

Article

Determinants of Entrepreneurship in Ambato, Ecuador: Statistical Predictive and Component Modeling

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Abstract

This study investigated the key determinants of entrepreneurship in Ambato, Ecuador, through the application of predictive statistical models. The primary objective was to identify critical variables that influence the success and sustainability of entrepreneurial ventures in the region. A quantitative research design was employed, utilizing multivariate statistical techniques, including decision trees, random forest, and Principal Component Analysis (PCA). Data were collected through structured surveys administered to local entrepreneurs, addressing variables including demographics, education, initial investment, and business operations. The analysis revealed that factors such as geographic location, the entrepreneur's educational attainment, business tenure, and operational characteristics have a significant influence on entrepreneurial viability. On the basis of these findings, the study proposes a predictive model to assist both policymakers and entrepreneurs in evaluating and enhancing business development strategies. The insights gained offer practical implications: entrepreneurs can refine their strategies for greater effectiveness, while local authorities can craft supportive policies, such as training programs and improved access to financing. The study highlights the importance of entrepreneurship education and targeted support for underdeveloped areas, thereby contributing to broader economic inclusion and enhanced employment opportunities in the region.

Keywords: entrepreneurship; strategy; innovation; financing; policies



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1. Introduction

Entrepreneurship has become essential for economic and social development in the 21st century [1]. As globalization and digitalization reshape markets, the ability to innovate and adapt quickly has become a competitive advantage for people [2]. From micro-enterprises to start-ups, they promote economic growth and job creation, serving as vehicles for technological innovation and solutions to persistent societal challenges. However, it is noted that the success of these ventures depends on a confluence of individual, sociocultural, and economic factors that vary widely across different contexts [3].

One of the most significant factors influencing the viability and success of businesses is their geographic location. Choosing where to set up a business can have profound implications for access to key resources, such as capital, talent, and markets [4]. Metropolitan areas, for example, typically offer higher resource density and networking opportunities, which can accelerate the growth of a new business [5]. Moreover, rural or less developed areas, while often lacking these concentrated resources, may offer unique niche markets and less competition [6]. The dynamics of geographic location also influence a company's ability to internationalize and expand beyond its local borders, making geography not only a starting factor but an ongoing strategic element in a company's life [7].

Likewise, an entrepreneur's level of education plays a critical role in their ability to manage and grow a business. A strong education provides practical skills and market knowledge while also cultivating critical thinking and problem-solving skills, which are crucial for innovation and adaptability [8,9]. Entrepreneurs with access to advanced education and specific training in business management can better navigate the complex challenges of the modern business environment, from understanding regulations to effectively managing technology and human resources [10].

Age also plays an important role in the ability to take risks, the energy to embark on new ventures, and the accumulation of experience and professional networks [11]. Young entrepreneurs may be more likely to embrace emerging technologies and pursue radically new ideas, while more experienced entrepreneurs can apply lessons learned and established connections to mitigate risks and ensure business sustainability [12]. This interplay between age and experience can define a company's strategy and structure, influencing everything from corporate culture to the adoption of innovations [13].

Gender is another critical factor that can significantly influence the entrepreneurial journey [14]. Despite women's increasing participation in entrepreneurship, structural barriers can still affect their access to resources and opportunities [15]. The challenges range from prejudices and stereotypes to differences in access to finance and support networks. Understanding these gender dynamics is crucial for developing policies and programs that promote greater inclusion and equity within the entrepreneurial ecosystem [16].

In this context, personal motivations for starting a business are the pursuit of financial independence, the desire to have a social impact, or the passion for an innovative idea [17,18]. These motivations are critical to the company's persistence and success. These motivations not only drive the initial creation of the business but also sustain the entrepreneur through the challenges and uncertainties of the entrepreneurial journey [19].

This study examined how various dynamic factors, including location, education, age, gender, and aspects of entrepreneurship, among others, interact to shape the contemporary landscape of entrepreneurship. Through meticulous quantitative analysis, we aimed to unravel the complexities of these variables and provide alternatives to formulate more effective strategies that support the development of resilient and adaptable ventures in diverse contexts. For this study, we define "sustainable ventures" as companies that have operated continuously for more than three years and have demonstrated consistent profitability, as per Ecuador's SRI tax records. In contrast, "unsustainable ventures" are those that ceased operations within three years or showed recurring losses. These thresholds, adapted from the Global Entrepreneurship Monitor framework for emerging economies, were validated with UTA's Economic Observatory and reflect the characteristics of the local entrepreneurial ecosystem.

In recent decades, entrepreneurship has emerged as a strategic component for economic development and reducing unemployment in Latin America, particularly in countries such as Ecuador, where the business fabric is comprised mainly of micro, small, and medium-sized enterprises (MSMEs). In this context, the Ambato canton, located in the

province of Tungurahua, has established itself as a productive and commercial pole of remarkable dynamism, characterized by the strong presence of enterprises in sectors such as footwear, clothing, agribusiness, and retail trade. However, many of these enterprises face difficulties in sustaining themselves over time due to structural conditions such as limited access to formal financing, informality, poor business planning, and a weak culture of innovation. This reality makes it essential to analyze the factors that determine the sustainability and viability of businesses in the local environment.

This research aimed to identify and analyze the variables that significantly influence the success of entrepreneurship in Ambato, considering key dimensions such as the educational level of the entrepreneur, the time spent on the activity, gender, age, and geographical location. These variables not only have theoretical support in the international literature but also acquire a particular nuance in the Ecuadorian context, where structural inequalities, traditional gender roles, the territorial distribution of resources, and gaps in human capital condition entrepreneurial performance. Using predictive models based on multivariate statistical techniques enables us to capture the complexity of these interactions and provides empirical evidence that contributes to the design of public policies and strategies aimed at strengthening the local entrepreneurial ecosystem.

This article contains (i) the introduction, (ii) the theoretical framework, (iii) the materials and methods, (iv) the results, (v) a discussion, (vi) the conclusions, and finally (vii) the bibliographic references.

2. Theoretical Framework

2.1. *Theory of Entrepreneurial Behavior*

The theory of entrepreneurial behavior provides a comprehensive framework for understanding the factors that drive the creation and sustainability of ventures. This theory focuses on identifying the main determinants of entrepreneurship, grouping them into motivational, personal, contextual, and intentional dimensions [20]. In the case of productive and commercial ventures in Ambato, this theory is especially relevant, as it enables an analysis of how the individual characteristics of the entrepreneur, combined with the local environment, influence the viability and sustainability of their businesses [21].

One of the main contributions of this theory is the identification of motivational factors, including the need for achievement, self-efficacy, and risk tolerance [22]. These personal motivations largely explain why specific individuals decide to undertake and persevere despite challenges, which is crucial in changing economic contexts [23]. Likewise, personality traits such as proactivity, the ability to innovate, and the willingness to take risks are considered key determinants of entrepreneurial behavior and, therefore, of the sustainability of entrepreneurship [24].

In addition, entrepreneurial intention, as understood from the theory of planned behavior, highlights the importance of individual attitudes, perceptions of control, and social norms in the decision to undertake a new venture [25]. This study is essential for understanding how entrepreneurs set their expectations and actions regarding their businesses. The theory also highlights the importance of contextual factors, including institutional support, market opportunities, and access to resources, all of which are particularly relevant in a city with a developing entrepreneurial ecosystem [26].

Finally, the theory offers a more dynamic perspective on entrepreneurial behavior, distinguishing between those who act according to the available resources (effectual) and those who do so according to pre-established goals (causal) [27]. This distinction enables us to understand the various entrepreneurial strategies observed in the region and their relationship with business sustainability. The theory of entrepreneurial behavior enables us to substantiate the hypotheses raised in this study by providing a comprehensive

understanding of the multiple factors that influence the success and sustainability of ventures, ranging from individual motivations to environmental conditions [28].

2.2. Theory of Gender Discrimination in Entrepreneurship

Gender discrimination theory in entrepreneurship focuses on understanding how social stereotypes, unequal structures, and systemic barriers limit women's access to and development in the business environment. Women entrepreneurs face particular obstacles, including employment discrimination, exclusion from traditionally male-dominated spaces, and a lack of support networks [29]. This situation is exacerbated by the widespread perception that women face more significant challenges than men in achieving sustainability in their businesses [30]. These factors condition not only the initiation of entrepreneurial activity but also its persistence and growth, which is especially relevant in an environment where many women view entrepreneurship as a means to achieve economic independence and family well-being [31].

In addition, it has been demonstrated that inequality of opportunities, particularly in the educational and technological fields, restricts female entrepreneurial intention [32]. The digital gender gap constitutes a significant barrier that restricts women's access to information technologies, digital marketing tools, and business skills training, directly affecting the competitiveness of their businesses [33–35]. However, the literature also suggests that the development of gender-responsive entrepreneurship networks, as well as the implementation of inclusive management policies, can be effective strategies to counteract these inequalities [36,37].

2.3. Human Capital Theory and Experiential Learning

Human capital theory holds that education, work experience, training, and the development of specific skills directly influence the performance and success of entrepreneurs. This approach is especially relevant in contexts where the characteristics of the entrepreneur, such as educational level and previous experience, are emerging as determining factors in the sustainability of productive and commercial initiatives [38,39]. In this sense, human capital not only enhances business management capacity but also increases the possibilities of innovation, market adaptation, and strategic decision-making. In addition, this theory is complemented by social capital approaches and the social cognitive theory of entrepreneurship, which expand the understanding of entrepreneurial behavior from a comprehensive perspective [22].

On the other hand, experiential learning, based on Kolb's theory, underscores the importance of learning from practice and reflection on action [40]. This perspective emphasizes that entrepreneurs develop key competencies such as problem-solving, identifying opportunities, and adapting to the environment through direct experience in managing their businesses [41,42]. For entrepreneurs, this form of learning is particularly significant, as many acquire knowledge and business skills through empirical experiences, facing real market challenges [43,44]. Therefore, integrating experiential learning into the processes of training and strengthening the local entrepreneurial ecosystem can substantially improve the quality of entrepreneurship and its long-term viability [45,46].

Elements such as social innovation, territorial competitiveness, and sustainable development are articulated through approaches like cluster theory and institutionalist frameworks, enabling the territory to generate favorable conditions for entrepreneurship, job creation, and equity. Thus, this theory provides a solid foundation for understanding how public policies, entrepreneurial training, and access to local resources can have a direct impact on the sustainability of entrepreneurship in the region [39,46].

2.4. Entrepreneurship Life Cycle Theory

The theory of the life cycle of entrepreneurship posits that ventures undergo distinct stages of development, from inception to consolidation or potential decline, and that success in each phase depends on several key factors. First, the managerial and leadership skills of the entrepreneur directly influence the sustainability and growth of the business, as proper management enables them to face operational and strategic challenges [47]. Likewise, entrepreneurial orientation and the capacity for innovation are essential for adapting to market changes and generating competitive advantages [48].

The economic and institutional environment also plays a determining role, as factors such as economic cycles or access to supportive policies can accelerate or slow down business development [49]. In addition, the ability to adapt to each stage of the organizational cycle—such as launch, growth, maturity, or renewal—enables entrepreneurs to make informed decisions at critical moments [50]. Finally, financial education and business training are essential for providing entrepreneurs with technical tools that improve their decision-making [51].

2.5. Institutional and Entrepreneurship

Institutional theory provides a valuable analytical framework for understanding entrepreneurship, as the performance and sustainability of businesses depend not only on individual or economic factors but also on the institutional environment in which they operate. In this sense, elements such as the quality of the regulatory framework, the presence of public policies to promote it, access to financing, and institutional support significantly influence business decisions [52]. Likewise, the social legitimacy of the enterprise and its alignment with the community's cultural and normative expectations also determine its acceptance and growth [53].

In situations where various sociocultural and economic dynamics coexist, institutionalism assumes special relevance, as it can act as either a facilitator or a barrier to business development [49,54]. Additionally, the ability of entrepreneurial initiatives to adapt to environmental changes and the various phases of their organizational life cycle is crucial for their consolidation [55]. This theory, therefore, enables us to analyze how structural, normative, and sociocultural factors intersect to influence the viability of local enterprises [30].

2.6. Data Mining and Decision-Making

Data mining and predictive statistical techniques are fundamental tools for optimizing decision-making in the entrepreneurial field [56]. These methodologies enable the processing of large volumes of information to identify hidden patterns, trends, and relationships that are not immediately evident, which is especially useful in dynamic and competitive contexts, such as those of local enterprises [57].

Through the use of predictive models, decision trees, neural networks, and classification algorithms such as random forests, entrepreneurs can anticipate market behaviors, assess risks, predict sales, and make more informed strategic decisions. In addition, these tools facilitate the identification of key factors that affect business success or failure, which contributes to the design of more effective and personalized growth strategies [57]. In this sense, the application of data mining in entrepreneurship studies not only enhances the quality of analysis but also improves the planning and sustainability of entrepreneurial initiatives [58].

2.7. Hypothesis

This research sought to respond to the following hypotheses, based on the variables and theories of study:

H1: *The educational level of the entrepreneur significantly influences the sustainability of entrepreneurship in the Ambato canton.*

H2: *The time spent on the activity is positively related to the viability and success of commercial and productive ventures.*

H3: *Individual characteristics (e.g., age, gender, educational level) and business-related aspects (e.g., initial investment, training, business model) significantly affect the level of sustainability and growth of entrepreneurship in Ambato.*

H4: *Predictive models based on multivariate statistical techniques (such as decision trees, random forests, and PCA) allow the identification of the factors that determine business success in the region with high precision.*

3. Materials and Methods

3.1. Approach

The research employed a quantitative approach, focusing on the collection and analysis of numerical data. The primary objective was to analyze the productive and commercial enterprises of the Ambato canton using statistical techniques that enable the identification of significant patterns and relationships. The information was processed and analyzed with statistical tools to obtain objective and replicable results [59].

3.2. Participants

The study population includes all productive and commercial enterprises registered in the canton of Ambato, covering both urban and rural areas. These companies represent a variety of sectors and economic sizes, from micro to small and medium-sized enterprises operating in the canton. The information on these ventures was obtained from the public database of the Internal Revenue Service (IRS), which was available and updated as of November 2023 and was filtered using the ISIC code, a classification system that categorizes companies' economic activities according to their productive or commercial nature.

To ensure adequate coverage and fairly represent the diversity of Ambato's firms, a cluster sampling method was used, dividing the total population into homogeneous natural groupings. These conglomerates correspond to the urban and rural parishes of the canton. This approach ensures that contextual differences between parishes, such as access to markets, human capital, and resources, are reflected in the analysis.

The final sample comprised 382 enterprises, which represents the total population of entrepreneurs in Ambato. The selected ventures encompass a diverse range of productive sectors, including manufacturing, commerce, services, and agriculture, among others. This study allows us to gain a comprehensive understanding of the entrepreneurial ecosystem of the canton. This selection provided a solid basis for the analysis, which allowed us to explore the economic dynamics and factors that influence the sustainability of these ventures.

3.3. Instrument

The instrument used in this research is a structured questionnaire that collects key information on productive and commercial enterprises in the Ambato canton. This questionnaire was designed to consider relevant socioeconomic and business variables, such as location (parish), the educational level of the entrepreneur, gender, age, initial investment, and time of business activity (Appendix A). In addition, the instrument collects information on various aspects of entrepreneurship, including personal motivations, the main challenges faced, sources of funding, and government support received. It also examines the

sustainability of the activity, the profitability of the venture, and the factors that could lead to its closure. To guarantee the validity and reliability of the data, the instrument was reviewed and validated by three experts in entrepreneurship from the Economic Observatory of the Technical University of Ambato, who performed content validity of the questionnaire using Lawshe's Content Validity Index (CVI), and the Kuder–Richardson coefficient ($KR-20$) was used) to know the reliability of questions with dichotomous answers with a coefficient of 0.83, demonstrating their internal consistency.

The application of a structured questionnaire is relevant in this research because it allowed us to collect a wide range of standardized socioeconomic and business data systematically, efficiently, and directly from entrepreneurs in the canton of Ambato. Unlike other instruments, such as interviews or focus groups, the questionnaire facilitates the quantitative collection of comparable information, ensuring representativeness and facilitating subsequent statistical analysis.

3.4. Structuring the Model

3.4.1. Decision Trees

Building a decision tree involves splitting the dataset on the basis of different conditions. Standard algorithms for constructing decision trees include ID3, C4.5, and CART. The decision tree is ideal for this study because it enables the identification and clear prioritization of factors that influence the sustainability of enterprises in Ambato. Its structure facilitates the interpretation of results and the generation of helpful decision rules to guide business support actions and policies in the local context.

Each algorithm uses a different criterion to select the variable and cut-off point that best divides the dataset. For the observed scenario, we used CART, and the criteria used are as follows:

- Gini Index Reduction: Similar to information gain, it measures the reduction of impurities.

$$G_{original} - \left(\frac{|D_{left}|}{|D|} G_{left} + \frac{|D_{right}|}{|D|} G_{right} \right) \quad (1)$$

- $G_{original}$ is the Gini index of the node before division.
- $|D|$ is the total number of samples in the node before division.
- $|D_{left}|$ and $|D_{right}|$ are the number of samples in the left and right nodes after division.
- G_{left} and G_{right} are the Gini indices of the left and right nodes after splitting.

3.4.2. Principal Component Analysis (PCA)—Theoretical Background

PCA is especially valuable in contexts with many correlated variables, as it simplifies the complexity of high-dimensional spaces without losing critical information. This approach is ideal in this study because it simplifies the analysis of multiple variables, reveals key patterns in Ambato's ventures, and enhances the efficiency of predictive models by eliminating redundancies and focusing the analysis on the most significant factors. This study makes it ideal for:

- Preprocessing in machine learning and statistical modeling;
- Exploratory analysis to identify hidden patterns or clusters in the data;
- Improving computational efficiency by reducing the number of variables to be considered.

Among the key formulas to run the model, we have the following.

- Covariance matrix (C)

$$\frac{1}{n-1} * (X - \bar{X})^T * (X - \bar{X}) \quad (2)$$

where X is the data matrix (with each column as a variable and each row as an observation) and y is the vector of means for each column $\bar{X}$.

- Eigenvectors (V) and eigenvalues (D)

$$CV = DV \quad (3)$$

where C is the matrix of covariances, V is the eigenvectors, and D is the diagonal matrix of eigenvalues.

3.4.3. Random Forest

Random forest can also calculate the importance of each feature by looking at how much each feature improves prediction on average across all trees in the forest. The use of random forest is ideal in this study because it allows accurate and robust predictions to be made, even with complex data or noise, as is often the case in local enterprises. It was chosen because it facilitates the identification of the most influential variables, which is key to understanding the factors that determine business sustainability in Ambato.

This study is measured by examining the average increase in purity (i.e., decrease in the Gini index) that results from divisions in that characteristic.

Although it is not a specific formula of random forest, each tree uses measures such as information gain to choose the best divisions

$$H(S) - \sum_{i=1}^k \frac{|S_i|}{S} H(S_i) \quad (4)$$

where $H(S)$ is the entropy of the set before division and S_i is the subsets resulting from division.

Each tree votes for a class. The model prediction is the class with the most votes.

$$Prediction = moda(votes)$$

The result is the average of the predictions of all the trees.

$$\frac{1}{N} \sum_{i=1}^N y_i \quad (5)$$

where y_i is the prediction of each tree, and N is the number of trees.

3.5. Characterization of the Sample

This segment describes the main sociodemographic, economic, and behavioral characteristics of the sample used for the study. This case enables us to understand the context of the data and the representativeness of the sample concerning the target population. In this case, the presence of dichotomous data is indicated, and the correlation coefficient proposed by Cramer, known as Phi, is identified. This case enables the evaluation of associations among variables, the detection of relevant patterns, and the construction of predictive models.

3.5.1. Descriptive Statistics

The sample consisted of 382 enterprises located in the canton of Ambato, with 66% in urban areas and 34% in rural areas, reflecting a high concentration of entrepreneurial activity in areas with a higher population density and access to services. In terms of gender,

52.6% of the representatives are women, indicating a slightly higher female participation, which aligns with the growing inclusion of women in the local entrepreneurial ecosystem. The analysis of operational time reveals that 38% of the ventures have had more than 10 years of activity, while 30.4% have had between 1 and 3 years, indicating a balanced combination of consolidated experience and new ventures (Figure 1). Regarding age, the group aged 31 to 40 years old predominates (30.4%), followed by those between 20 and 30 years old (28%), indicating a strong presence of entrepreneurs at key productive ages (Figure 2). In terms of educational level, it is observed that 36.9% have a university education, and 36.1% have completed secondary school, which reinforces the relevance of human capital as a determinant of entrepreneurship (Figure 3).

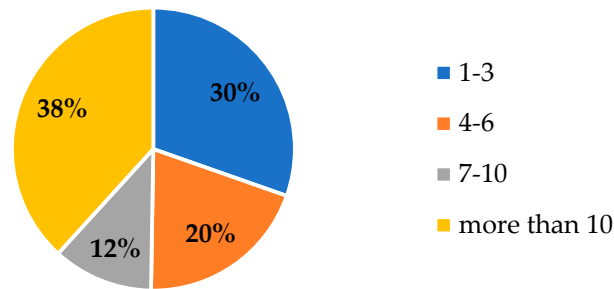


Figure 1. Activity time of the enterprises.

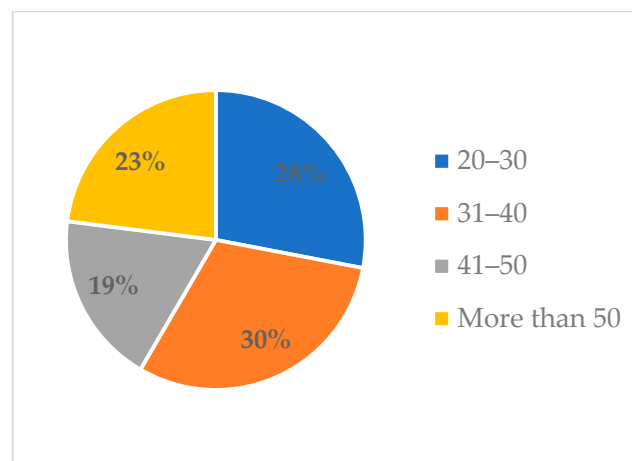


Figure 2. Age of the representatives of the enterprises.

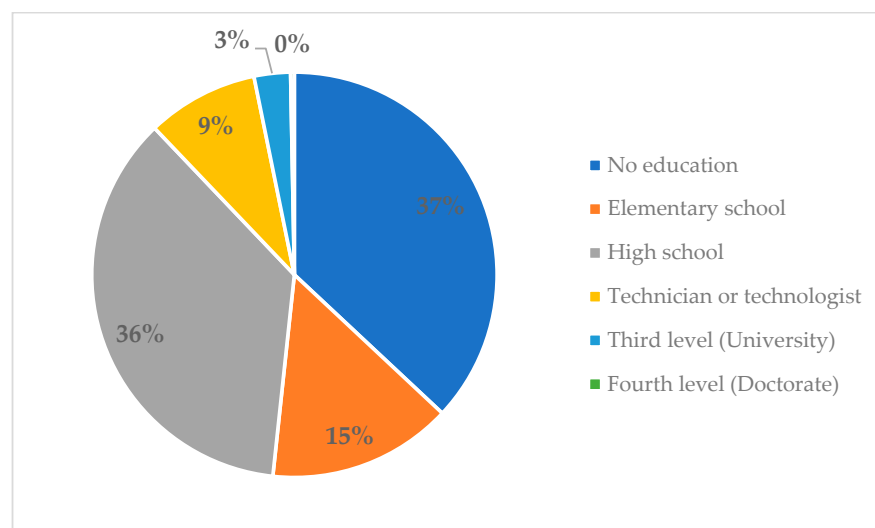


Figure 3. Level of education of the representatives of the enterprises.

3.5.2. Phi Correlation

In the analysis of the determinants of entrepreneurship in the canton of Ambato, significant associations were identified using the Phi coefficient between key variables (Table 1). A strong correlation ($\Phi = 0.81$) exists between training and the adoption of a business model, suggesting that training is crucial for the structured development of enterprises. Likewise, a moderate relationship is observed between profit and sustainable activity ($\Phi = 0.72$), as well as between profit and the business model ($\Phi = 0.61$), indicating that both sustainability and clarity in the model have a positive influence on profitability. It was also found that the lack of a solid business model is moderately associated with the suspension of activities ($\Phi = 0.65$) and that government support has a moderate correlation with utility ($\Phi = 0.78$), evidencing the relevant role of state support in the economic performance of enterprises. These findings highlight the importance of training, strategic design, and institutional support in promoting entrepreneurial success in the region. Additionally, it is demonstrated that technical and business training enhances the formalization and sustainability of enterprises within the local context.

Table 1. Phi correlation of variables.

Variable 1	Variable 2	Φ (Phi)	Interpretation *
usefulness	sustainable activity	0.72	Moderate
usefulness	business model	0.61	Moderate
business model	training	0.81	Strong
suspend _activity	business model	0.65	Moderate
governmental support	usefulness	0.78	Moderate

* The interpretation of results is based on Cohen's work [60].

4. Results

4.1. Model I. Decision Trees

Carrying out a confusion matrix in the analysis of the determinants of entrepreneurship in a geographical area such as Ambato is relevant mainly through the use of classification models to predict or categorize factors related to entrepreneurship. This type of study is adapted to the local reality since, in a canton like Ambato, where there are different types of entrepreneurship (commercial, agricultural, artisanal, technological, etc.), a confusion matrix helps to detect regional patterns that do not fit general models and, in turn, make more accurate decisions on policies to promote or finance entrepreneurship.

In the first instance, we start with the calculation of the confusion matrix (Figure 4).

The analysis of the confusion matrix applied to a sample of productive and commercial enterprises in the canton of Ambato enables us to evaluate the predictive capacity of the model in classifying activities as sustainable or unsustainable.

For Class 0 (unsustainable), the results show poor performance:

- Accuracy: 0.12, indicating that only 12% of activities predicted to be unsustainable are. This case suggests a high rate of false positives in this category.
- Recall: 0.08, which means that only 8% of the actual unsustainable activities are correctly identified by the model, showing a low capacity to detect truly unsustainable cases.
- F1-score: 0.10, a combined measure of accuracy and recall, confirms the low performance of the model in this class, which may affect decision-making related to interventions or support for these endeavors.

In contrast, the results for Class 1 (sustainable) show a solid performance:

- Accuracy: 0.89, indicating that 89% of activities classified as sustainable are indeed so.

- Recall: 0.93, which implies that the model correctly identifies 93% of all sustainable activities present in the sample.
- F1-score: 0.91 reflects a very favorable balance between accuracy and recall, showing that the model is reliable in predicting sustainable ventures in the context of Ambato.

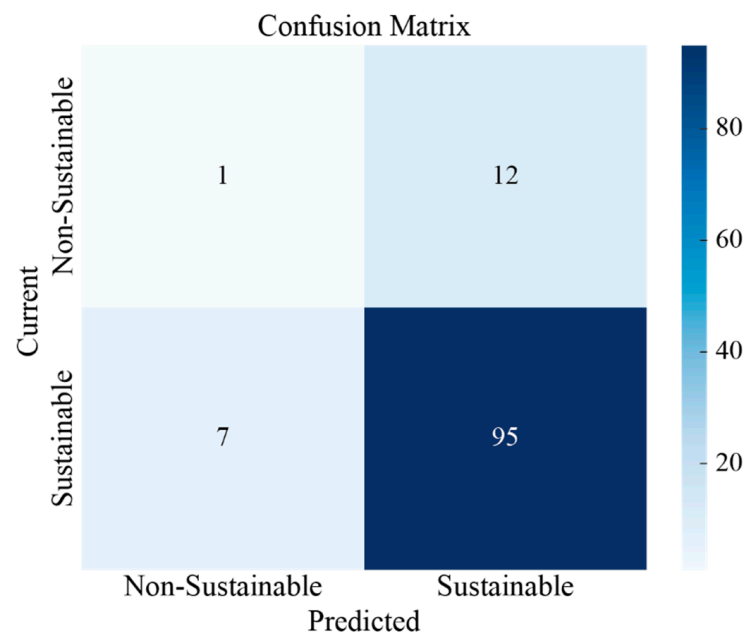


Figure 4. Confusion and prediction matrix for the tree model.

These results reveal a significant imbalance in the model's performance between the two classes. While the model is highly effective in identifying sustainable activities, it seriously fails to recognize unsustainable ones, which is concerning from a policy-making and resource allocation perspective. In the context of Ambato, where various types of enterprises coexist (agro-industrial, commercial, artisanal), it is essential to improve the detection of unsustainable enterprises, as their timely identification could facilitate the implementation of strategies for strengthening, restructuring, or productive reconversion.

The root node is the starting point of the tree (Figure 5). The first feature used to split the data is the most important. In the particular case of the male gender, this characteristic is used to divide the data into two groups: those belonging to the group of male entrepreneurs and those who do not. From the root node, the tree is divided according to the next most important feature, which is an initial investment of 1001–5000. Within each group (men and non-men), it is examined whether the initial investment was in the range of 1001 to 5000. If so, it splits again. The level of the second division is more than 50 years old. The groups are divided again on the basis of whether the entrepreneurs are over 50 years old. The third level of division has the following characteristic: profit. This level examines whether the company is generating profits. Finally, the fourth level of division assesses whether the business promotes itself through advertising or social networks.

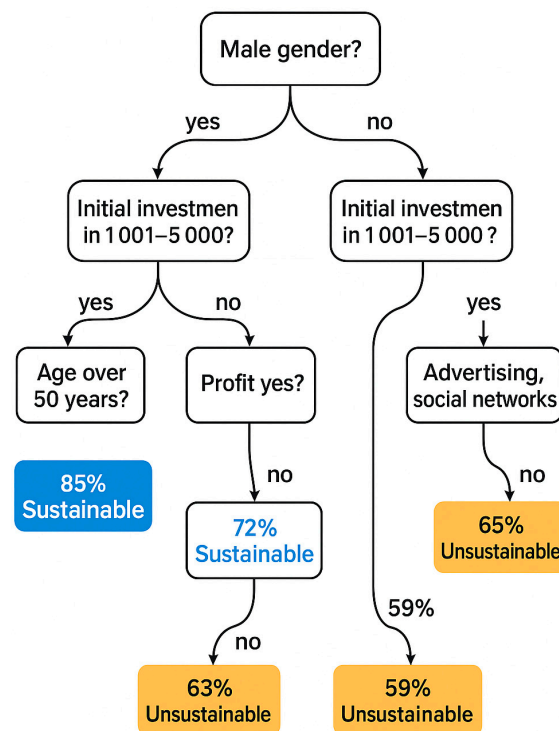


Figure 5. Decision tree model.

4.2. Model II. Dimensionality and Prediction

4.2.1. Principal Component Analysis (PCA)—Empirical Application

Principal Component Analysis (PCA) was applied to reduce the complexity of the dataset, extracting linear combinations of the original variables that explain most of the variability observed in the productive and commercial enterprises of Ambato.

The results show that the first two principal components (PC1 and PC2) explain more than 50% of the total variance (Figure 6), indicating that these two dimensions adequately summarize the most influential characteristics in the sustainability of economic activity. From an interpretive perspective,

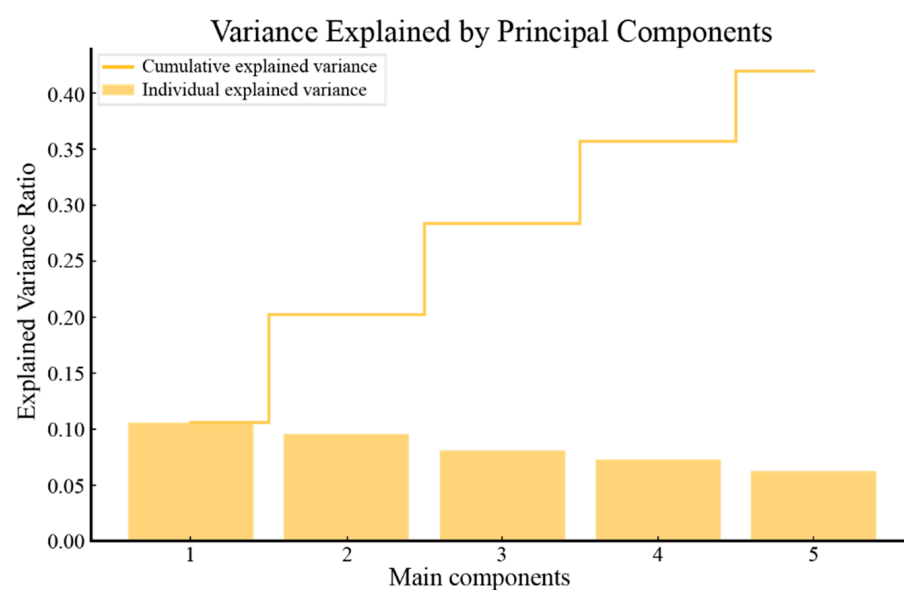


Figure 6. Principal Component Analysis.

- PC1 could be related to structural factors of the business, such as formalization, access to financing, or the level of training of the entrepreneur.
- PC2 could be associated with operational or environmental variables, such as the use of technology, support networks, or market stability.

These components have not only facilitated the reduction of dimensionality but have also enabled the identification of patterns and clusters in the data that were not evident with the original variables.

When using the variables derived from the PCA as inputs in a classification model to predict the sustainable activity variable, an accuracy of 88.7% was obtained, which validates the effectiveness of the approach; this case result demonstrates that the PCA not only simplifies the model but also enhances its predictive capacity by focusing on the most relevant components and minimizing statistical noise.

In the local context of Ambato, characterized by a diversity of enterprises with different levels of formalization, resources, and access to knowledge, the application of the GPA has been key to

- Highlight the main dimensions that affect the sustainability of businesses;
- Reduce the number of variables without losing relevant information, which is especially useful in field studies with limited resources;
- Strengthen analysis and prediction models for better decision-making in local economic development policies.

4.2.2. Random Forest

In the analysis of the productive and commercial enterprises in Ambato, the random forest classification algorithm was applied to predict the sustainable activity variable, which distinguishes between sustainable and unsustainable activities. This method, based on a set of decision trees, works using a voting system: each tree casts a vote on the class of the input instance, and the class with the highest number of votes becomes the final prediction of the model.

The results show that random forest achieved an accuracy of 88.7%, which shows a high level of success in identifying sustainable ventures. This performance demonstrates that the model is highly effective in capturing the key patterns that characterize business sustainability in the local environment.

One of the most prominent features of the random forest algorithm is its ability to mitigate overfitting. In the context of Ambato, where enterprises may present heterogeneous data with noise or outliers (for example, due to informality or a lack of systematized records), this property of the model is especially valuable. By averaging the results of multiple trees, a more stable and generalizable prediction is obtained.

Additionally, it enables the calculation of the relative importance of each predictor variable, providing key information on the factors that most significantly influence the sustainability of local enterprises. This case functionality not only enhances the interpretability of the model but also supports the design of public policies and the strengthening of programs for the entrepreneurial ecosystem.

The corresponding confusion matrix (Figure 7) enables us to evaluate the model's behavior more accurately for the two classes analyzed (sustainable and unsustainable). This tool is essential for identifying specific classification errors, assessing the model's sensitivity to difficult cases, and adjusting the prediction strategy as needed.

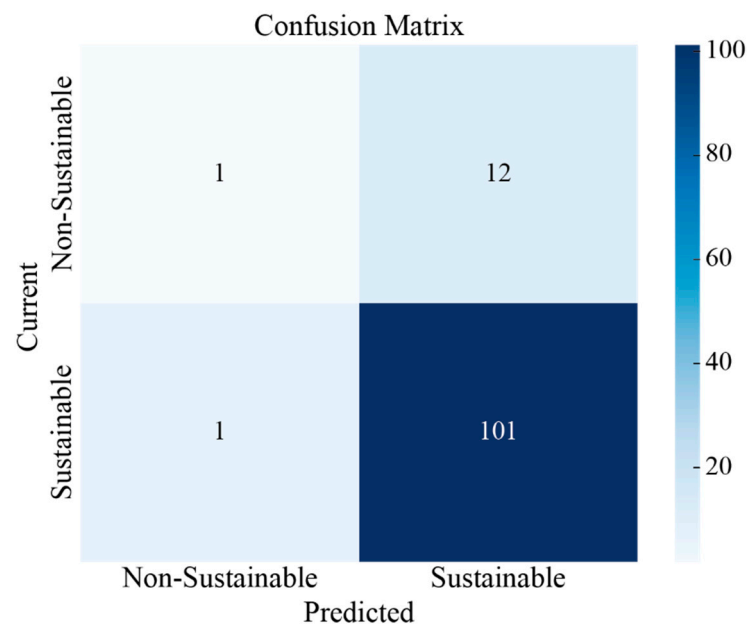


Figure 7. Confusion and prediction matrix for the random forest model.

To predict sustainable activity, we first applied PCA to reduce the dimensionality of the original dataset. We scaled the data using a standard scaler and applied PCA, extracting five main components that explain a significant portion of the variance in the original data.

We then split the data into training and test sets. We trained a random forest classifier with 100 trees ($n_estimators = 100$). The model showed high recall and an F1-score for Class 1 (sustainable), indicating that it is very effective in predicting sustainable activities. The model's accuracy was 88.7%, and the main components, PC1, PC5, and PC4, were the most influential, with significance levels of 37.56%, 18.38%, and 16.82%, respectively.

As reiterated, PC1 captures most of the variance of the original data. The variables with the highest loads in PC1 are as follows.

- Age: 0.511622. This case indicates that the variable contributes strongly positively to CP1. As age increases, PC1 also tends to increase.
- Education level: -0.434221 . The variable has a strong negative contribution to PC1. As the level of education increases, PC1 tends to decrease.
- Activity time: 0.299822. This variable also contributes positively to CP1, although less than age. A greater amount of time spent on the activity is associated with an increase in CP1.
- Entrepreneurship aspects: 0.200602. This variable has a positive and relatively lower contribution to PC1, indicating that a greater focus on entrepreneurship aspects is associated with an increase in PC1.

The first principal component (PC1) is the one that explains the most significant proportion of the variance in the original dataset; therefore, it can be considered a key dimension that synthesizes common patterns in the decisions and characteristics of entrepreneurs in Ambato. The factor loadings of the variables in PC1 allow us to identify which factors are most associated with this latent pattern.

Age (+0.5116)

Age has the highest positive sign in PC1, indicating that older entrepreneurs tend to cluster in this dimension. This case suggests that life experiences, possibly related to greater risk aversion, increased responsibility, or a preference for stability, significantly influence business decisions. In Ambato, where many enterprises are family-owned or

traditional, the age of the entrepreneur can be a crucial factor in determining the business's sustainability and maturity.

Educational level (−0.4342)

This variable has a strong negative sign, which means that a higher educational level is associated with lower values of PC1.

This case suggests that entrepreneurs with higher levels of education may employ different and possibly more innovative or disruptive strategies, which are not represented in the dimension captured by PC1. It is possible that in Ambato, entrepreneurs with higher academic training are less linked to traditional models and more oriented towards diversification, digital entrepreneurship, or the use of emerging technologies.

Time spent on activity (+0.2998)

With a moderately positive contribution, this variable indicates that the greater the dedication to entrepreneurship, the higher the score in PC1. This study suggests that commitment and permanence in business are elements associated with more structured and stable decisions. In local enterprises, where they are often combined with other economic activities, exclusive dedication can be an indicator of professionalization and strategic focus.

Aspects of entrepreneurship (+0.2006)

Although its weight is lower, its positive contribution indicates that a focus on entrepreneurial aspects (such as innovation, business vision, and management) is also associated with this dimension. This case indicates that entrepreneurs who pay attention to these elements tend to make decisions more aligned with PC1 patterns. It reinforces the idea that even within a traditional environment such as Ambato, the development of specific entrepreneurial skills contributes to the consolidation of the business.

PC1 appears to represent a business decision profile characterized by maturity, practical experience, and continuity over time rather than by formal education or innovative strategies. This case reveals a structural trend in Ambato towards ventures sustained by experience and constant effort, where practical knowledge and trajectory carry more weight than academic training in decision-making. This finding is crucial for

- Designing differentiated training programs according to age and educational level;
- Promoting the intergenerational exchange of experiences, where young entrepreneurs can contribute innovation and the elderly can provide stability and guidance;
- Focusing public policies on strengthening practical capacities without neglecting the incentive for formal training.

5. Discussion

This section analyzes the research's main findings in light of the hypotheses presented and the specialized literature on entrepreneurship. From the use of predictive models, such as decision trees, random forest, and Principal Component Analysis (PCA), significant patterns were identified that explain the sustainability, viability, and success of the ventures in the Ambato canton. The results are compared with recent studies that examine the individual, social, and contextual factors influencing business performance. This discussion enables us to gain a deeper understanding of how variables such as educational level, gender, age, geographical location, and time spent on the activity influence the development of enterprises, thereby providing a robust analytical framework for interpreting entrepreneurial dynamics in the local context.

H1: *The educational level of the entrepreneur significantly influences the sustainability of entrepreneurship in the Ambato canton.*

The results of the study confirm this hypothesis, as the variable “educational level” proved to be a key factor in the predictive models used, including Principal Component Analysis (PCA) and random forest. These models indicate that entrepreneurs with higher levels of education tend to develop more sustainable ventures. This case relationship is supported by those who highlight that education equips entrepreneurs with both technical skills and critical competencies, such as problem-solving and adaptability [61]. Likewise, the random forest model showed high accuracy in predicting sustainable activities, which supports claims about the importance of entrepreneurial education [10]. Therefore, it is validated that education not only improves the technical capacity of the entrepreneur but also enhances their resilience and strategic vision in the face of the challenges of the modern business environment [62].

The influence of educational level on the sustainability of entrepreneurship in Ambato is explained by the theory of human capital, which recognizes education, experience, and training as key factors for business success [38,39]. Entrepreneurs with more training tend to make better decisions, adapt more effectively to their environment, and generate more innovation. This perspective is enriched by social cognitive theory and social capital, which incorporate elements such as self-efficacy and support networks [22]. Likewise, experiential learning, based on practice and reflection, allows entrepreneurs to develop essential skills such as problem-solving and identifying opportunities [40]. In Ambato, where many entrepreneurs acquire knowledge empirically, integrating this methodology into entrepreneurial training is crucial [45,46]. In addition, theories such as cluster analysis and institutionalist frameworks emphasize the importance of environmental factors, social innovation, and public policies in enhancing business sustainability.

H2: *The time spent on the activity is positively related to the viability and success of commercial and productive ventures.*

Although this variable is not analyzed in isolation in the models, the results allow us to infer its relevance through correlated factors. The discussion highlights how personal motivation and passion, which are directly linked to commitment and time invested in entrepreneurial activity, influence the sustainability of a business [63]. In addition, the analysis reveals gender differences, indicating that women, due to traditional roles and care responsibilities, face more significant difficulties in dedicating time to entrepreneurship, which negatively impacts their growth [64]. This indirect relationship between available time and sustainability reinforces the hypothesis by demonstrating that the time that the entrepreneur can invest translates into more significant opportunities for success and viability for the business.

These motivations not only drive the creation of companies but also sustain entrepreneurs in difficult times, as reflected in the factors analyzed in this study, where passion and personal motivation appear as indirect variables that influence a business's ability to be sustainable [63].

The hypothesis is positively related to the viability and success of entrepreneurship in Ambato and can be based on the theory of entrepreneurial behavior, which considers motivational, personal, contextual, and intentional dimensions as key determinants [20]. In this context, factors such as the need for achievement, self-efficacy, and perseverance directly influence the dedication of the entrepreneur and, therefore, the sustainability of their businesses [22,23]. Traits such as proactivity, innovation, and a willingness to take risks also enhance commitment to the activity [24]. Additionally, according to the theory of planned behavior, entrepreneurial intention is reinforced by positive attitudes and a high perception of control [25]. In Ambato, where the entrepreneurial ecosystem is still consolidating, access to resources and motivation influence the time entrepreneurs can

dedicate to their initiatives. Finally, the distinction between causal and effectual strategies allows us to understand how different levels of commitment and approach affect the sustainability of enterprises [27,28].

H3: *The aspects of entrepreneurship affect its level of sustainability and growth in Ambato.*

This hypothesis is widely validated; the predictive models have identified multiple factors or aspects that influence the sustainability of the venture, including educational level, age, gender, geographic location, and access to resources. The study shows that location, for example, affects access to networks and capital, as noted in [65] and [66], which has a direct impact on the possibility of growth. In addition, the age and gender of the entrepreneur were found to be determining variables, as reflected in [14,67,68], which directly influence the venture's performance. These findings confirm that various contextual, individual, and social factors influence the sustainability and growth of entrepreneurship in the region. It is highlighted that younger entrepreneurs tend to embrace emerging technologies, while more experienced entrepreneurs rely on their networks and lessons learned to mitigate risks, consistent with age-related differences in decision-making.

Gender is also a determining factor, as observed in the root node of the tree model, where the male gender was the first division criterion [65]. This result suggests that significant differences persist in the entrepreneurial trajectories of men and women, a fact that is attributed to structural barriers and stereotypes that limit women's access to financial resources and support networks [66]. In Ambato, traditional gender roles can disproportionately limit women's access to essential entrepreneurial resources, including networks, mentoring, and capital. Additionally, male-dominated industries (e.g., manufacturing or technology) can perpetuate biases in funding allocations or customer perceptions, as observed in studies of Latin American entrepreneurship [67]. In Ecuador, women are more likely to rely on informal financing (e.g., family loans) than on bank loans, which limits their initial investment capacity—a key variable in our decision tree [68].

H4: *Predictive models based on multivariate statistical techniques (such as decision trees, random forest, and PCA) allow the identification of the factors that determine business success in the region with high precision.*

The results of the study strongly support this hypothesis; the models used—decision tree, random forest, and PCA—showed a high predictive capacity by identifying patterns consistent with the literature on entrepreneurship. Entrepreneurship is a key driver of economic development, and the use of these statistical tools has led to a better understanding of the factors that affect its success [64,69]. The effectiveness of these models is reflected in the ability to correctly classify sustainable enterprises and highlight variables such as education, gender, and age as determinants [57]. Thus, it is validated that the use of multivariate analysis provides an effective tool for strategic decision-making in the entrepreneurial ecosystem of Ambato.

The hypothesis that predictive models based on multivariate statistical techniques enable the precise identification of factors that determine business success in the region is supported by the use of tools such as data mining and advanced statistical analysis. These methodologies, including decision tree, random forest, and Principal Component Analysis (PCA), made it possible to process large volumes of information to detect patterns and relationships that are not directly evident [56,57]. In dynamic contexts, such as those of local enterprises in Ambato, these techniques are essential for anticipating market behaviors, evaluating risks, and predicting results, which improves strategic decision-making. Additionally, it facilitated the identification of determinants of business success,

enabling the design of more precise and sustainable growth strategies [57]. Thus, the use of predictive models not only increases analytical efficiency but also enhances the viability of ventures through more informed, evidence-based planning [58].

6. Conclusions

The study's findings, in combination with the literature reviewed, provide a nuanced understanding of the entrepreneurial ecosystem. Analysis of the decision trees reveals that gender, specifically male gender, acts as a significant divider in the database, highlighting the prevalence of gender differences in entrepreneurship—a topic that has already been widely discussed in the literature reviewed. These authors have identified how gender differences can significantly influence entrepreneurial trajectories, mainly due to structural barriers and limited access to resources. The importance of gender in our model could suggest that, despite progress towards equity, gender disparities remain a critical factor in business dynamics.

Initial investment and age are key variables in our model, which aligns with the researchers' findings. The age model positively impacted the sustainability of companies, reaffirming the theory that with greater age and experience, entrepreneurs can better manage business challenges. In addition, utility and advertising strategies, especially social media, emerged as key factors in the later stages of the decision tree split, underscoring their importance in the company's long-term survival and success.

This study has shown that entrepreneurship is a multifaceted phenomenon influenced by various factors, from personal and demographic to structural and economic. The models developed illustrate how factors such as gender, initial investment, age, utility, and advertising strategies determine the sustainability of a company. These findings underscore the importance of addressing gender barriers and implementing policies that promote greater diversity among entrepreneurs.

On the basis of the results and the literature review, it is recommended that gender-inclusive policies be developed to remove the barriers faced by women entrepreneurs, particularly in access to finance and support networks. In addition, although the analysis revealed a negative relationship between education and specific aspects of business sustainability, the importance of education in developing managerial and leadership skills is underscored. It is essential to prioritize the quality of training so that entrepreneurs can effectively face the challenges of the business environment. It is also recommended to promote access to adequate initial financing, as well as skills in digital marketing strategies, particularly regarding social networks, to enhance the reach and effectiveness of the ventures.

The interplay of these complex factors requires careful consideration by policymakers, educators, and business leaders to create an environment that fosters startups and supports their long-term growth and sustainability.

While this study provides valuable insights into the determinants of entrepreneurship in Ambato, certain limitations should be acknowledged. First, while the sample of 382 startups provides a comprehensive insight into Ambato's formal entrepreneurial ecosystem, it may not fully capture the diversity of all sectors. The reliance on companies registered in the SRI database could exclude informal or unregistered companies, which are prevalent in the region and often face distinct challenges, such as limited access to financing. Future studies could expand the sample to include these informal sectors, combining quantitative and qualitative methods to achieve a deeper understanding. Second, the cross-sectional design limits our ability to assess causal relationships or track business trajectories over time. Longitudinal research would help clarify how factors such as education or initial investment interact with changing market conditions.

Finally, future studies should (1) track firms longitudinally to validate the temporal patterns, (2) employ mixed methods to explore the contextual nuances of our quantitative findings, and (3) examine how these determinants operate in different regional contexts in Ecuador.

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Abbreviations

The following abbreviations are used in this manuscript.

PCA	Principal Component Analysis
SRI	Servicio de Rentas Internas
CART	Classification and Regression Trees
PC1/PC2	Main Component 1/2

Appendix A

This questionnaire aims to collect relevant information about the characteristics, experiences, and challenges faced by entrepreneurs in the Ambato canton. Participation is essential to identify the factors that influence the sustainability and success of local ventures. All information will be treated confidentially and used exclusively for academic purposes.

1. Geographical location

- In which parish is your business located?
- Is the area where your business operates urban or rural?

2. Characteristics of the entrepreneur

- What level of formal education have you attained?
 - () No instruction
 - () Primary

- ☐ Secondary
- ☐ Technical or technological
- ☐ The third level of university
- ☐ Fourth postgraduate level
- ☐ Fourth level (doctorate)
- What is your age range?
 - ☐ Between 20 and 30 years old
 - ☐ Between 31 and 40 years old
 - ☐ Between 41 and 50 years old
 - ☐ More than 50 years
- What is your gender?
 - ☐ Male
 - ☐ Female
- 3. Characteristics of entrepreneurship**
 - What do you consider to be the main aspects that motivated or facilitated your venture (e.g., experience, knowledge, economic need, market opportunity)?
 - What was the approximate range of initial investment in your venture?
 - ☐ Less than USD 1000
 - ☐ Between USD 1001 and USD 5000
 - ☐ Between USD 5001 and USD 10,000
 - ☐ More than USD 10,000
 - How long has your business been in operation?
 - ☐ Between 1 and 3 years
 - ☐ Between 4 and 6 years old
 - ☐ Between 7 and 9 years old
 - ☐ More than 10 years
 - What media do you use to promote your business?
 - ☐ Social networks
 - ☐ Traditional media (radio, press)
 - ☐ Word-of-mouth advertising
 - ☐ Other (please specify): _____
 - Has your business generated profits (profits)?
 - ☐ Yes
 - ☐ No
 - What kind of problems have you faced in your activity? (You can check more than one option.)
 - ☐ Competence
 - ☐ Government regulations
 - ☐ Lack of customers
 - ☐ Access to financing
 - ☐ Other: _____
- 4. Funding and support**
 - What was the main source of financing to start your business?

- ☐ Personal savings
- ☐ Bank loans
- ☐ Informal credits
- ☐ Help from family or friends
- ☐ Other: _____

- Have you received any government support for your business?

- ☐ Yes
- ☐ No

5. Sustainability and projection

- Do you consider your economic activity to be sustainable in the long term?

- ☐ Yes
- ☐ No

- In case of difficulties, have you considered suspending your economic activity?

- ☐ Yes
- ☐ No

- What do you think would be the main factor that could lead to the closure of your business (e.g., low profitability, competition, lack of support, changes in the market)?

6. Organization and development

- Does your venture have a defined business model?

- ☐ Yes
- ☐ No

- How many people do you currently have as support or staff?

- ☐ Work alone
- ☐ From 1 to 4 people
- ☐ From 5 to 10 people
- ☐ From 11 to 20 people
- ☐ More than 20 people

- Have you received training or training related to business management?

- ☐ Yes
- ☐ No

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