

Machine Learning Strategies Fueling Economic Progress for Start-ups

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Abstract: Environmental concerns worldwide have propelled businesses towards adopting eco-friendly practices. However, determining the success of these efforts remains a challenge. Start-ups are emerging as pivotal drivers of sustainable innovation. Leveraging machine learning models for predictive analysis allows businesses to explore this relatively uncharted territory using historical data. This study employs machine learning techniques to conduct predictive analysis, specifically investigating the influence of sustainable business practices on financial performance. Examining data from 152 diverse start-ups, our research provides compelling evidence that the implementation of sustainable business practices significantly enhances financial performance. These practices not only confer a competitive advantage but also empower start-ups to thrive in dynamic business landscapes. The study integrates a regression-based model to predict financial performance in real-time when start-ups adopt sustainable practices. The developed regression model facilitates a comprehensive overview of start-up performance and insights into potential areas for improvement. Furthermore, our research establishes a correlation between financial performance and the intermediary role of competitive advantage, elucidating the intricate relationship between these variables. Sustainable business practices thus offer start-ups a competitive edge, enabling not only survival but also flourishing in volatile business environments. This research contributes valuable insights for entrepreneurs, governments, and academics, advocating for the widespread adoption of sustainable business practices among start-ups. The regression model serves as a practical tool for start-ups to assess their performance and strategize for future enhancements. The implications extend beyond immediate financial gains, emphasizing the imperative of integrating sustainability into the fabric of start-up operations for long-term success and societal benefit.

Keywords: competitive advantage, financial performance, machine learning, predictive analysis, regression model, Start-up, statistical analysis, sustainable development goals.

1. Introduction

The advent of machine learning (ML) and artificial intelligence (AI) has ushered in a disruptive era in decision-making processes across various disciplines, and start-ups are no exception. With a growing reliance on these technologies, start-ups are emerging as enthusiastic adopters, leveraging ML algorithms to analyze vast datasets swiftly. This enables them to extract crucial insights for informed strategic decision-making. Predictive analytics, a cornerstone of artificial intelligence, empowers companies to forecast trends and customer behaviors, facilitating proactive decision-making based on anticipated future scenarios [1].

Moreover, AI facilitates personalized consumer experiences by tailoring products and services to individual tastes, thereby enhancing customer satisfaction and loyalty. The automation of routine operations, a hallmark of machine learning, liberates startup teams to concentrate on key projects, thereby enhancing overall efficiency and productivity. Machine learning's application in risk management enables companies to assess and mitigate

potential risks by recognizing trends in historical data. AI plays a pivotal role in supply chain optimization, controlling inventories, forecasting demand, and streamlining logistics for cost-effectiveness. Start-ups also employ AI for fraud detection, security enhancement, and the development of innovative products. Additionally, AI aids in human resource recruitment, employee engagement, and performance analysis. AI-driven financial research and investing methods contribute to improved financial decision-making.

While businesses in previous centuries have been primarily profit-driven with little regard for adverse effects, the contemporary global landscape is marked by alarming social and environmental issues, necessitating a shift away from unsustainable business practices [1]. The increasing emphasis on environmental concerns puts pressure on new ventures to address these issues creatively. Instead of merely exploiting vast potential resources for profit, businesses should focus on developing innovative processes that lead to environmental, social, and economic sustainability [2]. The creation of sustainable business solutions not only grants a competitive edge to new ventures but also reduces the risk of failure, a significant challenge in any startup journey. Business survival demands strong financial performance, achievable by gaining a competitive advantage (CA) through the adoption of sustainable business practices [3].

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In today's market, where consumers are increasingly aware and make rational choices, businesses must adopt sustainable business practices (SBP) to secure market share [4]. Sustainable business practices refer to economically, socially, and environmentally responsible business operations. The heightened awareness of environmental degradation among consumers has significantly increased the demand for green products [5]. Consequently, commercial firms have widely adopted sustainable business practices in recent decades to gain a competitive edge while also addressing environmental concerns [6]. Today, businesses strive to adopt a sustainable business model not only for financial reasons but also for non-monetary benefits. Previous research [7]–[9] suggests that stakeholders reward firms with good sustainable business practices (SBP), and investors find companies with a sustainable business model promising. The integration of sustainable business practices assists investors in making decisions based on the overall performance of the firm, not just financial performance.

Despite start-ups following sustainable business practices, there is a lack of studies on how the adoption of SBPs contributes to their financial performance (FP). Establishing a relationship between SBP and FP through predictive analysis can provide rational solutions. Recent years have witnessed a constant pressure on firms to develop and follow environmental management practices. Previous research indicates that mature firms are more likely to have the capacity and rationality to adopt sustainability compared to emerging counterparts. However, recent developments challenge this conventional wisdom, where emerging businesses act as torchbearers. This highlights the importance of integrating machine learning models into the day-to-day decision-making processes of emerging business ventures that adopt a sustainable business model while remaining financially sustainable.

This study focuses on start-ups, defined as new business ventures working on innovative business models with the objective of solving a problem. India is a significant context for this research, holding the fourth position globally in the start-up ecosystem, showcasing high levels of entrepreneurial activity and immense growth potential. The booming start-up culture is evident in various sectors, including information technology, defense, tourism, agriculture, and healthcare. This work specifically aims to develop a machine learning model predicting the financial success of start-ups in the travel and tourism sector. This sector contributes approximately 11.3% to the total global economy. However, its contribution to pollution accounts for 5% of the total pollution caused, making the inclusion of sustainable business practices in the tourism sector a necessity. Real-time data from 152 start-ups was collected and subjected to basic statistical analysis. The analysis establishes a strong correlation between SBP, CA, and FP.

Subsequently, a regression model is developed to predict the financial performance of start-ups adopting sustainable business practices. The paper is organized into seven sections. The second part provides a review of the literature, followed by a discussion of the research methods in section 3. Section 4 focuses on data analysis and interpretation. Section 5 presents a predictive model for financial performance, followed by implications, future scope, and conclusions in respective sections.

2. Literature Review

This section delves into the exploration of sustainable business practices and related concepts within the context of existing literature. Furthermore, the scope of study undertaken by researchers worldwide in ML and management domain is investigated, confirming the fact that ML models are utilized to solve business and management related problems and improve decision making. It is subdivided into multiple segments with the overarching objective of examining the significance of start-ups in embracing sustainable business practices, the integration of ML in decision areas in new business ventures.

2.1 Sustainable Business and Financial performance

According to [10] the businesses that adopt environmental practices tend to achieve production efficiency that reduces cost per production contributing to the improved firm performance [11]. Firm performance is a multifaceted notion represented in terms of an organization's performance and improvement in important areas such as product and service results, consumer happiness, financial and operational performance, human resource related outcomes, and social responsibility. [12] As per researcher corporate environment performance and financial performance reveal a positive relationship between the two [13]. The institutional theory's [14] theoretical components argues that a firm's commitment to strong environmental management practices increases the chances of improved financial performance as it allows the firm to reduce its carbon footprint, improve the brand value [15]. According to [16] When compared to external green practises, practises such as green distribution, green production and pollution control are also important drivers of Start-up performance. The link between sustainable business practises and firm success, as judged by shareholders and management, is positive. With increasing competition business environment is going under rapid changes and for long term survival the firms are opting sustainable business practices that goes beyond short term profitability towards social, environment and economic sustainability. [14] Sustainable business practices are specifically geared towards business and its operations aiming to conduct business activities in a sustainable manner like reducing resource usage, minimizing waste, emissions, carbon footprint and adoption

of renewal source of energy, green supply chain and integrating social responsibilities in the business strategies. Financial performance is an integral aspect of a Start-up where sound financial position promotes research and development and growth prospects and on the other hand poor financial position obstructs expansion and growth of business activities. Previous studies [17]–[19] assess FP using a diverse indicator such as “return on assets (ROA), return on investment (ROI), return on equity, market value added, and earnings per share (EPS)”. Previous studies [20]–[22] in a span of a decade have examined the relationship but results are inconsistent as some studies suggest a positive impact[23], [24], others suggest an insignificant relationship, a negative relationship[25],[26] an inverted U relationship [27], lopsided relationship [28]. These erratic results tend to discourage the entrepreneurs to take up new ventures making them unsure of financial benefits of opting sustainable business practices.

2.2 Sustainable Business and Competitive advantage

Competitive advantage can be defined as business’s capability to differentiate itself from others by offering a unique value to its stakeholders. As per researchers’ sustainable business practices can provide competitive advantages in terms of innovation, economic performance, and eco-efficiency [29]. Creating distinctive value through the integration of corporate strategies with sustainable objectives enables firms to achieve a competitive advantage by strengthening cost and operational efficiency. [30] Recent work suggest that sustainability practices increase customers loyalty and competitive advantage. In long run, competitive advantage becomes to key to sustain in a business. Similarly, Start-ups are under pressure to work on the business innovation model and competitive advantage that offers solution to the existing problems through innovation and invention.[31] The rate of failure among Start-ups is high being lack of competitive advantage among most crucial one. Some studies reveal a negative relation between sustainable business practices competitive advantage [22]. While there may not always be a direct relation between sustainability and competitive advantage [32] but it is clear that sustainability can contribute to the firm’s success by contributing in resource productivity and overall business performance. Studies have shown inclusion of triple bottom line factors into Start-up’s valuation model advances the non-financial indicators like market capture and acceptance, lower debt cost and customer satisfaction. [33]. Recent studies suggest implementing sustainable practices requires firms to adopt new technologies and processes that drives innovation. Sustainable business practices can reduce firm’s exposure to social and environmental risk along with better support from stakeholders. This support can provide access to resources, permits and financial backup giving a competitive advantage over others. However, gaining competitive

advantage through sustainable business practices is not an automated process rather it requires a strategic firm policy. According to mere green washing will not contribute in firm’s sustenance in long run.

2.3 Competitive advantage and financial performance

CA is the capability of a business to outperform its competitors by offering a value product/service/process. According to the literature (29), there is a considerable association between competitive advantage and financial performance. As per [34], technological capability and interorganizational collaboration have a positive direct influence on competitive advantage and vice versa. Start-ups must focus on building value through cost leadership and product differentiation in the niche market. Factors such as intellectual capital and interorganizational collaboration contribute to the development of competitive advantage for start-ups. [1] Though studies suggest it is not advisable to employ resources directly to gain competitive advantage instead, a business should focus on business model innovation in order gain competitive advantage [28]. Sustainable business practices are one of the integral ways of gaining competitive advantage in a niche market where competitive advantage playing a crucial role in firm’s performance.[2]

2.4 Competitive advantage as a mediating factor

Competitive advantage can be quoted as firm’s position where competitors fail to imitate its strategy which in return offers sustainable benefits to the firm. Literature suggests [4], [22], [35] that there are several benefits to competitive advantage including lower cost, improved productivity, better managerial ability and sustainability [36]. Porter highlighted innovation as the most integral determinant of increasing competitive advantage where companies working on a triple bottom line can generate competitive advantage. Past studies have investigated the competitive advantage as a mediator between sustainable business practices and financial performance where results reveal competitive advantage can make firm’s performance outperform the competitors.[37] The sustainable business practices bring environmental sustainability, social responsibility and economic stability that directly develops competitive advantage.[38] Start-ups that work on the model of unique value proposition and innovation to sustain in the market have to ensure CA in the field they serve their customers.[39]. Based on the literature survey it is identified that data analytics and multiple regression analysis can be used to determine relationship between variables. The proposed work aims to investigate start-ups on the hypothesis stated below and depicted in the proposed conceptual model in figure 1 based on structural equation.

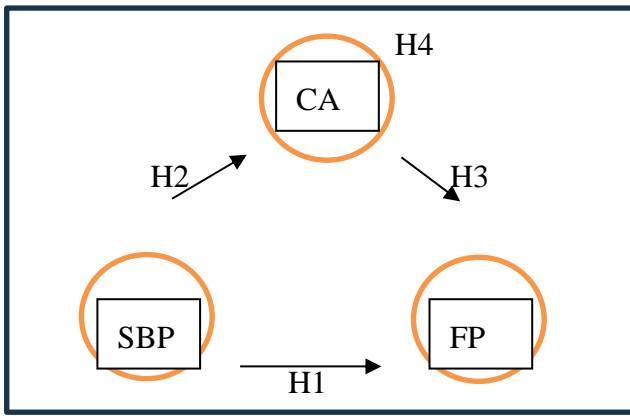


Fig. 1. Proposed Conceptual Model

2.4 Role of Machine Learning in decision making

Machine Learning (ML) is a subset of AI that focuses on developing algorithms and statistical models that allow computer systems to execute tasks without explicit programming. Machine learning is based on the fundamental principle of allowing computers to learn from data and improve their performance over time without being explicitly programmed for each task. Machine learning (ML) is playing a critical role in revolutionising the management decision-making process [49]. ML algorithms excel in extracting useful insights from massive datasets in today's business landscapes, where data abundance is a defining feature. These insights convert into educated strategic decisions in management, allowing executives to optimise operations, improve efficiency, and achieve organisational goals. Based on the literature review it is evident that ML algorithms have deep impact in making important decisions in business ventures [50]. ML aids risk management by detecting patterns and anomalies in historical data, allowing managers to make more educated decisions with a more nuanced understanding of potential risks and mitigations. ML's automation capabilities automate regular tasks, freeing up management teams to focus on high-level strategic planning and creative problem-solving [49]. As firms increasingly rely on data-driven strategies, the incorporation of machine learning (ML) in the management domain is critical in establishing a culture of informed decision-making and adaptable leadership [50].

Building upon the insights gained from the comprehensive literature survey, the subsequent section delves into the research methodology employed to investigate the intricate relationships outlined in the conceptual model. The literature review has established a foundation by exploring the significance of sustainable business practices, their impact on financial performance, and the mediating role of competitive advantage. Recognizing the evolving landscape of startups and the imperative of integrating innovative technologies, particularly machine learning, the study seeks to bridge theoretical knowledge with empirical

investigation.

3. Research Methodology

In order to Develop ML models good amount of data is required and the researchers have gathered data of 152 Start-ups registered and recognized in Uttarakhand by Department for Promotion of Industry and Internal Trade (DPIIT) India through structured questionnaires. The confidentiality of each respondent was guaranteed. To facilitate the response time frequent reminder mails were issued. A response rate of 73% was achieved with 111 responses. There were 80.27% male and 19.73% females between the ages of 18 to 60 years. Outline of participants is reflected are listed in table 1. Primary data is collected from DPIIT recognised Start-ups with the help of structured questionnaire. The questionnaire is adopted from the previous studies and few questions were added as per the need of the study.

3.1 Hypothesis

H0 (Null Hypothesis 1): There is absence of significant association between sustainable business practices and financial performance of a Start-up

H0 (Null Hypothesis 2) There is no significant association between sustainable business practises and a Start-up's competitive advantage.

H0 (Null Hypothesis 3) There is absence of significant association between competitive advantage and financial performance of a Start-up

H0 (Null Hypothesis 4) Competitive advantage has no significant role as a mediating factor between sustainable business practices and financial performance among Start-ups

Table 1. Demographics of Respondents

Gender	Male	89
	Female	22
Age	18 to 25 years	11
	26 to 30 years	47
	31 to 40 years	32
	41 to 50 years	14
	51 to 60 years	7
Education Level	High School	13
	Graduation	58
	Post Graduation	18
	Professional Degree	22

Year of Establishment	2013-2015	0
	2016-18	13
	2019-21	91
	2022-23	48

Table 2. Start-up Region wise details.

Region	Number of registered Start-ups
Almora	10
Chamoli	1
Champawat	3
Dehradun	65
Haldwani	5
Haridwar	13
Kashipur	2
Nanital	14
Mussorie	10
Pauri Garwhal	5
Pithoragarh	5
Rishikesh	5
Roorkee	4
Rudrapur	2
Ramnagar	1
Tehri Garwhal	1

3.2 Constructs Used

SBP: Sustainable business practices were assessed using academic and non-academic material on corporate environmental, financial and social activities. The Business Council for Sustainable Development recommends focusing on actions that reduce material intensity, energy intensity, and carbon intensity. hazardous dispersion, increased material recyclability, and increased sustainability increase material durability and usage of renewable resources.[40] Similarly, [41] emphasises the significance of corporations committed to minimising waste and pollution, as well as lowering and preserving energy and other natural resources, recycling solid garbage and minimising the impact of business on ecosystems [42]. CA: Competitive advantage is assessed using [43] 61 items questionnaire. This instrument gauges the three dimensions

of SBP and financial performance FP: Financial performance was assessed using [43] questionnaire.

Variables are defined as follows:

SBP: Sustainable business practices

Constructs Variables[3]

- SBP1 Our firm ensures green procurement such as purchase of efficient raw materials/products in terms of renewable energy/water consumption and non-polluting and non-toxic items.
- SBP2 My Start-up focuses on green processes that includes green product design, green manufacturing processes.
- SBP3 We design and develop products and/or services for the market that are environmentally friendly
- SBP4 We collaborate with channels of distribution in the market that are geared toward protecting the environment
- SBP5 We invest in research and development to develop new technologies that can help to reduce their environmental impact.
- SBP6 My Start-up ensure compliance with environmental legislations
- SBP7 We are successful at bringing in new customers and retaining them
- SBP8 Our Start-up's transparency about sustainability help us build brand value, trust with stakeholders and attract investors
- SBP9 In terms of sales, our Start-up's financial approach considers environmental costs
- SBP10 Our financial policy allots funds for environmental goals associated with the Start-up sales activity.
- SBP11 My startup invests in the development of environmentally friendly products and technologies for international markets.
- SBP12 My Start-up offers a diverse and inclusive workforce hiring people from all the backgrounds
- SBP13 Community activities like donation drive, volunteering and supporting local business are performed on regular basis
- SBP14 We educate our workers about environmental issues.
- SBP15 Our firm adhere to human resource laws and

regulations and ensure non discrimination

SBP16 Our products and/or services benefit the community economically and socially.

CA: Competitive Advantage

Constructs Variables[4]

- CA1 We develop a green brand image to help the company stand out in the market.
- CA2 Our ecologically friendly products outperform our competitors in terms of quality.
- CA3 Our ecologically friendly products provide greater value to customers than our competitors.
- CA4 Our environmentally friendly products are far more inventive than our competitors'.
- CA5 Our ecologically friendly products are more cost-effective than our competitors.
- CA6 The rate of sales has increased among current customers
- CA7 We focus on mass production and achieving economies of scale
- CA8 The Start-up's intellectual property (e.g., patents, proprietary technology) contributes to its competitive advantage.
- CA9 The Start-up's alliances contribute significantly to its growth and differentiation.
- CA10 The Start-up's unique value proposition is likely to withstand future challenges
- CA11 The Start-up's competitive advantage is likely to withstand future challenges
- CA12 Our company is competitive in terms of market share (regarding direct competitors).

FP: Financial Performance

Constructs Variables [5]

- FP1 Improved Revenue compared to previous years
- FP2 Net profit improved compared to previous years
- FP3 Sales intensity has increased over years
- FP4 Return on research-based investment has improved compared to previous years
- FP5 Return on capital invested has improved compared to previous years

3.3 Data Analysis

The work was supported based on the responses for which factor analysis and reliability test was done using SPSS and

validity and model fitness was assessed through AMOS software. The KMO is .922 depicting that the sample size is adequate. The communalities extracted results depict that all the questions are valid. Three factors are extracted from the set of parameters i.e. SBP, CA and FP. The results of rotated component matrix reveals that there is no cross loading. Content validity is checked with the expert opinions. All the questions are related to the specific set depicting convergent valid. No relationship has been obtained cross-sectionally depicting discriminatory validity of data. Cronbach's alpha is .963 depicts highly reliable data. The variables were identified on the basis of literature survey and additional factors obtained by mailing a questionnaire to field specialists. To perform EFA, the questionnaire and replies were entered into SPSS. The questionnaire contained 33 Likert scale items for the three identified independent variables. Table 3 demonstrates that KMO represents data sufficiency with a value of .922. The significance of Bartlett's Sphericity test is 0.000. The results show that factor analysis is appropriate since 'the value of KMO statistics is more than 0.5 and Bartlett's test of Sphericity is significant. The numbers for communality represent the squared multiple correlations of one variable with all other variables. The optimum value of communalities should be more than 0.5, and the findings show acceptable values for all elements. The total variation explained as a consequence of exploratory factor analysis is shown in Table 5. The variables are reduced to three components with Eigen values greater than one. The factors indicated the nature of variables such as "sustainable business practises," "financial performance," and "competitive advantage". The percentage variance described by these factors was 33.053%, 58.798%, and 70.827%, indicating that each component explains similar variance. The findings of the rotated component matrix suggested that the variables were divided into three uncorrelated factors. As seen in Table 6, the variable coefficients results indicate values above 0.70, indicating appropriate outcomes.

Table 3. KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.922
Bartlett's Test of Sphericity	Approx. Chi-Square	3424.536
	Df	110
	Sig.	.000

Table 4. Communalities

	Initial	Extraction
SBP1	1.000	.712
SBP2	1.000	.712

SBP3	1.000	.744
SBP4	1.000	.645
SBP5	1.000	.715
SBP6	1.000	.747
SBP7	1.000	.699
SBP8	1.000	.614
SBP9	1.000	.620
SBP10	1.000	.663
SBP11	1.000	.710
SBP12	1.000	.740
SBP13	1.000	.756
SBP14	1.000	.716
SBP15	1.000	.696
SBP16	1.000	.704
CA1	1.000	.708
CA2	1.000	.696
CA3	1.000	.647
CA4	1.000	.797
CA5	1.000	.751
CA6	1.000	.779
CA7	1.000	.687
CA8	1.000	.693
CA9	1.000	.747
CA10	1.000	.675
CA11	1.000	.710
CA12	1.000	.666
FP1	1.000	.754
FP2	1.000	.695
FP3	1.000	.673
FP4	1.000	.743
FP5	1.000	.759

Source: The authors (Principal extraction)

Table 5: Total Variance Explained

Component	Initial Eigen values	Extraction Sums of Squared Loadings	Rotation Sums of Squared Loadings

	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	15.468	46.874	46.874	15.468	46.874	46.874	10.907	33.053	33.053
2	5.210	15.787	62.661	5.210	15.787	62.661	8.496	25.745	58.798
3	2.695	8.166	70.827	2.695	8.166	70.827	3.970	12.030	70.827

Extraction Method: PCA

Table 6: Rotated Component Matrix

	Component		
	1	2	3
SBP1	.761		
SBP2	.831		
SBP3	.851		
SBP4	.782		
SBP5	.824		
SBP6	.817		
SBP7	.781		
SBP8	.735		
SBP9	.752		
SBP10	.740		
SBP11	.840		
SBP12	.837		
SBP13	.857		
SBP14	.755		
SBP15	.828		
SBP16	.755		
CA1		.791	
CA2		.819	
CA3		.784	
CA4		.870	

CA5		.861	
CA6		.873	
CA7		.798	
CA8		.732	
CA9		.854	
CA10		.695	
CA11		.750	
CA12		.764	
FP1			.831
FP2			.800
FP3			.725
FP4			.837
FP5			.848
Principal Factor Analysis			

Reliability of Research instrument: *Reliability Statistics*

Cronbach's Alpha	Number of Items
.963	33

4. Data Interpretation

The structural equation model (SEM) illustrates the relationship between sustainable business practises (SBP), competitive advantage (CA), and financial performance (FP). The model shows that SBP and FP have a positive connection, both directly and indirectly through CA. This implies that firms that adhere to sustainable business practises are more likely to gain a competitive edge and deliver higher financial returns. The results also demonstrate the relative strength of the correlations between the various components. The SBP to CA path outperforms the SBP to FP path. This highlights the importance of CA as a mediator in the interaction between SBP and FP. The results of SEM show a positive relationship between sustainable business practises (SBP), competitive advantage (CA), and financial performance (FP). As a result, SBP-using firms are more likely to have CA and FP. The SEM graphic shows that CA mediates the connection between SBP and FP. This means that SBP leads to FP through CA. In other words, SBP-using organisations are more likely to have CA, which leads to FP. A more detailed explanation of the SEM follows: The strength of the relationship between two variables is reflected by the standardised path coefficients, which are represented by the numbers on the arrows. A standardised route coefficient of 1.0 suggests a perfect connection, whereas one of 0.0 indicates no

association. The SEM diagrams depicted in Figure 2 standardised route coefficients are all positive and significant, indicating that SBP, CA, and FP have strong and positive associations. CA and FP have the strongest association (standardised path coefficient = 0.83), followed by SBP and CA (standardised path coefficient = 0.80). SBP has a 0.83 direct effect on FP and a 0.27 indirect effect via CA. This means that a one-unit increase in SBP results in a 0.83-unit increase in FP and a 0.27-unit increase in CA, which results in an additional 0.27-unit increase in FP. This implies that organisations that implement sustainable business practises are more likely to gain a competitive edge, which leads to higher financial success. The model is considered fit based on the conventional residual covariance as depicted in Table 7. It is possible to conclude that there is a considerable association between sustainable business practises and profitability and Start-up's competitive advantage. There is a strong link between sustainable business practises and a Start-up's financial performance. Competitive advantage and financial success of a Start-up have a considerable relationship, and competitive advantage plays an important role as a mediating element between sustainable business practises and financial performance among Start-ups. Firms that are serious about improving their long-term performance should invest in sustainable business practices. SBP can lead to FP via CA but Start-ups should not expect quick improvements in FP after using SBP. Instead, they should concentrate on CA development through SBP. Reliability is the consistency of measurement items in their manner of measuring a construct. The reliability test using Cronbach's Alpha for all the constructs generated results of 0.963 greater than the acceptable limit of 0.7, providing evidence of reliability. The results provide substantial support for the notion that sustainable business practices result in higher financial performance.

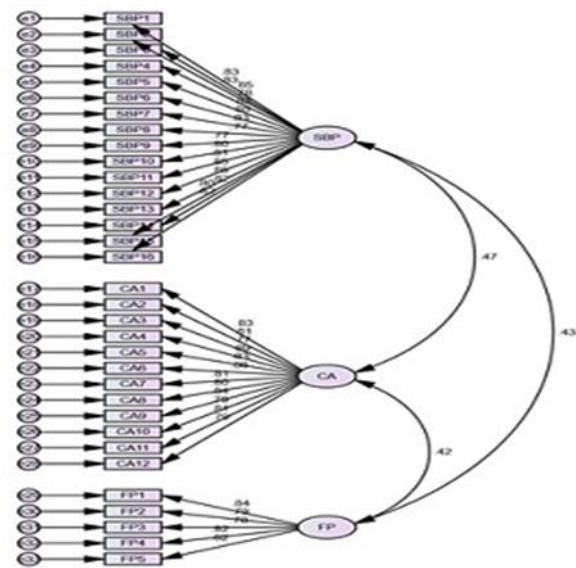


Fig. 2. Structural Equation modeling using AMOS

Table 7: Model validity measures

	C R	AVE	MS V	Max R(H)	SBP	CA	FP
SB P	0.97 0	0.669	0.22 3	0.971	0.818		
C A	0.96 1	0.672	0.22 3	0.962	0.472 ***	0.820	
FP	0.90 4	0.654	0.18 8	0.906	0.433 ***	0.422 ***	0.80 9

5. Predictive model for Financial Performance

In order to generate the predictive model an algorithm was developed to investigate the relationship between sustainable business practices and financial performance via competitive advantage.

Algorithm: Predicting Financial Performance from Sustainable Business Practices and Competitive Advantage

Step 1: Identify Variables

1. Sustainable Business Practices (SBP):

Identify and list the 16 variables (SBP1, SBP2, ..., SBP16) representing sustainable business practices.

2. Competitive Advantage (CA):

Identify and list the 12 variables (CA1, CA2, ..., CA12) representing competitive advantage.

3. Financial Performance (FP):

Identify and list the 5 variables (FP1, FP2, FP3, FP4, FP15) representing financial performance.

Step 2: Compute Correlation Values

1. Calculate Correlations:

Calculate the correlation values between SBP, CA, and FP variables.

Step 3: Generate Structural Equation Model

1. Specify Latent Variables:

Define latent variables SBP, CA, and FP.

2. Measurement Model:

Formulate measurement equations using approximate loadings based on correlation values for each observed variable.

3. Structural Model:

Establish structural equations between latent variables, considering the correlations between them.

4. Error Terms:

Include error terms for both measurement and structural equations.

Step 4: Statistical Analysis (using AMOS Software)

1. Estimate Model Parameters: SEM using AMOS to estimate the model parameters, including latent variable loadings and structural paths.

2. Assess Model Fit:

Evaluation of overall fit of the model using fit indices and statistical tests.

Step 5: Generate Regression Model

1. Regression Model for Financial Performance (FP):

Using the estimated parameters from the SEM, formulate a regression model to predict FP from SBP and CA.

$$FP = \beta_0 + \beta_{SBP} \times SBP + \beta_{CA} \times CA + \epsilon$$

2. Calculate Coefficients:

Use the estimated coefficients from the SEM analysis for β_{SBP} and β_{CA}

Step 6: Interpret Results

1. Analyse Coefficients:

Interpret the coefficients in the context of your study. Consider their magnitude, sign, and statistical significance.

2. Evaluate Model Performance:

Assess the performance of the regression model in predicting Financial Performance based on Sustainable Business Practices and Competitive Advantage.

Step 7: Refinement and Iteration

This algorithm is used to find to correlation between sustainable business practices and financial performance. Further, it also investigated the correlation between competitive advantage and financial performance.

Latent Variables:

SBP (Sustainable Business Practices)

CA (Competitive Advantage)

FP (Financial Performance)

Observed Variables:

SBP1, SBP2 ... SBP16 (16 Sustainable Business Practices variables)

CA1, CA2 ... CA12 (12 Competitive Advantage variables)

FP1, FP2, FP3, FP4, FP15 (5 Financial Performance

variables)

Structural Equations:

$$SBP \rightarrow CA = 0.47 \times SBP + \epsilon_1 \text{ ----- (a)}$$

- This equation suggests a structural relationship between Sustainable Business Practices (SBP) and Competitive Advantage (CA).
- The coefficient 0.47 signifies that, on average, for a one-unit increase in SBP, a 0.47 unit increase in CA.
- The term ϵ_1 represents the error term, capturing unobserved factors influencing the relationship.

$$CA \rightarrow FP: FP = 0.42 \times CA + \epsilon_2 \text{ ----- (b)}$$

- This equation represents the structural connection between Competitive Advantage (CA) and Financial Performance (FP).
- The coefficient 0.42 indicates that, on average, for a one-unit increase in CA, a 0.42 unit increase in FP.
- The term ϵ_2 is the error term, accounting for unobserved influences on the relationship.

$$SBP \rightarrow FP: FP = 0.43 \times SBP + \epsilon_3 \text{ ----- (c)}$$

- This equation reflects the structural relationship between Sustainable Business Practices (SBP) and Financial Performance (FP).
- The coefficient 0.43 implies that, on average, for a one-unit increase in SBP, we expect a 0.43 unit increase in FP.
- The term ϵ_3 serves as the error term, encompassing unobserved factors impacting the relationship.

The structural equations highlight the directional relationships between Sustainable Business Practices, Competitive Advantage, and Financial Performance. The positive coefficients (0.47, 0.42, and 0.43) suggest that an increase in Sustainable Business Practices and Competitive Advantage is associated with a positive impact on Competitive Advantage and Financial Performance, respectively.

Equation (a) represents a regression equation indicating a positive correlation between sustainable business practices (SBP) and competitive advantage (CA) and 0.47 indicates the strength and direction of the relationship. Equation (b) as representing a positive relationship between competitive advantage (CA) and financial performance (FP) and positive coefficient 0.42, suggest that, on average, an increase in CA is associated with an increase in FP. Equation (c) highlights that it represents the relationship between sustainable business practices (SBP) and financial performance (FP). Further, the positive coefficient (0.43), suggests that, on

average, an increase in SBP is associated with an increase in FP.

Regression model

The study formulated regression model and derives the following equations to predict the financial performance of Start-ups based on sustainable business practices and competitive advantage.

$$FP = 2.493 + 0.6504 \text{ SBP} \text{ ----- (d)}$$

$$FP = 2.1959 + 0.7525 \text{ CA} \text{ ----- (f)}$$

The above linear regression equations represent a relationship between financial performance and sustainable business practices and competitive advantage respectively. The coefficients indicate the expected change in the dependent variable (FP) for a one-unit increase in the corresponding independent variable (SBP or CA) while holding other variables constant. In equation (d), a one-unit increase in SBP is associated with an expected increase of 0.6504 units in FP. In equation (f), a one-unit increase in CA is associated with an expected increase of 0.7525 units in FP. This is pilot study that investigated the relationship on the basis of which regression model was obtained.

Further, this study will be extended in future and data from all the remaining Start-ups with an estimation of 400 respondents will be collected for which questionnaire has already been distributed. This study is poised for future extension, where data will be gathered from a minimum of 400 start-ups. A survey questionnaire has already been distributed to collect responses from prospective participants. Building on this, the regression model will undergo further refinement and generalization as data is collected from at least 400 start-ups. A subset of the dataset will be reserved for sampling to assess the model's performance and validity. Anticipated to conclude within the next 6 months, this phase of the work aims to enhance the robustness of the regression model. The pilot study aimed to validate the relationships posited in the hypotheses by examining the presence of a positive correlation between variables. The analysis of the available data strongly indicates that Financial Performance (FP) can indeed be predicted based on sustainable practices. Additionally, the study explores whether such practices contribute to providing a competitive advantage to the firm. The future work will focus on generating a comprehensive model that will be give accurate prediction of financial model as stated below in equation (g).

$$FP = 2.73 + 0.59 \times SBP + 0.725 \times CA \text{ ----- (g)}$$

The accuracy of the regression model was evaluated using key metrics, including Mean Squared Error (MSE) which represents the average squared difference between the observed and predicted values. Root Mean Squared Error (RMSE), is the square root of the MSE and provides a

measure of the average magnitude of errors in the same units as the dependent variable. The MSE and RMSE values are 0.262579826 and 0.512425434, respectively.

Mean Squared Error (MSE): 0.262579826; A lower MSE indicates better model accuracy. In this case, the MSE of 0.262579826 suggests that, on average, the squared difference between the observed and predicted values is relatively small.

Root Mean Squared Error (RMSE): 0.512425434; A lower RMSE indicates better model accuracy. In this case, the RMSE of 0.512425434 suggests that, on average, the difference between observed and predicted values is around 0.51 units.

Subsequently, this research will refine the model through the analysis of extended responses gathered from approximately 400 start-up owners.

6. Implications

This research has important implications for start-ups looking to incorporate sustainable business practices (SBP) into their operations. The research emphasises the importance of strategic decisions guided by sustainability considerations in impacting the financial performance of start-ups. The predictive regression model created in this study emerges as a strong tool for start-ups, providing a concrete and forward-looking method to predicting financial results.

Entrepreneurs are recommended to use the regression-based prediction model's findings to proactively incorporate sustainable practices into their business strategy. The model provides a roadmap for Start-ups to improve their operational efficiency and market success by negotiating the complicated interplay between SBP, competitive advantage, and financial performance. Start-ups can avoid risks related with environmental legislation, reputational damage, and supply chain disruptions by implementing the research's recommended sustainable practices. The predictive model is a risk management tool that allows businesses to anticipate and address possible difficulties, ensuring their long-term viability.

The consequences go beyond risk avoidance, as start-ups that demonstrate strong SBP and employ the prediction model stand to gain the attention of socially responsible investors, impact investors, and ESG-focused funds. This opens the door to more funding sources, strategic alliances, and development opportunities, promoting the long-term success of start-ups.

As the predictive model improves transparency and accountability, effective communication of sustainable practices becomes a strategic necessity. Start-ups can leverage this to attract ecologically and socially

conscientious clients, as well as to create trust and foster long-term customer loyalty.

Furthermore, the collaborative character of sustainable business practices is emphasised, emphasising the necessity of collaborating with external stakeholders such as suppliers, non-governmental organisations (NGOs), government agencies, and local communities. Start-ups that are actively involved in sustainability projects can establish better alliances and collaborations, resulting in shared resources, information exchange, and new market prospects.

In essence, the predictive regression model presented in this study not only enables Start-ups to navigate the challenges and opportunities associated with SBP, but it also positions them as pioneers in sustainable innovation, laying the groundwork for long-term success in a dynamic business landscape.

7. Conclusion

In conclusion, the Mean Squared Error (MSE) and Root Mean Squared Error (RMSE) values of 0.262579826 and 0.512425434, respectively, demonstrate the regression model's resilience in properly predicting financial performance based on sustainable business practices and competitive advantage. These metrics highlight the model's high accuracy, as seen by modest average squared differences and small average magnitude of errors between predicted and observed values.

This study puts light on the critical necessity of sustainability in the ever-changing global startup environment. The discovered positive association between sustainable company practices, competitive advantage, and financial success emphasises the strategic importance of implementing sustainability into business strategies. This study's predictive regression model emerges as a formidable ally for start-ups, delivering actionable information to forecast and improve financial outcomes.

The findings illustrate the effectiveness of machine learning in this context, with the regression model demonstrating predictive analytics' potential. As illustrated in this study, the use of machine learning algorithms provides a dependable technique for start-ups to negotiate the intricacies of sustainability and financial success.

The report recommends for a continuing commitment to the adoption and enhancement of sustainable business practices, emphasizing their importance in determining the future of start-ups. Decision-makers are encouraged to embrace long-term strategies that prioritize sustainability, with active government monitoring and mentoring playing a critical role in supporting the startup ecosystem.

8. Future Scope

Looking ahead, the research will expand beyond the pilot

database to include a comprehensive dataset encompassing all sustainable start-ups in the region. The goal of this expansion is to provide a more nuanced view of the prediction model's performance and importance in directing sustainable actions. The recommendation to allocate resources to sustainable business practices over competitive advantage remains a pivotal takeaway, positioning the regression model as a valuable tool for start-ups striving for enduring financial success in an ever-evolving landscape.

Author contributions

Riya Sharma: Conceptualization, Methodology, Writing-Original draft preparation, Data curation, Investigation.

Ambika Mani: Reviewing and Editing

Sharon Christa: Domain contribution, Field study, Software, Validation, Visualization, Investigation

Suma V: Field study, Reviewing and Editing

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Conflicts of interest

The authors declare no conflicts of interest.

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