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Effect of Contextual Factors on the Entrepreneurial Ecosystem in South Africa

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Abstract

Having the proper infrastructure is crucial because it fosters prosperous enterprise and a skilled labor force capable of solving environmental issues. There are worries about the potential negative effects of human capital centered on innovation, despite studies showing benefits. This study examines how contextual factors such as business environment, infrastructure, and human capital, influence South Africa's entrepreneurial ecosystem. Multiple Regression Technique was used for analysis. Findings showed that each of the three factors has a remarkable impact, with business environment showing the highest positive relationship to the Ecosystem Index. The results highlight the significance of focusing on sustainable activities when developing human capital. To promote a more sustainable entrepreneurship environment, the study suggests that policymakers should implement incentives, allocate finances for infrastructure, and establish educational and knowledge-sharing initiatives to encourage the sustainability of the entrepreneurial ecosystem. Future research directions will focus on investigating how additional contextual factors affect ecosystems in various regions and industries. The study also suggests the evaluation of gender equality in access to financial and business assistance.

Keywords: business environment; infrastructure; human capital; ecosystem; index

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1. Introduction

1.1. Introductory Context and Background

Economic growth is an essential concept for all economies, and more especially for countries with high poverty and unemployment rates. Entrepreneurship has proven to play an important role in economic growth [1–3], especially when innovative activities are part of the entrepreneurial functions [4]. Yet, economic growth does not necessarily lead to a reduction in unemployment and poverty when there is a high inequality of income distribution, and economic growth needs to be inclusive for poverty and unemployment to be reduced. Authors [5] opined that economic growth should be "enterprise-induced" and based on entrepreneurship development to be effective in the reduction of poverty, unemployment, and inequality.

The Ecosystem Index, a measure often used to evaluate the health, sustainability, and resilience of economic ecosystems, is heavily influenced by human capital, infrastructure, and the business environment. Each of these elements plays a vital role in shaping a region's or nation's ecosystem by affecting factors such as innovation capacity, productivity, and sustainability. Human capital, which encompasses the skills, knowledge, and competencies of a workforce, is foundational to economic and environmental ecosystems. It

directly impacts the Ecosystem Index by fostering innovation, adaptability, and productivity. Higher levels of human capital are associated with greater creativity and efficiency in using resources sustainably [6]. Additionally, countries with higher investments in education and training tend to have better innovation outcomes and higher resilience to economic and environmental shifts [7]. Research suggests that educated, skilled workers drive technological advancements that support sustainable practices, enhancing ecosystem productivity and resilience [8].

Infrastructure—encompassing transport, energy, and digital systems—provides the physical framework within which economic ecosystems operate. Efficient infrastructure reduces costs, increases connectivity, and supports the swift flow of goods, services, and information, which in turn positively impacts the Ecosystem Index. For instance, sustainable infrastructure such as green buildings and efficient public transport systems contributes to lower environmental footprints and more robust ecosystems [9]. Countries with well-developed infrastructure also see better environmental outcomes, as efficient systems reduce emissions and waste [10]. The business environment, which includes regulatory quality, ease of doing business, and market dynamics, plays a significant role in determining how effectively an economy can grow sustainably. Supportive business environments that minimize bureaucratic hurdles, promote competition, and encourage innovation tend to enhance the Ecosystem Index by enabling sustainable businesses to thrive [11]. An efficient regulatory environment allows companies to innovate and adopt green technologies more rapidly, improving both economic and environmental metrics of the ecosystem [7].

The combined effects of human capital, infrastructure, and business environment create synergies that significantly influence the Ecosystem Index. Economies that balance investment in education, sustainable infrastructure, and efficient regulation often outperform others in ecosystem resilience and sustainability. South Africa is currently facing significant challenges in terms of poverty and unemployment, with 62% of its population falling below the poverty threshold for upper-middle-income individuals [7]. Moreover, the COVID-19 pandemic has aggravated these problems, resulting in an unemployment rate of 35.3% in the fourth quarter of 2021. This is particularly alarming for women and young people. Even though entrepreneurship is known to stimulate economic growth, the current growth patterns have not effectively mitigated the issues of poverty and unemployment [12]. This highlights the necessity of implementing a well-targeted approach to fostering entrepreneurship. Furthermore, author [13] emphasized that the effectiveness of an entrepreneurial ecosystem is contingent on a multitude of contextual elements. It is imperative to understand the impact of these elements on the ecosystem in order to devise specific interventions that foster comprehensive economic expansion while mitigating poverty and unemployment. Tackling these variables is critical for addressing South Africa's underlying causes of poverty and unemployment.

Although the literature on entrepreneurial ecosystems mushroomed during the last three decades, it is still "undertheorized", and the empirical studies on entrepreneurial ecosystems are limited and use mostly qualitative case study analysis [5]. Author [14] emphasize the need for studies on entrepreneurial ecosystem development and studies on how it can "enhance productive entrepreneurship and positive welfare outcomes". Unfortunately, findings of studies on the performance of entrepreneurial ecosystems cannot be generalized due to the differences between entrepreneurial ecosystems. Each ecosystem is unique, and there are vast differences between developed and developing countries' ecosystems, as found by author [15]. Author [16] also base their study on the regional level due to the variation in entrepreneurship ecosystems between regions. This study contributes to scholarly literature in addressing the effects of contextual elements of the entrepreneurial ecosystem outcome, measured by an ecosystem index. The study is based

on a survey of 1486 small, medium, and micro enterprises in the Mpumalanga Province of South Africa.

1.2. Theoretical Framework

Entrepreneurial Ecosystem Conceptual Models: Over the last three decades, the literature on entrepreneurial ecosystem models has increased. One of the most widely cited models is that of [17]. This model includes six domains of the EE and twelve core components. The domains are policy, finance, culture, supports, human capital, and markets. Author [18] built on Isenberg's model and others, portraying the broad elements of institutions and resources in ten operational constructs. These institutional elements include formal institutions, culture, and networks, and the resourced endowments include physical infrastructure, demand, intermediaries, talent, knowledge, leadership, and finance. The model has, as third construct, productive entrepreneurship as the output of the EE. The main actors in the EE, according to [4], are entrepreneurs, public sector, service providers such as marketing and legal, financial institutions, academia, investors, non-government organizations, media, and others. Author [19] model focuses more on the actors, their roles, and the interaction of these actors with other role player, with the aim to provide a more practical model for actors to apply. These actors are identified as educational and training institutions, corporations and business associations, potential and existing entrepreneurs, government agencies or policy makers, financial institutions and investors, media organizations, the technology community, and business and advisory agencies.

Even though some actors do not wittingly work towards a better performance of the EE, some actors have the macro-outcomes as mandate. Where firms, banks, suppliers, investors, etc., have their own performance and well-being as goal, actors such as government institutions, and some advisory agencies and academic institutions, have the total increase in entrepreneurial performance of the EE—and, ultimately, economic growth and welfare of the community—at heart. Despite these differences, actors may benefit by understanding their roles in the system, either for their own benefit or that of the system. If entrepreneurs, for example, act in their own interest, by doing so they increase their output performance, which leads to the overall increase in performance of the system as a whole.

1.3. Research Question and Sub Questions

Based on the literature review and the current need for poverty alleviation and unemployment reduction in South Africa, the following questions guide this study:

To what degree do the elements of human capital, infrastructure, and business environment influence the SME entrepreneurial ecosystem?

Sub Research Questions:

(a) *What are the effects of elements of human capital on the Ecosystem Index?*
(b) *What are the effects of elements of infrastructure on the Ecosystem Index?*
(c) *What are the effects of elements of business environment on the Ecosystem Index?*

1.4. Structure of the Article

The article is structured as follows: Section 1 introduces the study, Section 2 reviews the literature on the entrepreneurial ecosystem and contextual factors, Section 3 outlines the research methodology, Section 4 presents the empirical results, and Section 5 concludes with key findings and recommendations.

2. Literature Review and Research Hypotheses

2.1. Literature Review

The literature on the development of entrepreneurship has evolved over time, shifting the focus from the individual entrepreneur to that of the entrepreneurial ecosystem (EE). In light of the importance of entrepreneurship in economic growth, employment, and poverty reduction, a recognition of the active roles that other actors must play and their complex interrelationships became essential. Author [20] brought attention to the importance of the entrepreneur, especially his role as innovator author [21] at the beginning of the 20th century when his theory (written in 1911) was not receiving mainstream economic attention. According to author [22], the conventional economic growth models, especially those based on the neoclassical framework initiated by economists such as Marshall, Keynes, and Samuelson, typically exclude entrepreneurship as a separate factor of production or a key component in the process of economic growth.

Scholars have further emphasized the importance of entrepreneurship as the source of economic and social development and have expressed Schumpeter's concern about neglect of the role of entrepreneurship in the process of economic growth in mainstream macroeconomic theory. Author [21] acknowledged the role that Schumpeter played in making the entrepreneur the key figure of economic change in his theory of economic development. It was only in the 1980s that Schumpeter's theories began to receive more attention, but expanded to the role of the entrepreneur in a system context [23–25]. Moreover, Author [26] criticized Schumpeter for neglecting the multiple sources of information inputs and the importance of a national system of innovation, due to his focus on the individual entrepreneur. Author [26], opined that it is necessary to specify the components of the system, the relationship among various components must be analyzed, and the attributes or characteristics of the components need to be specified. Authors [27], compared and distinguished the National System of Entrepreneurship from that of the National Systems of Innovation, indicating the main difference as individual-driven versus institution-driven.

The ecosystem concept in the business and entrepreneurial environment, using the analogy of natural ecosystems, appeared in author [28] publication, *Predators and Prey: A New Ecology of Competition*. Author [29] provides evidence of the shift in literature from entrepreneurial environments to entrepreneurial ecosystems, and he states that the term entrepreneurial ecosystem is more commonly used than the other similar concepts describing the environment or system within which the entrepreneurial firms function. According to author [18], there is still no generally accepted definition for entrepreneurial ecosystems.

To understand the concept of entrepreneurial ecosystem, it may be wise to begin by understanding the concept "entrepreneurship" as, according to author [30] and [31], no singular definition for entrepreneurship exists. Author [30] identify three different views that are used in defining the entrepreneurship concept. The first viewpoint is using constructs such as age (young), size (small), and ownership (self-employed); the second includes behavior, such as discovering or creating something new and commercializing it; and the third uses the performance of the entrepreneur or entrepreneurial firm. Entrepreneurship has been limited by many authors [2,5,32–55] in their definitions as being "new start-ups" and/or "small firms". Entrepreneurship and small business are not synonymous concepts, and, according to [36], entrepreneurship behavior can happen in both small and large businesses but also elsewhere. Author [4] reasons that the EE should create an environment conducive for new businesses as well as high-growth firms. From the viewpoint of the system approach and the need for the EE to result in economic growth with the aim of poverty reduction and employment creation, the performance or outcome of entrepreneurial firms, and ultimately of the EE, is of core interest.

Although there are also different definitions of the EE, most definitions include similar components, such as different actors, their functions, and the interaction between these actors, ultimately with an outcome of improved performance. Author [30] define the entrepreneurial ecosystem as the spatial organization, structural framework, and interactive relationships among organizations, companies, institutions, and individuals in a particular geographic area that collectively create an environment favorable for entrepreneurial endeavors. In a complementary perspective, author [37] describe the entrepreneurial ecosystem (EE) as a dynamic framework that includes consistent entrepreneurial participants, both existing and prospective, along with entities such as companies, venture capitalists, financial institutions, and angel investors. This system involves entities such as universities and public agencies, along with entrepreneurial activities such as business creation rates, the existence of high-growth companies, serial entrepreneurship, and entrepreneurial aspirations. Together, these elements, whether formal or informal, relate to influence, mediate, and govern entrepreneurial activities within a particular local setting.

The interaction amongst the participants in the system can be deliberate efforts to enhance entrepreneurship, or it can be entirely independent actions that, wittingly or unwittingly, have an influence on the other participants or on the entrepreneurial outcome. Author [30] state that entrepreneurs are often not even aware of the institutions' effect and the environment that they function in. Author [18], on the other hand, do not see the entrepreneurs as the only actors in the system that benefit but rather see the relationships between the elements in the EE as mutually beneficial.

A system does not stay stagnant but is dynamic and evolutionary [38]. Moreover author [29] indicates that as a system changes over time, its elements change, and relationships among elements change. It is also of importance to acknowledge the diversity of EEs. There are common characteristics among ecosystems, but every ecosystem is different. The environment that is conducive for new business creation is not necessarily sufficient for creating high growth firms author [37] and what works well in one EE does not necessarily work in another [5].

The empirical literature review, below, focuses on the importance of a conducive EE for entrepreneurial performance, followed by a discussion on the findings in literature of the roles of specific contextual factors, such as human capital, infrastructure, and the business environment, on the EE.

2.1.1. The Role of the EE in Entrepreneurial Performance

As was indicated earlier, despite the increased number of studies on EE, quantitative analysis of the constructs, their interrelationships, and the effect of these constructs or elements on the outcome or performance of the EE are not common. Author [18] addressed this problem and developed an EE index for the measurement of the EE in the Netherlands. Their findings conclude that the prevalence of high-growth firms in a region is strongly related to the quality of the EE. Author [18] found a very high correlation between the ten elements in their EE model, as well as that an index of these elements statistically explains large variations in the performance of the entrepreneurs in the different regions tested.

Author [16] confirm the findings of author [18] on the positive correlations of EE elements and the importance of a system approach for the entrepreneurial performance of the firm and the EE, in their study on 273 European regions, applying their study to the ten EE elements of author [18]. Similarly, authors [5] found a positive effect of the EE on entrepreneurship development in Africa, in their panel data study of 54 African countries. Authors [5] found venture capital, human capital, infrastructure, and support to have a positive relationship with entrepreneurship development in the long-run, but not in the

short-run, and ascribed it to the scarcity of these elements in Africa, resulting in a longer time to access capital and attract human capital.

The relative importance of the contextual factors for the EE was tested by author [39] when collecting data from 37 experts on the pairwise comparison of the elements. Their findings revealed that human resource development carries the highest weight, followed by finance, support, industrial relations, government's role, infrastructure, mentorship, and lastly, markets. Author [16] analysis, mentioned earlier, indicates physical infrastructure, finance, formal institutions, and talent as fundamental conditions for EE. The author [9] also indicates human capital, funding and finance, and accessible markets as essential for the success of the EE, as derived from the survey of a thousand entrepreneurs around the world.

2.1.2. Entrepreneurial Ecosystem Contextual Factors

Although the term "contextual factors" is not used commonly across all studies on entrepreneurial ecosystems, author [40] equate it to synonyms such as external or extrinsic variables, and entrepreneurial framework conditions. Author [40] mention some commonly studied contextual factors, including government policies and programs, infrastructure, market development, education system, self-employment values, and entrepreneurial competencies and intentions. Authors [41] found that there are, in literature, no clear definitions and functions of the different components of the EE and that the role, functions, and characteristics of these components are unclear. They reason that the distinctions are not clear between agents, resources, products, or contextual factors of the EE. Author [41] classify formal institutions, informal institutions, and physical infrastructure under contextual factors, financial capital, human capital, knowledge capital, social capital, business assistance, and products and services under resources, products and services. Following author [40] on distinguishing contextual factors as extrinsic or framework conditions, the contextual factors of interest in this study include human capital, infrastructure, and the business environment. The empirical findings of these contextual factors are further discussed.

Human Capital: The empirical literature on human capital and the EE is divided into publications with the view of human capital as it develops the entrepreneurial abilities of the entrepreneur themselves in author [42], the literature that focuses on the human resource component of the entrepreneurial firm in author [43], and the literature that includes both these aspects of human capital [44,45].

According to author [46], investment in human capital include schooling and on-the-job training as the most important factors, as well as others such as medical care, migration, and searching for information about prices and incomes. Author [46] opined that these investments influence "future monetary and psychic income". Author [44] expand author [46] definition by distinguishing entrepreneurial human capital from the general concept of human capital. Entrepreneurial human capital, according to Author [44], is the application of a variety of competencies, such as the ability to create ideas, find solutions, to take risks, deal with complexities, etc., with the aim of generating value and creating a sustainable advantage. Entrepreneurship education at post-school stage is indicated by [47], in his study using data of the 54 countries who participated in the Global Entrepreneurship Monitor (GEM) study by author [48], as a significant framework condition for entrepreneurial activity support. According to author [49], the more extensive business and management knowledge is, the higher the level of success entrepreneurs will reach, as was determined by his study on 206 entrepreneurs of SMEs in Vietnam. Author [50] further confirms the importance of entrepreneurship education by studying the influence of the entrepreneurial education ecosystem in higher education on entrepreneurial intention, and the findings reveal that entrepreneurial education systems directly influence

entrepreneurial intention. The study is based on Indonesian higher education, applying Structural Equation Modelling.

In a study by [43] conducting a survey on 23 Indian start-ups, receiving responses from 311 managers, they found that there is a connection between human capital and the EE. They were specifically interested in the digital knowledge and innovative capability of enterprises due to the era of digitalization and innovation and found that the digital knowledge and innovation capability has a significant impact on the EE. Author [43] emphasized the importance of human capital development due to the impact of knowledge capabilities on the EE. Author [51] study confirms the importance of training of employees for innovative performance by indicating a positive relationship in countries in economic transition. The study of author [52], although focusing on craftsmen only, found a positive correlation between human capital and productivity, implying the importance of human capital development in the EE. Based on 143 craftsmen in Indonesia, using Structural Equation Modelling, author [52], indicated that the indirect effect of human capital on productivity through entrepreneurial creativity is stronger than the direct effect. The EE in Pakistan was found by author [53] not conducive for successful SME performance partly due to the lack of skills of the labor force.

Author [45] study, analyzing the findings of 21 experimental and quasi-experimental studies on the effect of human capital on entrepreneurial performance, found that formal education has a positive effect on firm profits and entrepreneurial earnings, but the effect of human capital interventions on entrepreneurial performance is insignificant. Author [45] concluded that correlational studies (as opposed to experimental studies) showing high positive correlations between human capital and entrepreneurial performance often overestimate the benefits of human capital interventions. Empirical studies confirm, therefore, the importance of human capital development, especially if there is also a focus on entrepreneurial skills, for the successful functioning of the EE.

Infrastructure does not have a widely acknowledged definition, nevertheless. Author [54] describes it as a collection of capital assets that create the essential structure sup-porting both business operations and the provision of public services. This includes physical resources that facilitate the transportation of goods and individuals such as highways, airports, and seaports alongside those that provide critical utilities, such as power plants and water treatment facilities. Moreover, infrastructure includes organizations that facilitate human services such as education, healthcare, and justice (for example, schools, hospitals, and police stations), along with facilities that improve the production and distribution of goods and services, including industrial parks, factories, and shopping centers.

The relationship between physical infrastructure and entrepreneurial growth is found to be positive in studies such as Author [55] and [47]. Moreover, Author [55] measured entrepreneurial growth by the Total Early-Stage Entrepreneurial Activity (TEA). Authors [55] Apanel data study is based on data on the BRICS countries. Author [56] found in their empirical analysis that infrastructure enhances startup activity, and they went further in their analysis by finding that certain types of infrastructure, such as the types that enhance connectivity and linkages, are even more conducive to startup activity. In the technologically developed era, infrastructure such as telecommunication infrastructure became increasingly important. Author [57] tested the effect of broadband infrastructure on entrepreneurial activities in Germany by means of panel data study and Ordinary Least Squares (OLS) regressions and found a significantly positive relationship between broadband availability and entrepreneurial intensity in high-tech industries, yet they found no relationship when tested on all sectors. Author [54] agrees, in his study analyzing the data on the fifty USA states over the period 1993–2015 in a dynamic panel system Generalized Methods of Moments estimation on the heterogeneity of infrastructure investment in form

and effect. Author [54] further distinguished between private and public infrastructure investment and found that private infrastructure investment has a positive and significant effect on the creation of businesses, but that public infrastructure investment is associated with the destruction of businesses. Yet, Author [54] cautioned not to avoid public infrastructure investment but rather to ensure that the investment is well-planned, considering the diversity of investment and its outcomes to avoid "white elephant infrastructure projects".

Many developing countries suffer from insufficient infrastructure. Author [58] survey of 500 small and medium enterprises (SMEs) in Nigeria found that this deficiency in infrastructure has a negative impact of the profitability and performance of SMEs. The lack of infrastructure impacts the operational costs of businesses due to the need to self-provide the infrastructure. Insufficient electricity and water provision, as well as the poor state of roads, is evident in many African countries, including South Africa.

Business Environment: The business environment is shaped by numerous actors and their functions. These include, inter alia, government (through providing a socio-economic environment, political stability, law and order, and entrepreneurial support services), universities (providing research, entrepreneurship support services, etc.), and institutions providing financial services and support, markets, suppliers, consumers, etc.

The role of governments and their different functions play a crucial part creating conducive EEs. By attempting to determine the most important factors that shape the business environment, Author [59], found that there are significantly different opinions among the entrepreneurs (based on a questionnaire for entrepreneurs in Slovakia). Factors closely related to the public sector are indicated as having the biggest negative impact on the quality of the business environment, according to Author [59]. Moreover, Authors [60] confirm the importance and role of the public sector and found that a county's institutional framework conditions have a significant effect on the productive performance of the businesses. The macroeconomic environment, including the GDP, employment, and inflation, was found by author [61] to promote the business environment, whereas monetary policy and interest rates, corporate finance, and the population's consumption do not affect the business environment. The study of author [61] is based on regression and correlation analysis of the transport and services segment in East European countries. Authors [60] study is based on GEM data from 232 984 surveys in 16 Asian Development Bank-member countries. By testing the effect of governance on entrepreneurship, Author [62] found that political stability, regulatory quality, and corruption control have statistically significant effects on entrepreneurship. Authors [62] applied Pearson correlation and multiple linear regression, and the study is based on World Bank data of 126 countries from different levels of income over the period 2014–2018.

Similarly, Author [63] found, by analyzing the data of 85 developed and developing countries over the period 2012–2022, that political stability increases business entry. The proxies they used for political stability include democratic accountability, bureaucracy, government stability, law and order, social and economic conditions, investment status, corruption control, lack of internal and external conflicts, the absence of military presence in politics, and the absence of ethnic and religious tensions. These findings are confirmed by author [64] in finding that corruption negatively influences TEA, and procedural bureaucracy increases the percentage of informal entrepreneurs attempting to avoid formal procedures. The analysis includes data from 54 countries over the period 2006–2015 and was analyzed using hierarchical linear modelling. The study of [31], on the other hand, found that the relevance of institutional factors varies with income and that countries with low income levels and high corruption tendencies lead to higher TEA scores, due to the lack of a robust rule of law, and simple bureaucratic procedures. The study was based on data concerning 48 countries from different sources, using the qualitative comparison

analysis. Author [65] agree that corruption influences the number of start-ups, even in low-corruption environments such as Sweden. Author [65] study indicates that there are, although they are the minority, entrepreneurs who prefer to move to higher corruption areas with less bureaucracy.

Apart from the political and bureaucratic environment, the government and private sector actors in the EE can actively and deliberately play a role in creating an environment conducive for entrepreneurship. The study of Author [55] on the BRICS countries (mentioned earlier) found a positive long-run relationship between government entrepreneurship programmes (management advice, training, financing, and business incubators) and TEA, but a negative long-run effect of government support policies (access to resources, reduction of entry barriers) on TEA. Author [47] study of 54 countries indicates that entrepreneurship finance by government and government entrepreneurship programmes have a positive influence on entrepreneurship, while government policies and entrepreneurship education at school level are negatively affecting entrepreneurship. Investment by government in accelerators and incubators has a spill-over effect on the wider ecosystem [66–68]. The study of author [67] on 428 start-ups in the United Kingdom found that most of these firms regard incubators and accelerators as significant or vital to their business.

Although government plays an essential part in the EE, industries and universities' roles cannot be ignored. Author [69] provide empirical evidence of the role of the triple helix, industry–university–government, in entrepreneurial activities. Author [69] found in their study of Latvian regions, that in most advanced areas with higher shares of value-added, there is a strong triple-helix relationship, indicating that better clustering of the three role-players provides better support for entrepreneurial activities. An empirical study by author [70] confirms the importance of universities in the EE, indicating a significant positive relationship between students involvement in entrepreneurial-related curricular programs and start-up activities. Author [70]'s study is based on surveys from 31,927 respondents from 25 countries and 282 universities, applying hierarchical regression analysis. Although many studies confirm the importance of the university in the EE, this role is complex. Author [71] found, by using linear logistic regression on GEM 2017 data from 18 countries, that their results do not generally support the expectation that universities support entrepreneurial initiative. The study revealed that more fragile EEs benefit more from entrepreneurial universities, as they need more support.

The EE environment further depends on other support industries. Financial institutions, for example, play a role in access to funds, which has been indicated by many studies like authors [15,51,72–74] as one of the most important success or hampering factors (in the absence thereof) for entrepreneurial activities. Apart from new start-ups, which are generally small to medium, of which some grows to larger firms, the large corporations have an important role to play in the EE. Author [75] confirm the importance of corporations in the provision of resources, but also find that corporations often act in self-interest with a conservative mindset, leading to activities that negatively impact entrepreneurial culture. Author [75]'s empirical study was based on semi-structured interviews with 15 participants from large corporations in Munich.

The discussion and empirical literature on the EE environment are not exhausted by far. Only key elements have been highlighted, due to the vast number of actors and the complexity of the interactions and linkages between the actors, as well as the factors influencing the environment.

2.2. Research Hypotheses

Drawing from the theoretical frameworks and empirical findings discussed in the earlier literature review, this research develops hypotheses that investigate the linking between specific contextual factors such as human capital, infrastructure, and the business environment and the performance of the entrepreneurial ecosystem in South Africa. The basis for these hypotheses lies in the idea that these dimensions, being essential elements of the entrepreneurial framework conditions, have a quantifiable impact on ecosystem results. Based on systems theory and empirical research in both developed and developing nations, the study proposes that improvements in each of these elements will constructively influence ecosystem resilience, innovation, and entrepreneurial achievement. These assumptions are evaluated through a multiple regression model implemented on a graded sample of SMEs located in the Mpumalanga Province. The study proposes the following hypotheses test:

H1: *Human capital has a significant impact on the Entrepreneurial Ecosystem Index in South Africa.*

H2: *Infrastructure has a significant effect on the Entrepreneurial Ecosystem Index in South Africa.*

H3: *Business environment has a significant impact on the Entrepreneurial Ecosystem Index in South Africa.*

3. Data and Methods

The sample used for the analysis (stratified approach) was taken from a general survey of active SMEs in the Mpumalanga Province in South Africa. This article was premised on the EU's 2003 classification of SMEs, as businesses with fewer than 250 persons were defined as middle-sized establishments and those with fewer than 50 as small-sized. The stratified approach was used to derive our sample (2000 SMEs). The estimated target population was about 10,000. Thus, we distributed 2200 questionnaires. We divided the target population in Mpumalanga Province into three groups (strata). Each group consists of a Municipality [Ehlanzeni, Gert Sibande, and Nkangala], and then we selected samples from each of the local municipalities [stratum] for the survey via random sampling. Figure 1 below shows the map of Mpumalanga Province.

For this study, we applied a two-fold structured questionnaire. The first part of the questionnaire focused on the demographics, while the second segment focused on entrepreneurial perceptions of the business ecosystem and key firm- and entrepreneur-related indicators relevant to the scope of the study. Out of the 2200 questionnaires distributed, a total of 1937 were received back. After implementing data-cleaning processes, which involved eliminating incomplete, inconsistent, or unfit responses, a total of 1486 valid observations were kept for analysis.

The analysis is based on a structured questionnaire composed of two parts: firm demographics and ecosystem perceptions. All items were measured using a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree). The dependent variable is the Entrepreneurial Ecosystem Index, a composite score reflecting respondents' assessments of eco-system conditions (e.g., support services, market access, networks). The independent variables include: human capital (HC) (availability of skilled labor and education quality), infrastructure (INFR) (adequacy of physical and digital infrastructure), and business environment (BE) (perceptions of policy, regulation, and institutional support).

Control variables such as gender, age, and sector were assessed in the initial analysis. Due to their lack of statistical significance and minimal explanatory power, they were excluded from the final model to preserve parsimony and mitigate multicollinearity.

The instrument's reliability was verified with Cronbach's alpha of 0.875. Multiple linear regression was used to analyze the impact of HC, INFR, and BE on the entrepreneurial ecosystem index. All analyses were performed at a 5% significance level utilizing SPSS v25.

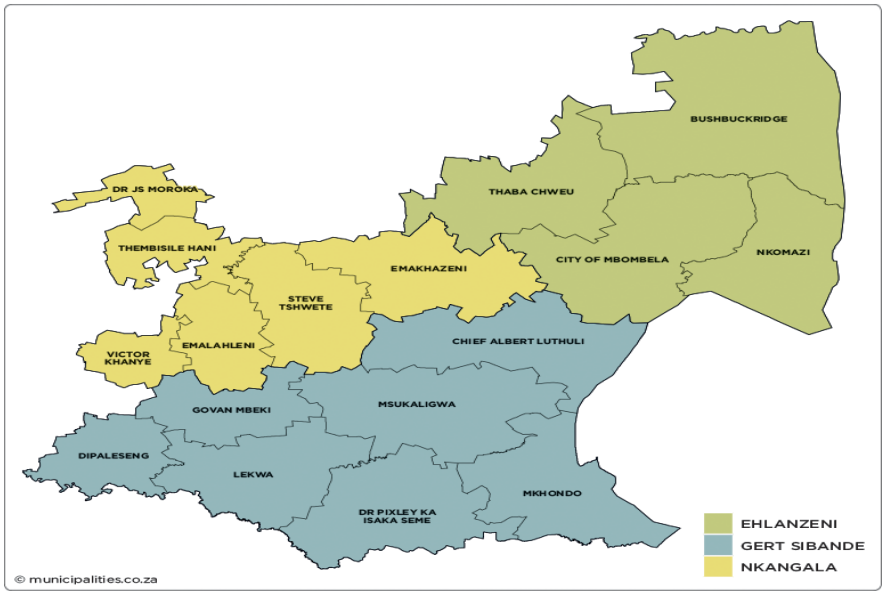

Figure 1. Mpumalanga Province map.

Multiple Regression

Multiple regression is a statistical technique used to analyze the relationships between a single dependent variable and several independent variables. The objective of multiple regression analysis is to use the independent variables with known values to predict the value of the single dependent variable. Each predictor value was weighed, and the weights denoted their relative contributions to the overall prediction. This study follows the methodology used in similar studies, such as the study of author [61], applying regression analysis and correlation analysis to the impact of economic factors on the business environment in East European countries. Author [16] also determined correlation and used regression analysis on entrepreneurial ecosystem elements and outputs for 273 European regions.

Data analysis: The model was conceptualized using a simple linear regression equation, as follows:

$$y = b1X1 + b2X2 + \ldots bnXn + c \quad (1)$$

where y is the dependent variable and X1, . . ., Xn are the n independent variables. In calculating the weights, a, b1, . . ., bn, regression analysis ensured maximal prediction of the dependent variable from the set of independent variables. This is usually performed by least squares estimation.

Where y is the output (Ecosystem),

b1, b2 + . . . bn are the coefficients of the variables to be estimated,

x1, x2 + . . . xn are the determinants of the Ecosystem, and c is the constant value. This can further be expressed as follows, taking our variables of interest into consideration:

$$Y = f\ (HC, INFR, BE) \quad (2)$$

where Y represents the output variable entrepreneurial ecosystem performance, and HC, INFR, and BE denote human capital, infrastructure, and business environment, respectively.

The dependent variable in this study is the Entrepreneurial Ecosystem Index, created as a composite measure that captures the perceptions of respondents regarding ecosystem performance. The independent variables consist of three contextual dimensions based on the literature: human capital, infrastructure, and business environment. These constructs were assessed using various survey questions and combined to analyze their individual impacts on the ecosystem index.

In the context of assessing the impact of human capital, infrastructure, and the business environment on the entrepreneurial ecosystem or broader economic ecosystem, linear regression enables the quantification of how each independent factor contributes to the outcome variable [76]. Linear regression is suitable when working with cross-sectional or panel data, which is typical in ecosystem studies. When assumptions such as linearity, independence, and homoscedasticity are met or accounted for, linear regression offers robust and replicable results. Furthermore, with the rise of digital and inclusive economies, recent studies, such as by author [77], use linear regression to analyze how education levels, access to finance, and infrastructure influence ecosystem vitality in developing regions. Linear regression effectiveness lies in its ability to isolate the individual contributions of these predictors while controlling for confounders.

Ecosystem data are often sparse, noisy, or only available as cross-sectional or short time series. Linear models perform relatively well with such data, whereas dynamic simulation and non-linear models often require long-term, high-frequency data and robust assumptions to be accurate. Linear regression can provide a baseline or benchmark for assessing the relationships between variables. Before modeling complex feedback loops, it helps to understand the direct, linear correlations between environmental and biological factors.

However, ecosystem models can quickly become complex with many interacting variables. Linear regression reduces the risk of overfitting and parameter uncertainty, especially when working with small datasets. In addition, the technique comes with a suite of well-established diagnostic tools (e.g., R^2, residual plots, *p*-values, AIC/BIC) that help assess the model's reliability and validity, making it more rigorous and statistically grounded for many empirical studies. Because of its simplicity, linear regression tends to be more replicable and generalizable across similar ecosystems, which is valuable for comparative studies and meta-analyses.

Table 1 presents descriptive statistics regarding the educational levels, sectoral distribution, and legal status of SME proprietors surveyed in Mpumalanga Province. The data indicate that a significant percentage of entrepreneurs have post-secondary education (56.4%), implying a substantial amount of human capital, which corresponds with the theoretical expectations that education improves entrepreneurial skills and involvement in ecosystems. Nevertheless, a significant portion of respondents have merely secondary education (35.5%), suggesting possible variations in skills and absorptive capacity, which could influence ecosystem integration and the spread of innovation.

Regarding business sectors, the dominance of service-focused companies (67.3%) illustrates the structural composition of the regional economy and aligns with worldwide trends where service industries increasingly accommodate small and medium enterprises. The relatively low representation in areas such as ICT (1.5%) and transportation (1.7%) might indicate restricted diversification, potentially limiting ecosystem resilience and adaptability, especially amid digital and logistical disruptions.

The legal-status distribution indicates that most SMEs function as limited liability companies (45.6%), with other informal or unclassified structures (28.3%) and corporations (26.1%) following. This legal diversity indicates different levels of formality, governance framework, and regulatory involvement, which are crucial related elements affecting entrepreneurial success and access to institutional support within the ecosystem. The

significant amount of missing data (~24%) across variables, though typical in survey studies, indicates the need for careful interpretation and may imply possible informational or reporting limitations among participants.

Table 1. Respondents' descriptives.

		Frequency	Percent	Valid Percent	Cumulative Percent
Highest Education Level of Owner					
Valid	No Education	25	1.3	1.7	1.7
	Primary	93	4.8	6.4	8.1
	Secondary	517	26.9	35.5	43.6
	Post-Secondary	822	42.8	56.4	100.0
	Total	1457	75.9	100.0	
Missing	System	462	24.1		
Total		1919	100.0		
Business Sector					
Valid	Services	992	51.7	67.3	67.3
	Tourism	89	4.6	6.0	73.4
	Agriculture	173	9.0	11.7	85.1
	ICT	22	1.1	1.5	86.6
	Manufacturing	109	5.7	7.4	94.0
	Construction	63	3.3	4.3	98.3
	Transportation	25	1.3	1.7	100.0
	Total	1473	76.8	100.0	
Missing	System	446	23.2		
Total		1919	100.0		
Legal Status					
Valid	Corporation	380	19.8	26.1	26.1
	Limited Liability Company	663	34.5	45.6	71.7
	Other	412	21.5	28.3	100.0
	Total	1455	75.8	100.0	
Missing	System	464	24.2		
Total		1919	100.0		

4. Findings and Discussion

The descriptive statistics shown in Table 2 offer essential insights into the distribution characteristics of the primary indices analyzed in this research specifically, the Ecosystem Index, human capital, infrastructure, and business environment across a sample of 1486 SMEs in Mpumalanga Province.

The Ecosystem Index shows an average value of 347.43, accompanied by a relatively high standard deviation of 181.97, indicating significant differences in the development of entrepreneurial ecosystems among the sampled businesses. This distribution implies that although some regions or companies may gain from robust ecosystem support systems, others face considerable shortcomings, possibly indicating uneven spatial or institutional growth.

The Summary Index of Human Capital indicates an average of 45.21 (SD = 27.74), highlighting restricted access to or development of necessary skills, education, and entrepreneurial

abilities among SME participants. The observed variability highlights differences in employee readiness, which may limit company productivity and innovation potential

Table 2. Descriptive statistics.

	Mean	Std. Deviation	N
Ecosystem Index	347.43	181.967	1486
Summary Index of Human Capital	45.21	27.744	1486
Summary Index of Infrastructure	45.37	26.329	1486
Summary Index of Business Environment	98.96	51.221	1486

Likewise, the Infrastructure Index, averaging 45.37 with a standard deviation of 26.33, indicates the overall weaknesses in the provision and quality of crucial infrastructure. This comprises both physical (e.g., roads, electricity) and digital infrastructure, which are essential for supporting enterprise activities and competitiveness. The degree of variation indicates unequal access to infrastructure, potentially obstructing entrepreneurial efforts in specific areas.

The Business Environment Index reveals an increased average of 98.96 (SD = 51.22), indicating that, in comparison, respondents view the regulatory and institutional environment more positively. However, the high standard deviation suggests that these conditions are not consistently encountered, and certain businesses may continue to encounter considerable administrative or financial obstacles.

In the aggregate, the data reveal that although some components of the entrepreneurial ecosystem—particularly the business environment—are perceived to be relatively well-developed, substantial heterogeneity exists across all dimensions. This underscores the need for geographically and sectorally targeted policy interventions aimed at enhancing human capital formation, addressing infrastructure gaps, and harmonizing institutional support to foster a more inclusive and cohesive entrepreneurial ecosystem in South Africa.

Overall, the data indicate that while certain elements of the entrepreneurial ecosystem, especially the business environment, are seen as fairly advanced, there is considerable variation across all aspects. This highlights the need for targeted policy actions that are geographically and sectorally focused to improve human capital development, tackle infrastructure gaps, and align institutional support to promote a more inclusive and unified entrepreneurial environment in South Africa

4.1. Post/Diagnostic Tests

1. Checking the Assumptions of Multiple Regression

Multicollinearity. The correlations between the variables in our model are provided in the table labeled correlations. The independent variables show reasonable relationship with our dependent variable. The values are all above 0.6. In this case, the three variables (human capital, infrastructure and business environment) correlate substantially with Ecosystem Index 0.791, 0.611, and 0.796, respectively). Also, the correlation between each of our independent variables is not too high. Author [78] suggest a bivariate correlation of less than 0.7, which is the case here to avoid multicollinearity. Thus, there is no need of omitting any variable from the model.

Nevertheless, SPSS also performs 'collinearity diagnostics' on the variables as part of the multiple regression procedure. This picks up on problems with multicollinearity that may not be evident in the correlation matrix. The results are resented in the table labeled Coefficients. Two values are given: Tolerance and VIF. Tolerance is an indicator of how much of the variability of the specified independent variable is not explained by the other

independent variables in the model and is calculated using the Formula (1)–R2 for each variable. If this value is very small (less than 0.10), it indicates that the multiple correlation with other variables is high, suggesting the possibility of multicollinearity. The other value given is the VIF (variance inflation factor), which is just the inverse of the Tolerance value (1 divided by Tolerance). VIF values above 10 would be a concern here, indicating multicollinearity. In this instance, the tolerance value for each independent variable is 0.730, 0.694, and 0.593, which is not less than 0.10; therefore, we have not violated the multicollinearity assumption. This is also supported by the VIF value, which is 1.369, 1.441, and 1.685, well below the cut-off of 10. These results are not surprising, given that the Pearson's correlation coefficients between these independent variables were not high.

2. Outliers, Normality, Linearity, Homoscedasticity, Independence of Residuals

One of the ways that these assumptions are checked is by inspecting the residuals scatterplot and the Normal Probability Plot of the regression standardized residuals that were done as part of the analysis. These are presented at the end of the output. In the Normal Probability Plot, it is expected that all points will lie in a reasonably straight diagonal line from bottom left to top right. This would suggest no major deviations from normality. In the Scatterplot of the standardized residuals (the second plot displayed), it is expected that the residuals will be roughly rectangularly distributed, with most of the scores concentrated in the center (along the 0 point). Our findings show that there is no clear or systematic pattern to our residuals (e.g., curvilinear, or higher on one side than the other).

Deviations from a centralized rectangle suggest some violation of the assumptions, which is not the case with our analysis. The presence of outliers can also be detected from the Scatterplot. Author [79] define outliers as cases that have a standardized residual (as displayed in the scatterplot) of more than 3.3 or less than −3.3. In our instance, there were only a few outlying residuals. The other information in the output concerning unusual cases is in the table titled Casewise Diagnostics. This presents information about cases that have standardized residual values above 3.0 or below −3.0. In a normally distributed sample, we would expect between 1% and 2% of cases to fall outside this range. In this study, we had less than 2% falling outside the range.

Nonetheless, to check whether these outliers are having any undue influence on the results for our model as a whole, we used the value for Cook's Distance given towards the bottom of the Residuals Statistics table. According to author [78], cases with values larger than 1 are a potential problem. In our analysis, the maximum value for Cook's Distance is 0.007, suggesting no major problems.

4.2. Evaluating the Model

A look in the Model Summary box indicates how much of the variance in the dependent variable (ecosystem) is explained by the model (which includes the variables of human capital, infrastructure and business environment). In this case, the value is 0.860. Expressed as a percentage (multiply by 100, by shifting the decimal point two places to the right), this means that our model explains 86 per cent of the variance in ecosystem. This is quite a respectable result (particularly when you compare it to some of the results that are reported in literature). Furthermore, our sample is quite high, so the R square value is not an optimistic overestimation of the true value in the population (see [78]). To assess the statistical significance of the result, the table labeled ANOVA provides the results. This tests the null hypothesis that multiple R in the population equals 0. The model in this example reaches statistical significance (Sig = 0.000, this really means $p < 0.0005$).

4.3. Evaluating Each of the Independent Variables

Partial R squared, which is an indication of the contribution of that variable to the total R squared, is estimated. In other words, it tells you how much of the total variance in the dependent variable is uniquely explained by that variable and how much R squared would drop if it were not included in the model. In this instance, the human capital has a part correlation coefficient of 0.425. If we square this (multiply it by itself), we get 0.18, indicating that mastery uniquely explains 18 percent of the variance in ecosystem scores. For infrastructure, the value is 0.158, which squared gives us 0.02, indicating a unique contribution of 2 percent to the explanation of variance in Ecosystem. business environment has a value of 0.339, which squared gives us 0.11, indicating 11 percent explanation to variance in ecosystem. Note that the total R squared value for the model (in this case 0.860, or 86 percent explained variance) does not equal all the squared part correlation values because the part correlation values represent only the unique contribution of each variable, with any overlap or shared variance removed or partialled out. The total R squared value, however, includes the unique variance explained by each variable and that shared.

The beta values obtained in this analysis can also be used for other, more practical purposes than shown here. Standardized beta values indicate the number of standard deviations that scores in the dependent variable would change if there were a one-standard-deviation-unit change in the predictor. This can be useful information, particularly when used in business settings.

The first step in our empirical analysis was the descriptive analysis, as shown in Table 2. The initial analysis revealed business environment as the variable with the greatest influence (mean = 98.96, SD = 51.22) on the Ecosystem Index, followed by infrastructure (mean = 45.37, SD = 26.33). The variable with the smallest influence on the ecosystem was human capital (mean = 45.21, SD = 27.74). The significant influence of business environment on the Ecosystem Index aligns with author [80] research, which indicated a significant impact on business development. This shows that firms that operate sustainably and responsibly may assist and contribute to a healthier environment. Furthermore, infrastructure's positive impact is likely due to its role in building productive entrepreneurship author [81] and supporting the development of skilled employees that can handle environmental issues [82].

To explore deeper into these relationships, the correlation matrix was computed as shown in Table 3. The correlation coefficients in the matrix show the correlation coefficient, which indicates the degree of the linear relationship between the variables. The results obtained show substantial positive correlations between the independent factors (human capital, infrastructure, and business environment) and the dependent variable (Ecosystem Index). Correlation coefficients between each independent variable and the Ecosystem Index are all more than 0.6 (range from 0.611 to 0.796), showing significant connections. In addition, the correlations between the independent variables are shown below 0.7, addressing issues regarding multicollinearity [78]. Business environment had the highest correlation with the Ecosystem Index, with a value of 0.796, closely followed by human capital, with 0.791. The lowest correlation between variables and the ecosystem index was 0.611. Table 4 demonstrates that multicollinearity, which can affect results, is not an issue in this analysis. Tolerance for values of all variables that are independent exceed 0.10 (ranging from 0.593 to 0.730), whereas VIF values range from 1.369 to 1.685. These values are below the concerning thresholds, showing that the independent variables are not strongly correlated and do not distort each other's effect in the model. This is consistent with the prior finding that Pearson's correlation coefficients amongst the independent variables were not high.

Another main assumption for regression analysis is normality of residuals. Figure 2 shows evidence indicating the normality of residuals, which is a necessary assumption for regression analysis. The Normal Probability Plot displays a straight diagonal line, showing no significant departures from normality [83]. In addition, the Scatterplot of standardized residuals shows a roughly rectangular distribution with the majority of scores categorized in the center, indicating no obvious patterns or biases in the residuals. Figure 3 illustrates the absence of deviations from a centralized rectangle, further demonstrating normality. While there are a few outliers, their standardized values are within acceptable limits ([78]: −3.3 to 3.3). Table 5 confirms this, showing that less than 2% of instances go beyond the predicted range for a normally distributed sample. Table 6 analyzes the possible impact of outliers on the entire model. Cook's Distance values for all instances are substantially below 1 (highest value: 0.007), suggesting that no single outlier has a significant impact on the regression findings. Collinearity and Casewise diagnostics are shown below as Tables 5 and 7. Table 8 lists the variables entered or removed. Also, Model Summary and ANOVA results are shown as Table 9 and Table 10 respectively.

Table 3. Correlations matrix.

		Ecosystem Index	Summary Index of Human Capital	Summary Index of Infrastructure	Summary Index of Business Environment
Pearson Correlation	Ecosystem Index	1.000	0.791	0.611	0.796
	Summary Index of Human Capital	0.791	1.000	0.365	0.509
	Summary Index of Infrastructure	0.611	0.365	1.000	0.544
	Summary Index of Business Environment	0.796	0.509	0.544	1.000
Sig. (1-tailed)	Ecosystem Index		0.000	<0.001	0.000
	Summary Index of Human Capital	0.000		0.000	0.000
	Summary Index of Infrastructure	0.000	0.000		0.000
	Summary Index of Business Environment	0.000	0.000	0.000	
N	Ecosystem Index	1486	1486	1486	1486
	Summary Index of Human Capital	1486	1486	1486	1486
	Summary Index of Infrastructure	1486	1486	1486	1486
	Summary Index of Business Environment	1486	1486	1486	1486

Table 4. Coefficients [a].

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-Order	Partial	Part	Tolerance	VIF
1	(Constant)	−14.458	4.259		−3.395	<0.001	−22.813	−6.103					
	Summary Index of Human Capital	3.266	0.075	0.498	43.813	<0.001	3.119	3.412	0.791	0.751	0.425	0.730	1.369
	Summary Index of Infrastructure	1.313	0.081	0.190	16.298	<0.001	1.155	1.471	0.611	0.390	0.158	0.694	1.441
	Summary Index of Business Environment	1.563	0.045	0.440	34.902	<0.001	1.475	1.651	0.796	0.672	0.339	0.593	1.685

[a] Dependent variable: Ecosystem Index.

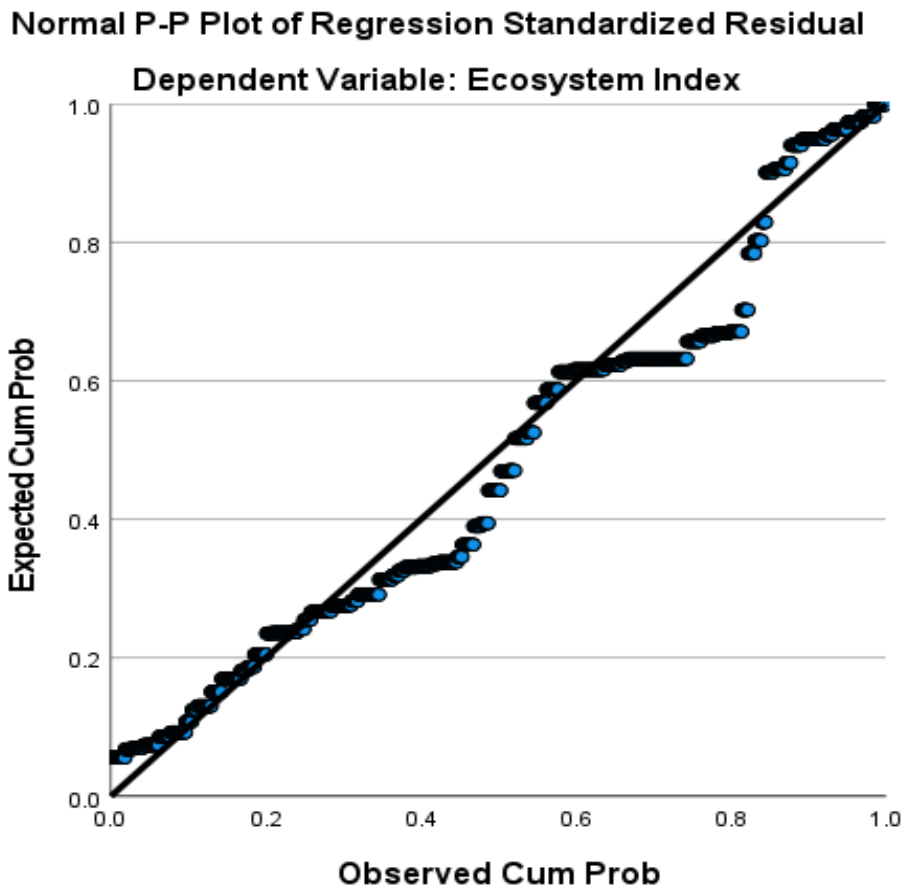

Figure 2. Normal P-plot.

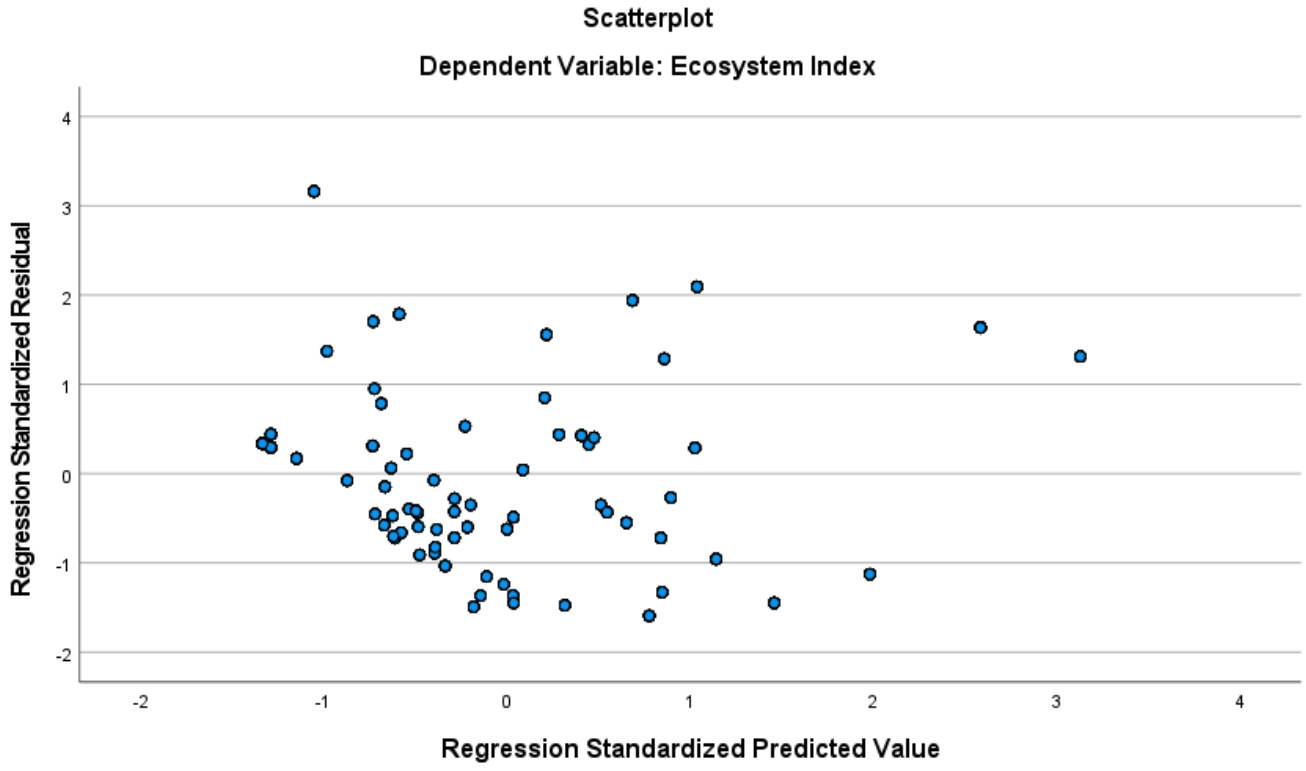

Figure 3. Scatterplot.

Table 5. Casewise diagnostics [a].

Case Number	Std. Residual	Ecosystem Index	Predicted Value	Residual
47	3.162	385	169.65	215.352
195	3.162	385	169.65	215.352
240	3.162	385	169.65	215.352
293	3.162	385	169.65	215.352
437	3.162	385	169.65	215.352
490	3.162	385	169.65	215.352
537	3.162	385	169.65	215.352
628	3.162	385	169.65	215.352
719	3.162	385	169.65	215.352
902	3.162	385	169.65	215.352
955	3.162	385	169.65	215.352
1002	3.162	385	169.65	215.352
1025	3.162	385	169.65	215.352
1085	3.162	385	169.65	215.352
1233	3.162	385	169.65	215.352
1278	3.162	385	169.65	215.352
1435	3.162	385	169.65	215.352
1583	3.162	385	169.65	215.352
1679	3.162	385	169.65	215.352
1724	3.162	385	169.65	215.352
1754	3.162	385	169.65	215.352
1807	3.162	385	169.65	215.352
1952	3.162	385	169.65	215.352

[a] Dependent variable: Ecosystem Index.

Table 6. Residuals Statistics [a].

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	122.06	875.51	347.43	168.771	1486
Std. Predicted Value	−1.335	3.129	0.000	1.000	1486
Standard Error of Predicted Value	1.969	6.450	3.324	1.198	1486
Adjusted Predicted Value	122.01	874.74	347.40	168.702	1486
Residual	−108.390	215.352	0.000	68.031	1486
Std. Residual	−1.592	3.162	0.000	0.999	1486
Stud. Residual	−1.593	3.165	0.000	1.001	1486
Deleted Residual	−108.538	215.661	0.035	68.254	1486
Stud. Deleted Residual	−1.594	3.174	0.001	1.001	1486
Mahal. Distance	0.243	12.323	2.998	3.218	1486
Cook's Distance	0.000	0.007	0.001	0.001	1486
Centered Leverage Value	0.000	0.008	0.002	0.002	1486

[a] Dependent Variable: Ecosystem Index.

Table 7. Collinearity diagnostics [a].

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions			
				(Constant)	Summary Index of Human Capital	Summary Index of Infrastructure	Summary Index of Business Environment
1	1	3.606	1.000	0.01	0.01	0.01	0.01
	2	0.169	4.622	0.02	0.74	0.37	0.00
	3	0.132	5.223	0.91	0.08	0.30	0.02
	4	0.093	6.227	0.06	0.17	0.32	0.97

[a] Dependent variable: Ecosystem Index.

Table 8. Variables entered/removed.

Model	Variables Entered	Variables Removed	Method
1	Summary Index of Business Environment, Summary Index of Human Capital, Summary Index of Infrastructure		Enter

Table 9. Model summary [b].

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	0.927 [a]	0.860	0.860	68.100	0.860	3040.236	3	1482	0.000	1.917

[a] Predictors: (Constant), Summary Index of Business Environment, Summary Index of Human Capital, Summary Index of Infrastructure; [b] Dependent variable: Ecosystem Index.

Table 10. ANOVA [a].

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	42,298,248.837	3	14,099,416.279	3040.236	0.000 [b]
	Residual	6,872,931.934	1482	4637.606		
	Total	49,171,180.771	1485			

[a] Dependent variable: Ecosystem Index; [b] Predictors: (Constant), Summary Index of Business Environment, Summary Index of Human Capital, Summary Index of Infrastructure.

The strong positive correlation (0.796) between business environment and Ecosystem Index aligns with author [84] study, which demonstrates that a healthy business climate that encourages sustainable practices has the greatest positive influence on the ecosystem. Infrastructure has the lowest correlation (0.611), but still has a favorable impact. However, authors [85] research, on the other hand, shows that more research into human capital is required. The high correlation between the Environmental Performance Index (EPI) and human capital implies that skilled labor is essential for maximizing the positive impact of a strong business environment on the ecosystem. Moreover, the regression analysis reveals that human capital has the strongest unique effect on explaining the ecosystem, even when considering the variance explained by other variables in the model, as shown by the largest beta coefficient (0.498). This suggests a critical role for a skilled workforce in fostering a healthy ecosystem. However, the role of human capital in ecosystem explanation is a complex and multidimensional subject. Author [86] highlights the potential of a negative influence, suggesting that human capital focused on innovation could hinder ecological growth. This highlights the significance of addressing the direction and kind of human capital development.

While human capital has the greatest impact, the business environment also plays a vital role. Its beta value (0.440) is the second highest, indicating a significant unique impact on the ecosystem. According to author [87], the business environment is impacted by several kinds of elements and plays an important role in the development of business ecosystems. These ecosystems, which differ by their influence on human potential and the market, are controlled by technological developments and self-regulation [88]. Business and ecosystems have a complex relationship that presents both challenges and possibilities [89]. A conducive business environment that promotes sustainable practices is critical for development and profitability, making it an important goal for governments as well as companies [90]. This supports the notion that an efficient business environment has a positive effect on the ecosystem. Human capital, as measured by education and skill levels, has a substantial positive effect on environmental performance [91,92]. This is particularly clear in terms of biodiversity, habitat, as well as sustainable agriculture [91]. The relationship between human capital and environmental sustainability is complicated, with the influence of human capital on ecological footprint varying depending on income level and population size [93]. However, the consensus holds that a one-standard-deviation increase in human capital might result in a greater shift in ecosystem scores than an equivalent rise in infrastructure or business environment.

The significant coefficients of human capital (0.4980), infrastructure (0.190), and business environment (0.440) on the Ecosystem Index suggest a layered and impactful relationship, each with distinct contributions to the strength and resilience of economic ecosystems. With the highest coefficient, human capital (0.4980) shows the strongest positive impact on the Ecosystem Index, underscoring the role of skilled, educated, and adaptable workforces in fostering sustainable economic environments. Human capital enhances productivity, innovation, and efficiency, driving competitive and sustainable economic ecosystems. This aligns with findings from author [94] and [8], who emphasize the critical link between education, skills development, and ecosystem resilience. Regions with strong human capital tend to better adopt sustainable practices and technology, amplifying their capacity to respond to environmental and economic shifts effectively.

The business environment coefficient of 0.440 highlights the significant influence of favorable regulatory and competitive landscapes on the Ecosystem Index. An efficient business environment encourages innovation and the adoption of eco-friendly practices, reducing barriers and fostering a robust ecosystem. Author [11] theories on competitive advantage suggest that business environments conducive to innovation and efficiency boost the economy's ability to sustain growth and environmental balance. Policies that reduce bureaucratic constraints and promote business adaptability enable firms to respond to market demands, incorporating sustainable practices that strengthen the ecosystem overall.

Although lower than human capital and business environment, infrastructure's coefficient of 0.190 is still notably positive, reflecting its essential yet supporting role. Effective infrastructure—particularly in energy, transport, and digital networks—provides the physical foundation necessary for sustainable growth. The impact of infrastructure, according to studies by author [7] and [10], is critical for reducing operational costs, lowering emissions, and enhancing connectivity, all of which support sustainable economic ecosystems. Sustainable infrastructure can thus minimize environmental impacts and increase resilience to economic and ecological disruptions, positively contributing to the ecosystem. These interactions highlight the need for integrative policies to enhance ecosystem resilience through human, structural, and environmental efficiencies.

5. Conclusions

The study looked at how contextual variables affected South Africa's entrepreneurship ecosystem. The analysis, which was supported by existing literature, looked at how the business environment, infrastructure, and human capital affected the overall health of the ecosystem. The findings highlight the importance of all three elements, with business environment having the largest positive link with the Ecosystem Index. This is consistent with previous study, which found that a business climate that prioritizes sustainable practices promotes healthier ecology [84]. Similarly, proper infrastructure is crucial, most likely because it promotes productive entrepreneurship and the development of a competent workforce capable of dealing with environmental issues. Remarkably, human capital emerged as the element with the most distinctive effect on the ecosystem, even after accounting for the effects of other factors. This suggests that skilled labor is necessary for a healthy ecology. However, the relationship between human capital and the environment is complicated. While research indicates positive effects on environmental performance [91], ref. [86] highlights worry about the possible detrimental consequences of innovation-focused human capital on ecological health. This highlights the need to guide human capital development towards sustainable activities.

Government policies and procedures should encourage sustainable business practices. This might include encouraging the implementation of environmentally friendly technology, providing incentives for responsible waste management, and creating a culture of corporate social responsibility. Strategic investments in infrastructure projects could significantly help the ecosystem. This involves increasing access to reliable energy sources, upgrading transportation networks, and building communication infrastructure, particularly for disadvantaged areas. Educational programs and training efforts should be developed to provide the workforce with the knowledge and skills required to handle environmental issues. This might include encouraging green technology, sustainable agriculture methods, and environmental management knowledge. An "information apparatus" that facilitates the free flow of knowledge, especially in rural regions, is critical. This might include establishing online information portals, organizing workshops and seminars, and using local media outlets to convey pertinent information about sustainable business practices and related support services. The government should explore expanding the number and scope of incubator and accelerator programs aimed exclusively at ecologically conscious entrepreneurs. Such programs can help with business planning, mentoring, and access to financing.

5.1. Synthesis and Policy Recommendations

The regression coefficients indicate that improving the Entrepreneurial Ecosystem Index requires a multidimensional policy strategy that simultaneously focuses on education, institutional changes, and infrastructure growth. A synergistic approach that promotes a skilled and environmentally conscious workforce, enhances regulatory policies, and allocates resources for sustainable infrastructure is expected to produce fundamental enhancements in the ecosystem's resilience and efficiency.

5.2. Policy Recommendations Include

- **Human capital**: Allocate resources for educational and vocational training initiatives that support goals of the green economy. Curricula must highlight sustainable technologies, environmental stewardship, and entrepreneurial skills.
- **Business environment**: Simplify regulatory processes to minimize bureaucratic obstacles and supports environmentally sustainable businesses. Priority should be given

to incentives for embracing green innovation and implementing corporate social responsibility practices.

- **Infrastructure**: Enhance accessibility to dependable energy, upgrade transportation and communication systems, and promote fair infrastructure growth throughout urban and rural regions with an emphasis on sustainability

In addition, establishing effective information-sharing infrastructure digital platforms, community workshops, and media involvement can boost awareness and promote knowledge transfer regarding sustainable practices. Enhancing incubator and accelerator initiatives targeting environmentally aware businesses can strengthen both entrepreneurial achievements and environmental results.

6. Limitations and Directions for Future Research

6.1. Limitations of the Study

Several limitations need to be recognized. Firstly, the analysis relies on cross-sectional data, which restricts the ability to determine causal links. Secondly, while stratified sampling was utilized, the research was geographically limited to Mpumalanga Province, which may constrain the applicability of results to other areas in South Africa. Third, the model did not include demographic control variables (e.g., gender, age, sector), which could influence ecosystem dynamics. Finally, the Entrepreneurial Ecosystem Index was based on self-reported views, which could lead to response bias.

6.2. Future Research

Future studies should explore longitudinal or panel data designs to reflect the changing dynamics of ecosystem evolution over time. Furthermore, broadening the geographic range to encompass various provinces or performing comparative regional studies would yield more profound understanding of spatial ecosystem diversity. Further studies should additionally include control variables and investigate the interactions among demographic and contextual factors (e.g., gender-related access to finance, sectoral variations). Lastly, incorporating qualitative methods or mixed-method approaches eventually enhances the understanding of ecosystem mechanisms, particularly the influence of informal institutions and cultural factors.

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