised mediating role of the relationship between digital transformation and sustainability (H3 and H4). Theoretical implications emphasize the importance of deepening collaborative strategies that contribute to sustainable development, while economic, business, operational, and social implications emphasise the integration of digital technologies and collaborative practices in strategic emphasis for sustainable effectiveness, improved economic performance and positive social change. These acumens help sharpen sustainable digital business practices and guide future research and practical applications.

REFERENCES

Arora, S., & Kaur, S. (2018). Perceived risk dimensions and its impact on intention to use E-banking services: A conceptual study. *Journal of Commerce and Accounting Research, 7*(2), 18.

Barney, J. B., Ketchen Jr, D. J., & Wright, M. (2011). The future of resource-based theory: Revitalization or decline? *Journal of Management*, *37*(5), 1299-1315.

Bauer, J. M., & Prado, T. S. (2020). Digital Platforms and Innovation: Lessons for Innovation Policy and Regulation (December 15, 2020). Quello Center Working Paper, TPRC48: The 48th Research Conference on Communication, Information and Internet Policy. Retrieved from https://ssrn.com/abstract=3749670; doi:http://dx.doi.org/10.2139/ssrn.3749670

Bauldry, S. (2015). Structural equation modeling. *International Encyclopedia of the Social & Behavioral Sciences,* 615-620. doi:https://doi.org/10.1016/b978-0-08-097086-8.44055-9

Bharadwaj, A., El Sawy, O. A., Pavlou, P. A., & Venkatraman, N. V. (2013). Digital business strategy: Toward a next generation of insights. *MIS Quarterly*, 471-482.

Boudreau, K., & Lakhani, K. (2009). How to manage outside innovation. *MIT Sloan Management Review, 50.*

Changati, V., & Kansal, P. (2019). Factors influencing technology acceptance in the banking sector: A binary recursive partitioning approach. *Journal of Commerce and Accounting Research, 8*(1), 68-82.

Chesbrough, H. W. (2003). *Open innovation: The new imperative for creating and profiting from technology.* Harvard Business Press.

Elkington, J. (1998). Partnerships from cannibals with forks: The triple bottom line of 21st-century business. *Environmental Quality Management*, *8*(1), 37-51.

Etzkowitz, H., & Leydesdorff, L. (2000). The dynamics of innovation: From National Systems and "Mode 2" to a Triple Helix of university–industry–government relations. *Research Policy*, *29*(2), 109-123.

Fornell, C., & Larcker, D. F. (1981). *Structural equation models with unobservable variables and measurement error: Algebra and statistics*.

Gaskin, J., & Lim, J. (2016). Model fit measures. *Gaskination's StatWiki*, *37*(3), 814-822.

Gassmann, O., Frankenberger, K., Choudury, M., & Csik, M. (2020). *The business model navigator: The strategies behind the most successful companies*. UK: Pearson.

Hair Jr, J. F., Sarstedt, M., Hopkins, L., & Kuppelwieser, V. G. (2014). Partial least squares structural equation modeling (PLS-SEM): An emerging tool in business research. *European Business Review, 26*(2), 106-121.

Hair, J. F., Ringle, C. M., & Sarstedt, M. (2013). Partial least squares structural equation modeling: Rigorous applications, better results and higher acceptance. *Long Range Planning, 46*(1-2), 1-12.

Halme, M., Rintamäki, J., Knudsen, J. S., Lankoski, L., & Kuisma, M. (2020). When is there a sustainability case for CSR? Pathways to environmental and social performance improvements. *Business & Society*, *59*(6), 1181-1227.

Hendieh, J. (2023). Budgeting and financial techniques used by SMEs during crisis. *Journal of Commerce and Accounting Research, 12*(3), 1.

Henseler, J., Hubona, G., & Ray, P. A. (2016). Using PLS path modeling in new technology research: Updated guidelines. *Industrial Management & Data Systems, 116*(1), 2-20.

Hirschi, A. (2009). Career adaptability development in adolescence: Multiple predictors and effect on sense of power and life satisfaction. *Journal of Vocational Behavior, 74*(2), 145-155.

Hussain, N., & Li, B. (2022). Entrepreneurial leadership and entrepreneurial success: The role of knowledge management processes and knowledge entrepreneurship. *Frontiers in Psychology, 13,* 829959.

Iansiti, M., & Lakhani, K. R. (2020). *Competing in the age of AI: Strategy and leadership when algorithms and networks run the world*. Harvard Business Press.

Kline, R. B. (2015). The mediation myth. *Basic and Applied Social Psychology, 37*(4), 202-213. doi:https://doi.org/10.1080/01973533.2015.1049349

Marcon, A., & Ribeiro, J. L. D. (2021). How do startups manage external resources in innovation ecosystems? A resource perspective of startups' lifecycle. *Technological Forecasting and Social Change*, *171*, 120965.

Nhemachena, C., & Murimbika, M. (2018). Motivations of sustainable entrepreneurship and their impact of enterprise performance in Gauteng Province, South Africa. *Business Strategy & Development, 1*(2), 115-127.

Nunnally, J. C. (1978). An overview of psychological measurement. *Clinical Diagnosis of Mental Disorders: A Handbook,* 97-146.

Reinartz, W., Haenlein, M., & Henseler, J. (2009). An empirical comparison of the efficacy of covariance-based and variance-based SEM. *International Journal of Research in Marketing, 26*(4), 332-344. doi:https://doi.org/10.1016/j.ijresmar.2009.08.001

Sarstedt, M., Ringle, C. M., Smith, D., Reams, R., & Hair Jr, J. F. (2014). Partial least squares structural equation modeling (PLS-SEM): A useful tool for family business researchers. *Journal of Family Business Strategy, 5*(1), 105-115. doi:https://doi.org/10.1016/j.jfbs.2014.01.002

Schaltegger, S., & Wagner, M. (2011). Sustainable entrepreneurship and sustainability innovation: Categories and interactions. *Business Strategy and the Environment*, *20*(4), 222-237.

Schaltegger, S., Etxeberria, I. Á., & Ortas, E. (2017). Innovating corporate accounting and reporting for sustainability - Attributes and challenges. *Sustainable Development, 25*(2), 113-122. doi:https://doi.org/10.1002/sd.1666

Schaltegger, S., Lüdeke-Freund, F., & Hansen, E. G. (2016). Business models for sustainability: A co-evolutionary analysis of sustainable entrepreneurship, innovation, and transformation. *Organization & Environment*, *29*(3), 264-289.

Sulthana, A., & Subrahmanyam, N. (2022). Financial problems and prospects of MSMEs in the State of Telangana. *Journal of Commerce and Accounting Research, 11*(4), 9-14.

Upadhaya, G., & Chadha, P. (2019). Entrepreneurial motivations and barriers among management students in Himachal Pradesh: An empirical study. *Journal of Commerce and Accounting Research, 8*(2), 48-58.

Westerman, G., Bonnet, D., & McAfee, A. (2014). *Leading digital: Turning technology into business transformation*. Harvard Business Press.

Yoffie, D. B. (1997). *Competing in the age of digital convergence Harvard.* Boston, MA, USA: Business School Press.