The impact of entrepreneurial ecosystems and sustainable digital innovation on business performance: a study of Gilgit-Baltistan Pakistan

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Small and medium-sized enterprises (SMEs) in Gilgit-Baltistan are faced with
several critical sustainability-oriented problems within the entrepreneurial
ecology. This includes resistance to change, myopic thinking of looking for
short-term gains and facing problems accessing advanced technology in a
new environment. Thus, this study examines the multifaceted relationships
(considering entrepreneurship education, entrepreneurial culture, government
support, and social support), sustainable digital innovation, and business
sustainability performance, with a particular emphasis on SMEs in rural areas.
A total of 13 hypotheses are proposed in this study to examine the above
phenomena. Data were collected from 431 participants in Gilgit-Baltistan,
Pakistan, through a questionnaire survey, and the data was analyzed using
partial least square structured equation modeling (PLS-SEM) to reveal empirical
outcomes. The findings acknowledge that the entrepreneurship ecosystem
(entrepreneurship education, entrepreneurial culture, government support, and
social support) and sustainable digital innovation play a significant role in
influencing the performance of sustainable businesses. Furthermore, sustainable
digital innovation plays a positive mediating role between the entrepreneurial
ecosystem and business sustainability. The research revealed that business
sustainability increases with the positive role of different dimensions of the
entrepreneurship ecosystem. The findings of this study are discussed within
the "ecological modernization theory (EMT)" and add to the understanding of
different sets of relationships that provide a theoretical framework. The study
provides ways for different stakeholders in SMEs to handle the entrepreneurship
ecosystem, sustainable digital innovation, and sustainable business performance.

KEYWORDS

entrepreneurship ecosystem, sustainable digital innovation, business sustainable
performance, social performance, small and medium-sized enterprises

1 Introduction

The entrepreneurship ecosystem is the network of people, resources, and
environmental conditions that facilitate entrepreneurial action in a locality (Trabskaia
et al., 2023). This system fast forward not only the roles of entrepreneurs but also investors,
mentors, schools and learning institutions (including policymakers), and agencies for

management authorities. It also involves the law and order scenario that is followed around business houses, availability of infrastructural facilities, and technology. A robust entrepreneurship ecosystem ensures the production, propulsion, and proliferation of start-ups by offering a conducive environment as well as a support system (Fubah and Moos, 2022). It also encourages participants to work together and share information that will ultimately promote innovation and economic growth.

Multiple research investigations demonstrate the relationship between entrepreneurial ecosystem strength and business operational outcomes. According to Alkaabi et al. (2024), healthy entrepreneurship ecosystems promote startup development along with developing infrastructure that supports long-term family business expansion. According to Autio and Thomas (2022) research findings, businesses located in entrepreneurial ecosystems that prioritize innovation exhibit greater productivity features. Studies indicate that R&D promotion together with technology adoption across ecosystems results in better sustainable outcomes. According to Audretsch et al. (2021), the sustainable performance of businesses depends on regulatory structures and access to markets and financial resources that function within entrepreneurial ecosystems.

In contrast, the entrepreneurship ecosystem in developing countries typically faces numerous critical challenges, inhibiting its growth and effectiveness (Zaidi et al., 2023; Abid et al., 2024). Regulatory obstacles and government red tape also converge beyond to significantly hamper the ability of entrepreneurs to launch and expand businesses (Basit et al., 2024). Potential entrepreneurs are unaware of how to move in complex business terrains due to the lack of technical skills and low entrepreneurial training. In addition, cultural and social factors prevent and penalize entrepreneurial efforts as a high-risk activity (Fubah and Moos, 2022). These issues require a well-rounded solution including accessing capital, better infrastructure development, reducing red tape, and improving education.

Researchers have seen significant growth in studies about business sustainable performance throughout the past several decades, but multiple research gaps need further exploration. Extensive research already investigates how business sustainable performance interacts with external variables. In their study, Abid et al. (2024) showed sustainable performance strengthens entrepreneurial orientation, which enables businesses to innovate proactively while taking risks to achieve long-term value creation. Basit et al. (2024) analyzed how government policies as well as workplace elements impede entrepreneurial leaders from following sustainable standards. Mokbel Al Koliby et al. (2024) discovered a direct positive relationship between sustainable performance and entrepreneurial competencies. Figueiredo et al. (2024) studied the effects of diverse forms of business cooperation on small and medium-sized enterprise (SME) environmental sustainability innovation through their finding that national and European partnerships significantly enhance this innovation. Aisjah et al. (2023) found that strategic agility acts as a moderator to enhance social capital as a predictor of business performance through combined activities of holding social capital and collaborative knowledge creation and technology adoption. Aggressive integration approaches for sustainability into

business models encounter complex challenges when applied to environmental ecosystems and technological advancements. Academic progress demands attention to these knowledge gaps because their resolution delivers both theoretical insights and actionable options to businesses pursuing sustainable practices without compromising their competitive abilities.

However, it is also the case, especially in developing countries that many of these problems are a combination of systemic and structural issues within the entrepreneurship ecosystem (Ahmetaj et al., 2023). One primary issue is that the limited infrastructure (electricity, transport, and internet access in rural areas) leads to major operational challenges for entrepreneurs (Kuebart, 2022). A related critical factor is the lack of an incremental push for entrepreneurial education and training, which has led to a dearth of these requisite skills among many newcomers. Finally, the sociocultural stigmas related to failure as a negative attribute can deter people with potential entrepreneurial cultures from entering their businesses. Not surprisingly, these problems tend to be related: a vicious circle that keeps entrepreneurship and innovation at bay.

The entrepreneurial ecosystem of Gilgit-Baltistan's mountainous northern Pakistan territory encounters three major obstacles involving educational deficits for entrepreneurs alongside cultural resistance and scarce state and societal backing. To harness the entrepreneurial potential of the area, governmental institutions alongside outside stakeholders must unite in comprehensive support that emphasizes educational development and skills training alongside productive networking initiatives to address the existing obstacles. Strategic investments combined with targeted interventions present the opportunity for Gilgit-Baltistan to build a dynamic, sustainable entrepreneurship ecosystem.

An obvious problem of entrepreneurship education, due to the shortage of good educational resources and experienced instructors leads to incompetency in training programs. Furthermore, the educational content is also disconnected from what the businesses require as often does not address the actual needs faced by entrepreneurs in these regions (Sitaridis and Kitsios, 2024). Another problem is the fear of failure, which comes both from social stigmas around business failures and the absence of a safety net for them (Bejarano Auqui et al., 2022). Meeting these challenges requires a cultural shift, improved support mechanisms, and an environment that values entrepreneurial activities.

Furthermore, There is a lack of mentors and professionals in the industry who directly provide insightful suggestions to upcoming entrepreneurs. Moreover, the informal networks and professional associations may be immature creating limited opportunities for entrepreneurs to meet peers, investors, or potential partners (Kipkosgei, 2022). Social support is an essential component of the entrepreneurship ecosystem, and it includes all informal and formal networks that provide entrepreneurs with positive encouragement emotional resources, and guidance (Kipkosgei, 2022). Social support networks can provide useful information and emotional encouragement: as well as help connect with possible investors, customers, and partners. In addition, political instability and policy shifting impede investment by creating ambiguity that precludes long-term planning for entrepreneurial projects (Belitski et al., 2024).

Despite the potential, in Gilgit-Baltistan, there are many critical challenges for a sustainable and equal opportunity development of enterprises (Batool et al., 2024). Sustainable operational success within the entrepreneurship ecosystem is difficult to achieve and maintain over extended periods. Sustainable Business Performance is a way for businesses to achieve long-term success by focusing on their economic, environmental, and social impact. The main problem is related to unreliable infrastructure (Thai et al., 2023; Mokbel Al Koliby et al., 2024). Second, the very nature of regulatory and legal gray areas can lead to an unpredictable business environment that businesses often find difficult to scope. The unavailability of skilled workers and entrepreneurial education even worsens the issue as entrepreneurs may not know useful information on how to plan strategically and administer well. Unpredictable market volatility and economic instability, including the demand that shifts frequently due to social or commercial trends as well as currency devaluation, will further frustrate efforts at maintaining sustainable performance.

Based on the above dimensions, this research specifically considered certain aspects and defined specific problems to achieve sustainable business performance in the SMEs of Gilgit-Baltistan via the entrepreneurship ecosystem and sustainable digital innovation in their pursuit of sustainability dimensions. A conceptual model was initially developed to explain how each aspect of the entrepreneurship ecosystem (governmental support, education and training, social dimension, and culture) could ameliorate business sustainability performance. The study also aims to investigate the influence of support mechanisms (e.g., government policies, incubators, and mentorship programs) on entrepreneurial resilience and performance. In light of the above research problem, the following research objectives have been developed:

(1) To investigate the impact of entrepreneurship ecosystem (education, culture, government, and social support), and sustainable digital innovation on SMEs performance in terms of business sustainable performance.
(2) Investigate the relationship of sustainable digital innovation with entrepreneurial ecosystem (education, culture, government, and social support) and business sustainable performance with direct and mediating mechanisms.
(3) Utilize modern analytical methods to precisely and realistically depict data, providing valuable theoretical and practical insights.

The findings of this study will extend the Ecological Modernization Theory (EMT) to a new domain and also discover relationships among variables that are not well documented in the existing literature. These findings are useful for small business owners who can use them to improve performance by creating positive environmental externalities in neglected areas and also help them save on productivity costs via resource efficiency. In the end, we hope to arrive at suggestions and ideas of how entrepreneurship can be supported as a lasting activity in low-income countries which might enhance sound business behavior with positive economy-wide effects.

2 Literature review

2.1 Theoretical foundation

According to Ecological Modernization Theory (EMT), sustainable environmental outcomes can be reached by putting environmental priorities inside contemporary economic models and technological structures instead of seeking total lifestyle and economic structure alterations (Ratnawati et al., 2024). The theory states that development and environmental protection exist independently of each other because contemporary institutions, along with modern technologies, work together to maintain harmony for both. EMT sets forth a positive prediction of societal trends by arguing economic expansion and ecological welfare representation do not need to operate against each other (Siddik et al., 2023). EMT indicates the potential to launch societal modernization accompanied by better environmental performance through technological progress and institutional evolution together with market-based solutions.

Both fields of entrepreneurship and ecosystems work together because they focus on technological innovation while encouraging institutional and market-oriented solutions and sustainable business practices. Through EMT, we grasp how environmental tools fit economic expansion, and the entrepreneurship ecosystem demonstrates real methods through which integration occurs. The combination reveals entrepreneurship ecosystems as essential elements for creating sustainable institutional changes and innovation, which paves the way for businesses to pursue economic development alongside environmental sustainability.

EMT demonstrates entrepreneurs' vital contribution to sustainability through their work developing green technologies along with business models that support ecological aims in entrepreneurship ecosystems. Smart energy management systems and resource-efficient digital platforms propel operational efficiency while advancing environmental sustainability, which enables better business sustainable performance. The entrepreneurship ecosystem enables sustainable digital innovation commercialization through government and private sector and entrepreneurial collaboration mechanisms. EMT's basic philosophy of economic development, supporting environmental protection through innovative practices, guides long-term sustainability in business operations (Ratnawati et al., 2024). Industrial ecosystems benefit from EMT guidelines to achieve sustainable digital transformation, which yields environmental benefits alongside economic development. This alignment helps to ensure that sustainability efforts have both the right metrics and a pathway for making them more meaningful in underpinning business longevity.

2.2 Entrepreneurship education and business sustainable performance

Aspiring entrepreneurship education is imperative to the development of future entrepreneurs and successful businesspeople. It provides people with the necessary ideas on how to spot opportunities, conceptualize business ideas,

and manage startup necessities (Banha et al., 2022). The ability to think critically, solve problems, and take risks is honed by entrepreneurship education, as actual practice is bled with theoretical concepts. Entrepreneurship education has a huge impact on sustainable business performance by empowering entrepreneurs with crucial skills and knowledge to lead their businesses sustainably (Miço and Cungu, 2023). It gives them a base in strategic planning, financial management, and risk assessment to make the informed decisions they need to maintain operational efficiency.

In the current literature, there is strong evidence of a positive association linking entrepreneurship education and business sustainable performance indicating that an educational program focusing on entrepreneurship has a substantial influence on the sustainability outcomes for organizations (Miço and Cungu, 2023). Ratnawati et al. (2024) demonstrated that financial literacy acts as a main force behind Indonesian citizens' access to finance through fintech solutions that improve sustainability performance. Siddik et al. (2023) established that sustainability performance in firms requires both fintech adoption (FA) and financial literacy (FL). Research also shows that entrepreneurship education provides critical competencies on sustainability (Lv et al., 2022), such as new forms of enterprise creation (innovative business models), means for resource use and stewardship/resource efficiency, and environmental management. This kind of learning helps build a mindset that is about embedding sustainability right from the start, principles with which executives are already familiar. Examples of this include a greater likelihood to adopt eco-friendly practices, develop green technologies, or pursue business models that balance long-term environmental and social objectives. In addition, rather than simply showing the pros and cons of becoming a sustainable entrepreneur in traditional formats experiential learning opportunities must demonstrate to students via practice how sustainability principles can be incorporated into their business (Motta and Galina, 2023). Starting with an education on the benefits and cost savings that implementing sustainable practices can have as a future entrepreneur will undoubtedly benefit in terms of environmental impact, while at the same time improving business performance (Carpenter and Wilson, 2022). However, the nature of this relationship can differ in terms of how broad and or focused such programs are, as well as whether sustainability is part of regular curricular components.

Entrepreneurship education is critical for sustaining economic growth, job creation, and sustainable performance through fostering creativity and resilience. It also creates a link between knowledge and practical application, preparing students for the challenges of an actual business situation. Therefore, the following hypothesis is postulated:

H1: Entrepreneurship education positively impacts the business sustainable performance.

2.3 Entrepreneurial culture and business sustainable performance

An entrepreneurial culture is a necessary ingredient to stimulate innovation and economic development in any community or organization. It is a set of values, attitudes, and practices that encourage innovation, risk-taking, creativity, and an action-oriented approach to problem-solving (Porfírio et al., 2023). A strong entrepreneurial culture encourages people to think outside the box, challenge norms, and take advantage of opportunities with persistence only found in a few places.

Using earlier research as a basis, it can be argued that there is indeed an important relationship between the culture of entrepreneurship and business performance in terms of sustainability. By using innovation-, risk-taker- and adaptability-focused entrepreneurs for one's company, one may create more focused results to improve its surrounding society (Emon and Khan, 2023). Likewise, empirical studies suggest firms with a culture that is highly entrepreneurial and also scores high on ethical values result in strong sustainability performance due to ethic-based business practices (Daradkeh, 2023). The extent to which entrepreneurial culture influences sustainable performance would probably depend on to what extent the organization is committed to embedding sustainability as core values and practices (Rosário et al., 2022). On aggregate, the literature suggests that nurturing such an entrepreneurial culture for innovation and ethics largely enhances business sustainability.

An innovative, adaptive, and effective entrepreneur culture can greatly increase the sustainability of business operations (Arabeche et al., 2022). Additionally, an entrepreneurial culture typically places importance on social responsibility and ethical practices. This can help companies manage the expectations of more socially aware consumers through a positive brand reputation. This drives a wellspring of creativity, reminding people that truly green choices are risky but invaluable ones as they lead to better outcomes and innovation in sustainability, advancing business solutions that bridge both corporate deliverables with universal aspirations (Wang and Huang, 2022). In the end, an entrepreneurial culture delivers agility and energy that allows continuous growth in active alignment with business objectives as well as societal mores. Hence the following hypothesis has been developed:

H2: Entrepreneurial culture positively impacts the business sustainable performance.

2.4 Government support and business sustainable performance

Governmental assistance plays a very pivotal role in the sustenance of an active ecosystem, through proffering varied support tools and plans that will enable them to keep budding startups. This typically involves financial support in the form of grants, rebates, and concessional loans to phase out some burden placed on new businesses (Khan et al., 2022). Outside financial help, governments often finance infrastructure like business incubators and accelerators on innovation hubs that connect entrepreneurs to mentors, networking services as well as crucial resources.

The literature highlighted that effective government support is necessary to improve how businesses perform in a sustainable composting system and can be used as a driver of pro-environmental behavior by reducing financial and informational hurdles while providing again with regulation (Kurniawan et al.,

2023; Ullah et al., 2023). Recent research shows that financial support in the form of government subsidies, tax allowances, grants, and policy frameworks reduce transaction costs as well as uncertainties related to adopting sustainable practices (Huang et al., 2022a). This type of support incentivizes enterprises to invest in clean technologies, renewable energy, and green processes that they may not have otherwise due to cost barriers. Research also suggests that transparent and consistent environmental regulations help create a stable atmosphere in which all businesses are motivated to ensure their operations match society's sustainability ideals (Almeida and Wasim, 2023). In addition, government-sponsored programs that supply advice, resources, and technical assistance to help businesses develop tailored sustainability solutions must be strengthened (Wentzel et al., 2022). The government's positive role in enhancing sustainable performance depends on appropriate policy congruence with industrial requisites and how the policies are carried out.

Similarly, state and federal government-backed institutions in the form of business incubators and accelerators can supplement an ecosystem by providing valuable mentorship networks (Pattanasak et al., 2022). Government support that nurtures stability in the operating regulatory system and removes entry barriers helps companies to develop their resilience, flexibility to market adjustments, and competitiveness which will eventually lead them to increased sustainability of performance over time (Chowdhury et al., 2022). Government initiatives play an integral role in the growth and sustenance of a vibrant ecosystem by creating an environment conducive to innovation, and risk-taking which is essential for sustainable performance. Thus, the following hypothesis is formulated:

> H3: Government support positively impacts the business's sustainable performance.

2.5 Social support and business sustainable performance

Social support is crucial for helping entrepreneurs navigate the highs and lows of starting and running a business (Li et al., 2022b). Moreover, networks can provide useful aid as well; guidance in the going of business cases and contacts with industry assistance besides extensive chances for teamwork. In addition, community learning and networking events have helped those obstacles even more blurred with access by allowing people to dip in and out of communities where they also may meet potential investors or previous company owners who will suddenly become mentors (Rehman et al., 2022). The evidence indicates that solid social support may have both a decisive and instrumental value in improving sustainable business performance through promoting an enabling environment as well as aligning corporate practices with those of societal values (Canedo-García et al., 2022).

Prior research points toward a robust link between social support and business sustainable performance revealing how community collaboration and stakeholder engagement may result in sustainability outcomes (Suriyankietkaew et al., 2022). The presence of social support, (i.e., that received from

local communities, consumers, NGOs, and other operational stakeholders) contributes an important determinant to any organization adopting the principles of sustainability (Abiddin et al., 2022; Kipkosgei, 2022; Elshaer et al., 2023). The social support for this will then tend to be converted into consumer loyalty and make the market differentiation where companies who are more sustainable find themselves applauded simply through public perception with it translating well on their overall performance. Similarly, it offers an immense pool of resources and expertise complemented by rich networks related to sustainability from NGOs and various community groups which can enrich the way businesses can implement a sustainable strategy (Sanchez-Planelles et al., 2022). Additionally, research illustrates that firms that enjoy a supportive social environment, tend to engage in more socially responsible practices and possess an improved environmental profile as well due both to external pressures and also owing their accountability toward the stakeholder base (Ogujiuba et al., 2022). This relationship can, however, be contingent on the type of support and business response to stakeholder advice or the level of community engagement.

Powerful social networks provide emotional support that helps an individual to decline the natural problems with developing a business (Hossain et al., 2024). The collaborative relationships and community engagement create an environment of knowledge sharing, and innovation to support better problem-solving methods and strategy planning (Tseng et al., 2022). It helps entrepreneurs build resilience, adapt to variable market conditions, and keep a competitive edge leading to higher performance levels of businesses for sustainable growth. When a favorable sociocultural environment is well taken care of, this reassures entrepreneurs and they feel the courage to prolong their actions and come up with sustainable business growth that helps economic increases. Therefore, the following hypothesis is proposed:

> H4: Social support positively impacts the business's sustainable performance.

2.6 Sustainable digital innovation and business sustainable performance

Sustainable digital innovation coordinates principles of sustainability to the deployment, design, and development of digital technologies aiming to reduce ecological impact in parallel with improving operational efficiency (Khrais and Alghamdi, 2022). In practical terms, this could include activities such as the development of energy-efficient software, encouraging data centers to rely more heavily on renewable sources for power generation, and building platforms that facilitate a circular economy.

Prior studies suggested that technological innovation can positively affect the quality of sustainable performance in business by fostering improvements both on the environmental and operational fronts (Huang et al., 2022b; Sarfraz et al., 2022; He et al., 2024). According to studies, these responsible digital innovations such as sustainable technologies and processes aimed at saving energy costs reducing waste, or enhancing resource utilization have positive effects on business by optimizing the allocation of

resources (land, water, or other materials), eliminating deadweight loss in production or distribution cycle and decline costing for operations (Sarfraz et al., 2022; Figueiredo et al., 2024). These efficiencies have to do with environmental sustainability and a lead leg up by allowing companies not only to comply more effectively through regulatory obligations but also meet consumer demand for increasing appetite for greener practices. The research confirms companies using these technologies are typically more efficient and productive, which pays off by enhancing the bottom line while simultaneously advancing sustainability targets (Yin et al., 2022). This will encourage business model innovation to support circular economy principles and long-term environmental goals. The actual outcomes are contingent on several factors such as an organization's ability to incorporate new technology, investment in digital infrastructure, and also how coherent a particular strategy is with wider sustainability goals. In sum, the literature suggests that sustainable digital innovation is critical for a business to be sustainably performant and offers many potential resultant environmental savings as well as operational efficiency benefits (Xu et al., 2022; Aisjah et al., 2023).

Finally, taking a sustainable approach toward digital innovation tends to not only increase long-term economic growth but also benefit in terms of a positive reputation for companies and ecosystem alignment with wider environmental and social goals which all indicate more resilient system longevity (Agrawal et al., 2022). Pakistan can facilitate digital innovation in an environmentally and economically sustainable way by providing a conducive environment of infrastructure investment, policy support, education, and collaboration. Businesses have to embed sustainability next to their digital advancements, for them not only to reap long-term value but also to reduce their carbon footprint and contribute toward a more equitable society aside from being environmentally friendly. Thus, it is proposed that:

> H5: Sustainable Digital Innovation positively impacts the business's sustainable performance.

2.7 Entrepreneurship ecosystem and sustainable digital innovation

The entrepreneurship ecosystem and sustainable digital innovation are highly interrelated, where the former system is influencing the latter (motivating the development of eco-friendly technologies) in a big way (Baranauskas and Raišiene, 2022; Bejjani et al., 2023). It is essential to create an environment for sustainable digital innovations, which encapsulates access capital, mentorship, and a network of industry experts. It gives a space for such startups to invest in exploring as well as applying green technologies and sustainable practices. Moreover, such an ecosystem also produces a culture of innovation which further imbues the startup scene with ideals that internalize environmental responsibility and thus lead to entrepreneurs prioritizing these in their digital ventures (Herman, 2022).

Research indicates that new sustainable digital innovations emerge and scale in an active entrepreneurship ecosystem, including investor support, mentorship access to network connectivity, and venues for collaboration (Herman, 2022). Entrepreneurs working in these ecosystems are provided with resources needed to create and commercialize tech, which not only makes economies more sustainable, energy efficiency solutions, and waste disposal but also helps businesses reduce their carbon footprint (Sassanelli and Terzi, 2022). These ecosystems include vital incubators, accelerators, and innovation hubs that supply the requisite experience as well as infrastructure to expedite outgoing sustainable digital solutions. More importantly, a robust entrepreneurship ecosystem frequently facilitates the sharing of knowledge and partnerships which can increase the effectiveness and diffusion rates of sustainable innovations (Li et al., 2022a). Nevertheless, the effectiveness of this relationship is contingent on the ability of ecosystems to accommodate and embody sustainability in their basic operations as well as its congruence with broader environmental objectives. Collectively, the literature suggests that it is essential to have a strong entrepreneurship ecosystem for laws such as this right to be recognized; and more importantly supported, fostering digital innovation on sustainable grounds (Sassanelli and Terzi, 2022).

The entrepreneurship ecosystem fosters a culture of innovation and creates an enabling environment for the development, nurturing, supporting, and scaling up of sustainable digital solutions ensuring rapid deployment into existing eco-systems thereby enhancing accelerated adoption that supports the realization of environmentally conscious businesses. Therefore, the following hypotheses are proposed:

> H6a: Entrepreneurship education positively impacts sustainable digital innovation.
> H6b: Entrepreneurial culture positively impacts sustainable digital innovation.
> H6c: Government support positively impacts sustainable digital innovation.
> H6d: Social support positively impacts sustainable digital innovation.

2.8 Mediating role of sustainable digital innovation

Sustainable digital innovation has an essential mediating role between business strategies and sustainability goals to enable the integration of eco-friendly practices at the heart of core operations to achieve long-term performance (Martínez-Peláez et al., 2023). It centralizes the idea of sustainable digital innovation, which does this by moving traditional processes into tech that works more efficiently and in a way less impactful to our environment (Huang et al., 2022b). Digital tools and platforms can be used to enhance how resources are managed, supply chains are maneuvered, and decisions are driven in a more data-savvy way that fulfills sustainability objectives. This mediation makes businesses more impactful on sustainability and places them at the heart of their strategy room (Chen and Kim, 2023). Using and scaling sustainable digital innovations is a successful approach for targeting new value pools (compliant markets, resilient or competitive behaviors) to meet regulatory demands of greener practices (Yin et al., 2022).

Prior studies stress the meditational relationship by which sustainable digital innovation plays a role in not only entrepreneurship ecosystem and business sustainability performance but also steps of how new digital methods ease the transformation of structure support for entrepreneurs to genuine outcomes concerning sustainability (Xiao and Su, 2022). Research indicates that access to finance, mentorship, and networking in a stronger entrepreneurship ecosystem is critical for the creation and application of successful digital innovations (Xu et al., 2022). These include innovations such as green technologies, energy-efficient systems, and resource optimization tools which act as mechanisms by leveraging entrepreneurial resources to improve business sustainability. Sustainable digital innovations help companies to be more environmentally friendly, make better economies of scale, and achieve sustainability regulations (He et al., 2024). Results show that the main steam effect of the entrepreneurship ecosystem on sustainable business performance is likely without catalytic role digital innovations, which leads to typically pragmatic application in implementation entrepreneurial support with less effective. Sustainable digital innovation mediates this relationship by translating entrepreneurial resources and opportunities into actual sustainability outcomes, bridging the support of ecosystems with business performance improvements.

Digital innovation for sustainability involves the creation and use of digital tools that actively contribute to environmental, social, and economic improvement (Finger, 2023). It incorporates the development and use of digital tools and solutions that advance technology while positively contributing to sustainability objectives. Features like energy-efficient technologies, smart resource management systems, and digital platforms supporting sustainable production practices and transparency dominate the scale of innovation (Nasiri et al., 2023). Meanwhile, solar energy solutions increase the accessibility of renewable power in the most isolated regions. These innovations thus bridge the gap between profitability and sustainability where businesses generate economic success while fulfilling their environmental and social responsibilities, illustrating that long-term profit centers can emerge through sustainable practices (Xu et al., 2023).

From the dual perspectives of the entrepreneurial ecosystem and business sustainable performance, sustainable digital innovation as a mediator supports both facets by nurturing the proper amalgamation of environmentally friendly practices with new technologies inside entrepreneurial ventures. Digital innovations in and around entrepreneurship concern sustainable digital products that startups can use to innovate more effectively, and scale faster, all while limiting their environmental footprint. This mediation happens with digital tools and platforms, which help operations to be done more smartly, using resources rather than wasting them and reducing waste contributing toward optimized resource consumption.

In sum, this body of literature underscores that sustainable digital entrepreneurship is an important intermediate mechanism through which the effects of a favorable ecosystem for entrepreneurship on business sustainability may be enhanced by boosting positive influences both in terms of environmental and operational performance. Digital innovation is an essential enabler of sustainability, directly nurturing environmental stewardship and economic efficiency and helping businesses to meet a growing list of regulatory requirements while creating new market differentiation opportunities by increasing resilience as well as social responsibility. Thus, the following hypotheses are suggested:

H7a: Sustainable digital innovation positively mediates the relationship between entrepreneurship education and business sustainable performance.
H7b: Sustainable digital innovation positively mediates the relationship between entrepreneurial culture and business sustainable performance.
H7c: Sustainable digital innovation positively mediates the relationship between government support and business sustainable performance.
H7d: Sustainable digital innovation positively mediates the relationship between social support and business sustainable performance.

Following the hypotheses, the Figure 1 shows the conceptual model.

3 Research methodology

3.1 Sample and data collection

The research was conducted on small and medium enterprises operating in Gilgit-Baltistan the self-administered territory of Pakistan. Given the strategic and economic importance of Gilgit-Baltistan, it does pay dividends to build this region leveraging its geography and culture that is fundamentally unique. Gilgit-Baltistan is enriched with natural beauty and cultural heritage, benefiting from a large number of SME opportunities in tourism, agriculture, and handicrafts (Hussain et al., 2024). There are also opportunities for local businesses to benefit from employing eco-tourism, traditional crafts, and organic agriculture (Batool et al., 2024). But SMEs contend with infrastructure challenges, and reduced access to finance, and face difficulty in reaching larger markets due to their location (Batool et al., 2024). There is also a call for better business training and support to which entrepreneurs can turn if they run up against the concerns of regulation or just need help with managing new technologies (Shah et al., 2024). Addressing these concerns by targeted investments in infrastructure, financial support, and entrepreneur training can help establish the SMEs in Gilgit-Baltistan which could contribute to sustainable regional development and economic resilience.

Adequate sample size is important to reduce the sampling error in survey research. Building a good sample size is important to achieve confidence and generalizability, ultimately increasing the quality of research as well as the reliability and validity of results (Iqbal et al., 2022). Cumulatively, to fulfill the sample size criterion of Kline (2023), a measurement item is allowed for ten times its developed initial sample size. As a result, there are 370 responses in the total sample for this analysis. Therefore, the authors decided to collect 550 sample size to address the problem of inaccurate responses. Structural equation modeling has a low chance of obtaining inconsistent results when a large sample size is applied (Siyal et al., 2019).

FIGURE 1
Conceptual framework.
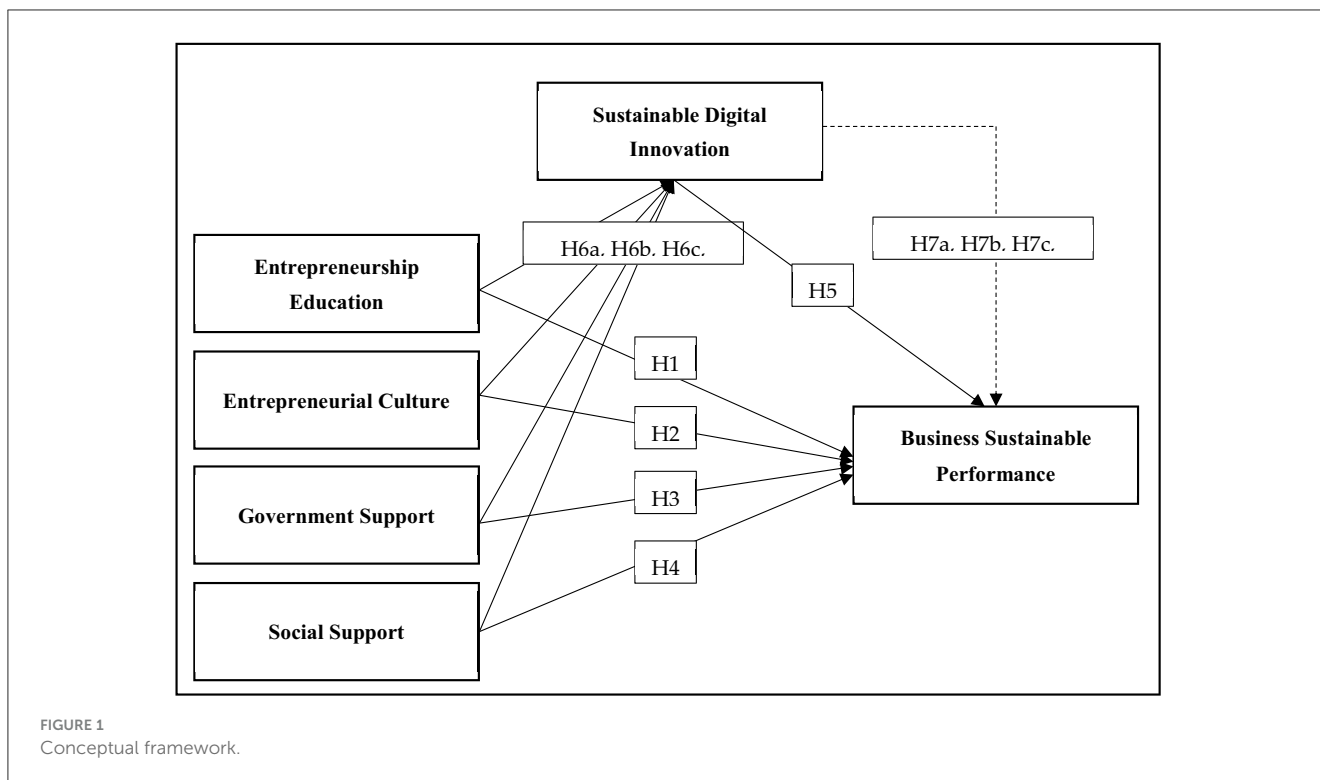
The present study selected the participants through a convenient non-random sampling. Non-random sampling is widely used for geographic convenience of the study; owing to its very nature it makes economic sense, so non-random measures are employed fairly more often and feasibly targeted at using specific problems that may arise during research in remote areas (Jan et al., 2023). This trick works when people are readily available and accessible (Taherdoost, 2016). The practical advantages of convenient non-random sampling make it a handy method in cases where at times access, speed, and cost matter.

The data for the present research was collected through the questionnaire survey method. The questionnaire survey method is a significant portion of the quantitative research, its main emphasis lies on swiftly collecting and summarizing data from varying respondents that can cover a wide range of different kinds of research studies (Iqbal et al., 2022; Jan et al., 2023). Data were accumulated after receiving formal written consent from the participants. A cover sheet of the survey informed about such purposes and requested consent to participate. The participants were told that the data would be kept confidential and was for this research only, it would not reach any hand outside. The respondents are free to withdraw from the survey at any time. Data were collected in two separate rounds with an interval of 3 months between March and May 2024 to prevent common method bias (Podsakoff et al., 2012).

Five hundred and fifty respondents met the criteria to participate in this study, of whom 495 returned completed surveys. Due to insufficient information provided by respondents, 64 questionnaires were denied, while 431 completed questionnaires were used for data analysis in this study. This study enrolled 275 females (64%), and 156 males (36%). Key informants ranged in age from under 25 (60), 26 to 35 (216), 36 to 45 (120), and over 45 (35), with percentages of 14, 50, 28, and 8 respectively. In this study, career levels ranging from supervisor/worker (26, 6%), middle-level management (190, 44%), manager (105, 24%), and owner/CEO (110, 26%) were recorded. Similarly, respondents with basic/secondary (86), undergraduate (225), master's (120), and doctoral (0) degrees had 20%, 52%, 28%, and 0%, respectively. demographic diversity and characteristics of the study population are delineated in Table 1.

3.2 Variables and measurement

The variables are divided into three sets in this study; independent, dependent, and mediator. These variables were assessed using the same indicators employed in prior research. Entrepreneurship education consisted of four items taken from the study of Misoska et al. (2016) and Liñán and Chen (2009). The seven items measured the entrepreneurial culture (Dimitratos et al., 2012). Government support was measured by adopting the five items from the previous study (Pryor, 2002). Social support was assessed using the three-item scale that has been developed by Sequeira et al. (2007), and Abebe (2012). The mediators, sustainable digital innovation was measured through the scale developed by Khin and Ho (2019). The sustainable business performance scale which was developed by Asadi et al. (2020), is regarded as the research instrument for this study. The scale is composed of thirteen items measuring social, environmental, and economic performance. All items were measured on a 5-point Likert scale.

TABLE 1 Respondents' characteristics.

Respondents characteristics	Frequency	Percent
Gender		
Female	275	64
Male	156	36
Total	431	100
Age group		
Below 25	60	14
26–35	216	50
36–45	120	28
Over 45	35	8
Total	431	100
Education		
Secondary or basic	86	20
Undergraduate	225	52
Masters	120	28
PhD	0	0
Total	431	100
Position		
Supervisor/worker	26	6
Middle manager	190	44
Manager	105	24
Owner/CEO	110	26
Total	431	100

3.3 Data analysis

In this research, the conceptual model was tested employing PLS-SEM. PLS-SEM allows statistically more precise tests via a bootstrapping approach that gives also standard errors for path coefficients (Martínez-Martínez et al., 2017; Iqbal et al., 2022; Jan et al., 2023). Several assumptions were analyzed, such as Multicollinearity, Normality, and Common method variance (Hair et al., 2010; Umrani et al., 2019). The researchers then reviewed the reliability, validity, and structural path analyses in the data. Partial Least-Squares Structural Equation Modeling (PLS-SEM) was used for structural model evaluation, which is the second step of SEM after the measurement model analysis (Henseler et al., 2015).

To ascertain the measurement model, it is imperatively necessary to measure each concept's reliability, internal consistency, convergent validity, and discriminant validity (Hair et al., 2010). Measurement models using Cronbach's alpha, heterotrait-monotrait (HTMT) ratio, composite reliability (CR), and average variance extracted (AVE) as indicators were validated in the initial phase. Moreover, discriminant validity and correlation were used in this study to test the theoretical model. Finally, the performance of the structural model was tested by predictive relevance (Q^2) and coefficient of determination R^2 in addition to variance inflation factor (VIF) for assessments collinearity as well as common method

bias. SEM (structural equation modeling) was the final method used to examine the hypothesis in this research.

4 Results

4.1 Descriptive analysis

Table 2 displays the values of mean, minimum, and maximum. There are a total of 431 observations in the data. It has a minimum value of 1 and a maximum value of 5. Mean values varied from 3.313 (sustainable digital innovation) to 4.220 (business sustainable performance). The standard deviation values range from 0.932 to 1.217 Moreover, the values of skewness and kurtosis were within normal limits according to the recommended threshold interval of −2 to +2 (Sharma and Ojha, 2020).

4.2 Measurement model assessment

Regarding measurement model evaluation, it is important to estimate the reliability, internal consistency, convergent validity, and discriminant validity of each concept (Hair et al., 2010). More specifically, the factor loadings of each item in a construct are necessary to find out if the individual items represent reliability (Iqbal et al., 2022). Hair et al. (2019) proposed that maintaining an item with a value equal to or above 0.5 is considerable. In this investigation, all the respective outer loadings met the criteria in this investigation (Table 3). The variance inflated factor is used to measure the research design and collinearity bias. According to Henseler et al. (2015), a VIF value of 5 or less is considered acceptable. In this study, all VIF values are under an acceptable threshold. Cronbach's alpha scores are between 0.828 and 0.906, which is consistent with the required CA range (>0.7). CR should be ≥0.7 (Shrestha, 2021), and it ranges from 0.891 to 0.920. The convergent validity values are also endorsed in line with Saengchai et al. (2019).

4.3 Structural model analysis

4.3.1 Common method bias (CMB)

Harman's single-factor test is used to check the presence of common method bias (CMB) in collected data. The test shows that a single factor contributes 34.09% of the total variance, which is <50.0% adequate threshold (Liang et al., 2021). The test used for CMB has shown that the data were not influenced by common method bias. R^2 is the available metric for assessing the future usefulness of a model that predicts (Sarstedt et al., 2014). The R^2 value represents the proportion of variance in the dependent variable(s) that can be explained by independent predictor variables (Umrani et al., 2019). According to Umrani et al. (2019), the context of a specific study influences what level of R^2 value is acceptable. Chin (1998) characterizes R^2 values >0.60 as strong, with about 0.33 moderate, whilst 0.19 is regarded as a weakly influential signal (Iqbal et al., 2022). According to our findings, the coefficient of determination for business sustainable performance is = 0.601 and sustainable digital innovation is = 0.517 (Table 4). The value is significantly higher than the minimum allowable cutoff.

TABLE 2 Descriptive statistics.

Constructs	Items	Obs	Min	Max	Mean	Std. Dev	Kurtosis	Skewness
Sustainable digital innovation	SDI 1	431	1.000	5.000	4.107	0.827	0.960	−0.917
	SDI 2	431	1.000	5.000	4.218	0.866	0.434	−0.996
	SDI 3	431	1.000	5.000	4.077	1.062	0.660	−1.155
	SDI 4	431	1.000	5.000	4.000	0.961	0.288	−0.866
	SDI 5	431	1.000	5.000	3.847	0.919	1.520	−1.114
Entrepreneurship education	EE1	431	1.000	5.000	3.988	1.018	0.890	−1.088
	EE2	431	1.000	5.000	4.107	1.067	0.633	−1.179
	EE3	431	1.000	5.000	4.026	0.981	1.282	−1.161
	EE4	431	1.000	5.000	4.014	0.794	0.681	−0.666
Entrepreneurial culture	EC 1	431	1.000	5.000	3.947	0.921	0.474	−0.787
	EC 2	431	1.000	5.000	3.875	0.877	0.497	−0.728
	EC 3	431	1.000	5.000	4.116	0.909	1.107	−1.068
	EC 4	431	1.000	5.000	4.005	0.883	0.472	−0.801
	EC 5	431	1.000	5.000	3.965	0.849	0.798	−0.779
	EC 6	431	1.000	5.000	3.933	0.895	0.849	−0.882
	EC 7	431	1.000	5.000	4.051	0.889	0.701	−0.895
Government support	GS1	431	1.000	5.000	3.840	1.066	−0.136	−0.795
	GS2	431	1.000	5.000	3.870	1.167	−0.098	−0.889
	GS3	431	1.000	5.000	3.754	1.003	0.032	−0.709
	GS4	431	1.000	5.000	3.712	0.937	0.763	−0.858
	GS5	431	1.000	5.000	3.682	1.129	−0.405	−0.662
Social support	SS1	431	1.000	5.000	3.580	1.063	−0.021	−0.705
	SS2	431	1.000	5.000	3.452	1.153	−0.549	−0.545
	SS3	431	1.000	5.000	3.499	1.140	−0.278	−0.667
Business sustainable performance	BSP1	431	1.000	5.000	3.926	0.965	0.313	−0.814
	BSP2	431	1.000	5.000	4.220	0.932	1.172	−1.230
	BSP3	431	1.000	5.000	3.849	0.991	0.451	−0.828
	BSP4	431	1.000	5.000	3.777	1.120	−0.245	−0.766
	BSP5	431	1.000	5.000	3.645	1.202	−0.461	−0.690
	BSP6	431	1.000	5.000	3.313	1.217	−0.753	−0.455
	BSP7	431	1.000	5.000	3.448	1.184	−0.633	−0.510
	BSP8	431	1.000	5.000	3.664	1.128	−0.253	−0.713
	BSP9	431	1.000	5.000	3.610	1.180	−0.343	−0.703
	BSP10	431	1.000	5.000	3.543	1.187	−0.485	−0.654
	BSP11	431	1.000	5.000	3.476	1.175	−0.533	−0.552
	BSP12	431	1.000	5.000	3.701	1.223	−1.025	−0.528
	BSP13	431	1.000	5.000	3.858	1.401	−0.327	−1.021

4.3.2 Discriminant validity

Saengchai et al. (2019) state that the square root of AVE for each variable should be greater than the inter-correlations of other variables. Thus this study compared the square root of AVE with the respective inter-correlation coefficients. The data has discriminant validity because the AVE is greater than the respective inter-correlation coefficients. To ensure that the data are free of the "multi-collinearity issue and common

TABLE 3 Factor loadings, VIF, CA, CR, and AVE.

Construct	Items	Loadings	VIF	CA	CR	AVE
Entrepreneurship education	EE1	0.896	3.329	0.828	0.891	0.679
	EE2	0.891	2.686			
	EE3	0.904	3.383			
	EE4	0.550	1.145			
Entrepreneurial culture	EC1	0.752	2.017	0.872	0.901	0.566
	EC2	0.761	2.054			
	EC3	0.696	1.506			
	EC4	0.792	2.104			
	EC5	0.729	1.855			
	EC6	0.745	1.987			
	EC7	0.786	2.229			
Government support	GS1	0.810	2.319	0.871	0.906	0.659
	GS2	0.842	2.568			
	GS3	0.834	2.347			
	GS4	0.772	2.447			
	GS5	0.800	2.607			
Social support	SS1	0.860	2.016	0.868	0.919	0.791
	SS2	0.903	2.429			
	SS3	0.904	2.522			
Sustainable digital innovation	SDI1	0.652	1.348	0.864	0.904	0.657
	SDI2	0.850	2.902			
	SDI3	0.896	3.989			
	SDI4	0.908	4.282			
	SDI5	0.715	1.651			
Business sustainable performance	BSP1	0.628	2.266	0.906	0.920	0.473
	BSP2	0.580	1.822			
	BSP3	0.531	2.035			
	BSP5	0.791	2.768			
	BSP5	0.770	2.742			
	BSP6	0.739	2.842			
	BSP7	0.781	2.615			
	BSP8	0.735	2.854			
	BSP9	0.710	2.789			
	BSP10	0.704	2.772			
	BSP11	0.660	2.730			
	BSP12	0.623	2.696			
	BSP13	0.632	2.631			

VIF, Variance inflated factor.

method bias," each item must relate to its variable while demonstrating no strong link to other variables. If the item loading is less than cross-loading, then that specific item will not measure any variable (Vinzi et al., 2010). Accordingly, this study indicates that the all of items related to variables are held (Table 5).

4.3.3 Hypothesis testing

PLS-SEM is a set of statistical techniques that enable the estimation of complex, multivariate sets to be associated with independent variables. The variables could be either elements or measured constructs and could belong to the independent or dependent variable. In this way, SEM provides a method by

which to address research questions that involve the assessment of variables among each other in more complex ways than can be done with an ordinary multiple regression test (Iqbal et al.,

TABLE 4 Predictive relevance and model fit.

Constructs	F^2	R^2	Adjusted R^2	Q^2
BSP		0.601	0.597	0.258
EC	0.020			
EE	0.022			
GS	0.026			
SDI	0.162	0.517	0.513	0.329
SS	0.110			

TABLE 5 Discriminant validity.

Constructs	1	2	3	4	5	6
Fornell-Larcker Criterion						
BSP	0.688					
EC	0.574	0.752				
EE	0.512	0.664	0.824			
GS	0.549	0.383	0.338	0.812		
SDI	0.686	0.643	0.563	0.491	0.811	
SS	0.525	0.266	0.173	0.553	0.377	0.889
Heterotrait-Monotrait Ratio (HTMT)						
BSP						
EC	0.634					
EE	0.581	0.796				
GS	0.603	0.429	0.402			
SDI	0.743	0.743	0.676	0.564		
SS	0.581	0.303	0.203	0.640	0.432	

2022; Jan et al., 2023). As a result, this study investigated SEM as a variance-based procedure using SmartPLS to test the research model's direct and mediating hypotheses (Legate et al., 2023). Table 6 and Figure 2, show that all hypotheses proposed in this study (H1, H2, H3, H4, H5, H6a, H6b, H6c, H6d, H7a, H7b, H7c, H7d) are supported with the criteria of t-value > 1.96 and p < 0.05.

H1: EE→ BSP: The positive coefficient of 0.128 implies that business sustainable performance increases with the increase in entrepreneurship education as evidenced by existing research (Kanaan-Jebna et al., 2022). The P-value (0.008) and T-statistic (2.634), both indicate that this relationship is statistically significance.

H2: EC → BSP: The positive coefficient (0.134) shows a higher entrepreneurial culture is linked to high business sustainable performance. This is further confirmed by the significance of a P-value (0.005) and T-statistic (2.805). Al Doghan et al. (2022) reported similar results.

H3: GS → BSP: Government support enhances the performance of business sustainability as per the positive coefficient (0.133) and results of the prior study (Pu et al., 2021). The T-statistic (3.053) and P-value (0.002) show that this correlation is statistically significant.

H4: SS → BSP: Social support is evidenced to have a positive coefficient (0.256) as seen from previous study studies. This correlation is statistically significant, as indicated by a T-statistic (6.210) and P-value (0.000).

H5: SDI → BSP: The study showed a positive relationship between SDI and BSP with a coefficient of 0.366. The P and T values (0.000, 7.190) affirm the statistical association.

H6a: EE → SDI: A positive coefficient (0.213) shows that a more favorable attitude toward sustainable digital innovation results in higher sustainable performance. The P-value (0.000) and T-statistic (5.400) show a significant relationship. Corresponding results were also found in the (Sousa et al., 2022).

H6b: EC → SDI: Entrepreneurship culture positively affects the degree of sustainable digital innovation with a coefficient of 0.392, similar to previous studies (Stojanova et al., 2022). Both

TABLE 6 Structural model.

Hypothesis	Relationship	Beta	SE	t-value	p-value	Decision
H1	EE -> BSP	0.128	0.049	2.634	0.008	Supported
H2	EC -> BSP	0.134	0.048	2.805	0.005	Supported
H3	GS -> BSP	0.133	0.044	3.053	0.002	Supported
H4	SS -> BSP	0.256	0.041	6.210	0.000	Supported
H5	SDI -> BSP	0.366	0.051	7.190	0.000	Supported
H6a	EE -> SDI	0.213	0.039	5.400	0.000	Supported
H6b	EC -> SDI	0.392	0.046	8.516	0.000	Supported
H6c	GS -> SDI	0.201	0.054	3.735	0.000	Supported
H6d	SS -> SDI	0.125	0.048	2.600	0.009	Supported
H7a	EE -> SDI -> BSP	0.078	0.018	4.393	0.000	Supported
H7b	EC -> SDI -> BSP	0.143	0.026	5.441	0.000	Supported
H7c	GS -> SDI -> BSP	0.073	0.021	3.504	0.000	Supported
H7d	SS -> SDI -> BSP	0.046	0.020	2.277	0.023	Supported

FIGURE 2
Bootstrapping results.
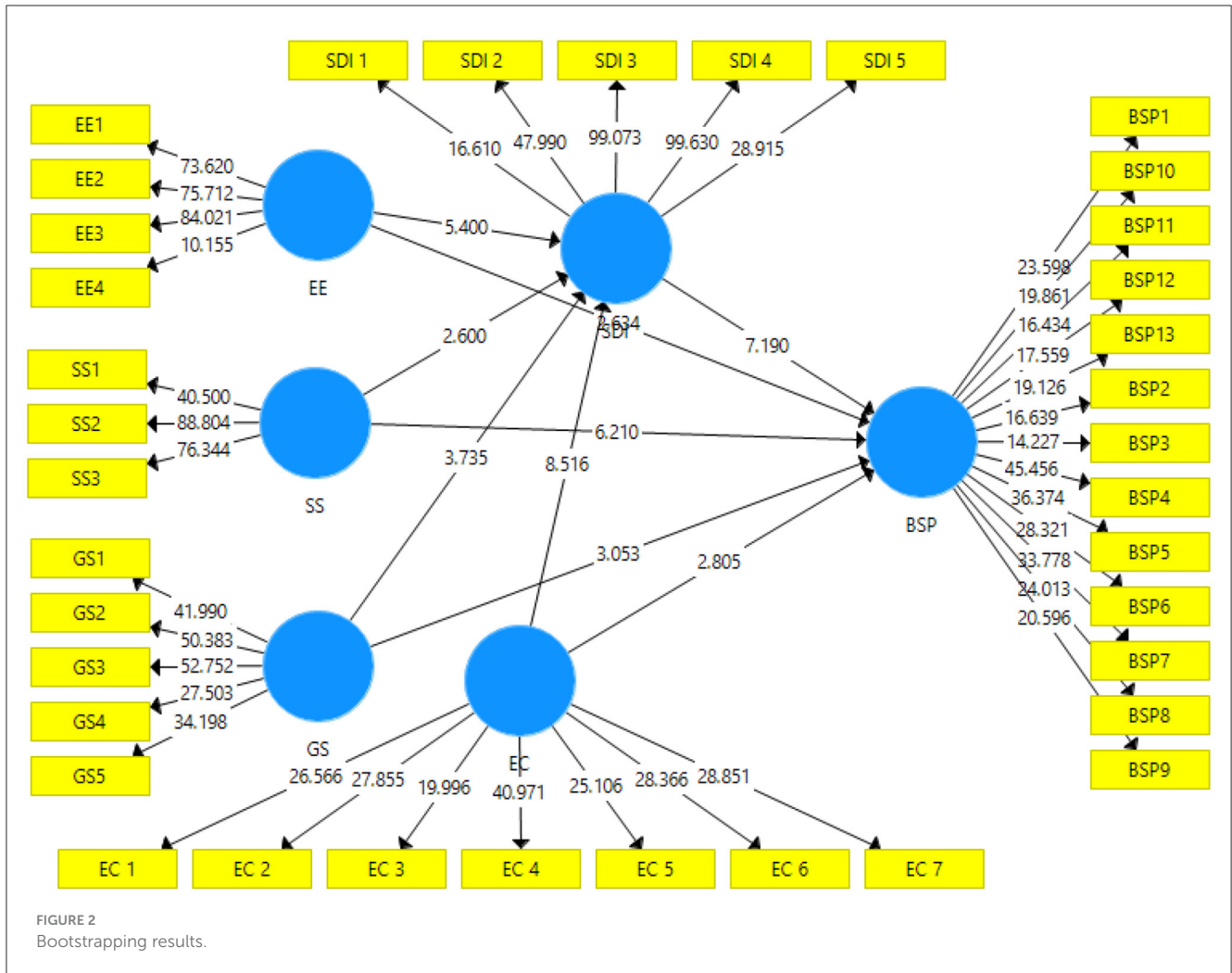
of these stats (*T*-statistic = 8.516, *P*-value = 0.000) indicate a statistically meaningful relationship.

H6c: GS → SDI. The results show a positive relationship between GS and SDI with a coefficient value of 0.201, *T*-value = 3.735, and *P*-value <0.001. The results are consistent with previous studies (Bakar et al., 2020).

H6d: SS → SDI: The positive coefficient (0.125), indicates that social support has a significant effect on sustainable digital innovation. This relationship is confirmed by a significant *T*-statistic (2.600) and *P*-value (0.009).

H7a: EE → SDI → BSP: The findings imply that the impact of entrepreneurship education on business sustainable performance is significantly mediated by sustainable digital innovation. This is supported by the positive coefficient (0.078) of the indirect effect as well as the *T*-statistic (4.393) and *P*-value (0.000).

H7b: EC → SDI → BSP: The indirect effect of sustainable digital innovation in the relationship between the entrepreneurial culture and business sustainable performance has a positive coefficient (0.143). The results show a *P*-value of 0.000 and a *T*-statistic of 5.441.

H7c: GS → SDI → BSP. The *P*-value and *T*-statistic of 0.000 and 3.504 and a positive coefficient of 0.073 suggest a mediating effect of sustainable digital innovation between government support and business sustainable performance.

H7d: SS → SDI → BSP: the findings suggest that the SDI mediates the relationship between social support and business sustainable performance. This is supported by the positive direct coefficient of 0.046, *P*-value of 0.23, and *t*-statistic of 2.277.

5 Discussion

A robust entrepreneurship ecosystem provides businesses with crucial resources, including funding, mentorship, and networking opportunities. This support helps businesses implement sustainable practices and technologies, contributing to long-term viability and efficiency (Rosário et al., 2022). Hence the H1, H2, H3, and H4 are proved. The results are consistent with previous studies. Numerous studies demonstrate the vital role that entrepreneurship ecosystems with their interwoven networks of organizations, regulations, resources, and entrepreneurial endeavors play in promoting the

sustainability of businesses. Entrepreneurship education is a critical part of the entrepreneurship ecosystem through which aspiring entrepreneurs are provided well-needed knowledge and skills with an entrepreneurial-oriented mindset to enable them to launch and scale great ventures (Astuty et al., 2022). It promotes an entrepreneurial approach; creativity, resilience, and adaptability. On the other hand, a successful entrepreneurship culture is one in which the attitude to risk, innovation, and failure are seen as positive drivers of change allowing entrepreneurs to remain unfazed by potential setbacks (Crnogaj and Rus, 2023). Government support is a key element of the entrepreneurship ecosystem directly influencing policies that affect starting, scaling, and succeeding in an entrepreneurial venture (Yuan et al., 2022). When there is no single policy and program that forges a clear approach to build innovation capacity and give rise to startups, this can result in atomized activities not converging into an integrated ecosystem.

An active ecosystem promotes the exchange of knowledge and best practices among entrepreneurs. Access to insights on sustainability trends and strategies helps businesses integrate eco-friendly practices and stay ahead of regulatory requirements, improving their sustainability performance. A solid infrastructure makes way for sustainable innovation. An entrepreneurship ecosystem contributes to developing an enabling culture, combining the missing resources needed for business sustainable performance with innovations and best practices being facilitated from knowledge sharing to market access up until supporting infrastructure/policy development. Collectively, this holistically supports businesses to embed sustainability into their activities and ensure long-term growth.

According to H5 sustainable digital innovation plays a crucial role in business performance sustainability. Numerous research articles demonstrate how digital technologies, including artificial intelligence (AI), the Internet of Things (IoT), and blockchain, enable sustainable business practices (Ref). Businesses benefit from these technological tools through waste reduction capabilities along with optimal resource utilization and enhanced energy performance, leading to superior long-term business results. Energy-efficient technology and paperless options that can reduce energy use, waste, cost accruals as well as carbon footprint are some examples of sustainable digital innovation. Incorporating sustainability into their digital strategies allows businesses to meet targets for operational and wider environmental impact while differentiating themselves from competitors, ensuring they remain resilient in today's eco-centric economy.

Research has found a connection between the entrepreneurship ecosystem with sustainable digital innovation positivity. A flourishing entrepreneurial environment not only reinforces sustainable digital innovation, it is also a key driver to bringing together creativity with shared resources and expanding the resourceful use of eco-technology (Bărbulescu et al., 2021). Therefore it had backed the H6a, H6b, H6c, and H6d. In such an ecosystem, startups and innovators are connected with a group of mentors and investors who help them grow. The network invites activities in digital solutions geared toward sustainability, e.g., energy-efficient software and green technology platforms. The ecosystem supports entrepreneurs in finding market opportunities and makes policy recommendations that facilitate the creation

of sustainable digital innovations, which can then be brought to market driving environmental innovation with economic impact. This has been instrumental in one of the major reasons for this positive relationship being that entrepreneurship driven by an effective ecosystem can lead digital solutions to long-term sustainability.

Our research showed a significant mediating role of sustainable digital innovation between the entrepreneurship ecosystem and sustainable business performance (H7a, H7b, H7c, and H7d). An entrepreneurship ecosystem provides critical enablers such as funds, mentoring, and networking opportunities for budding innovators in building digital solutions. These resources motivate businesses to use sustainable tech solutions such as energy-efficient software, and green digital tools. It operationalizes opportunities for sustainable digital innovation by developing and embedding solutions that improve environmental performance, while also improving economic performance (Jia et al., 2022). For example, a startup might build an entirely new multi-sided digital platform that maximizes resource utilization and minimizes waste because it has access to mentorship and capital. This innovation results in enhanced operational efficiency, cost reduction, and environmental compliance leading to overall business sustainability and performance.

5.1 Study implications

5.1.1 Theoretical implications

The investigation analyzed entrepreneurial ecosystem effects on business sustainable performance within Gilgit-Baltistan while evaluating how sustainable digital innovation serves as a mediator. This section presents findings about each hypothesis as well as theoretical foundations and practical implications. This research elaborates on detailed ecosystem relationships to add knowledge about entrepreneurial ecosystems alongside their performance effects on sustainable businesses in academic research. This investigation generates substantial theoretical implications that become apparent through the results. This study solves a few critical issues within the existing body of knowledge about an integrated connection of entrepreneurship ecosystem, sustainable digital innovation, and business sustainable performance. The first contribution is related to the enhanced understanding of the connection between entrepreneurship education, entrepreneurial culture, government, and social support, and business sustainable performance differently, predicated upon different channels. The integrated theoretical framework offers a balanced perspective that is not aware of general beliefs but demonstrates that education, culture, government, and social support influence will bring only positive implications on the firm's performance (Rosário et al., 2022).

This study contributes to the current body of literature, particularly as it describes the four main dimensions of the entrepreneurship ecosystem. It addresses critical knowledge gaps to ascertain the complex and novel connections between the entrepreneurship ecosystem, sustainable digital innovation, and business sustainable performance. The framework of EMT demonstrates theoretical value for linking entrepreneurial

ecosystems to sustainable business performance by uniting environmental sustainability with economic growth through technological innovation across institutional change and market mechanisms. Through EMT we learn about entrepreneurial ecosystems as enablers of sustainable practices by generating innovative solutions for addressing ecological pitfalls alongside economic advancement. Entrepreneurs working inside supportive ecosystems develop environment-friendly technologies together with sustainable business approaches that minimize environmental damage alongside optimizing operational performance. The research demonstrated that seeking insight from EMT required entrepreneurial ecosystems to direct sustainable business growth by combining innovative solutions with market dynamics to achieve lasting success and ecological benefits. The study demonstrates how business strategies can join sustainability objectives with economic profitability to enable businesses to succeed in markets where environmental concerns grow stronger.

Through this study, a framework establishes how sustainable digital innovation approaches, including energy-efficient technologies, smart systems, and digital resource management solutions, help businesses accomplish environmental goals alongside improved productivity and competitiveness. According to the theory, digital technology innovation functions as an essential measure to tackle environmental problems through resource management improvements and waste reduction, which create smaller environmental footprints. Through environmental integration across digital transformation processes, EMT demonstrates how sustainable digital innovation builds sustainable operations that cut costs while raising brand value and securing future market expansions. The research finds crucial evidence to support digital innovation's central role as a driver for simultaneous ecological and economic sustainability in business operations. Finally, the study states that sustainable digital innovation will independently prove to be a mediating variable to boost business sustainable performance rather than just promoting business operation efficiency.

5.1.2 Practical implications

Several key outcomes emerge from the current investigation. Business sustainable performance benefits greatly through practical outcomes attained through entrepreneurship education. Through enterprise education, entrepreneurs gain sustainability tools, mindsets, and business knowledge to embed sustainability into their operational models, thus creating businesses that function resourcefully and creatively. Organizations targeted for entrepreneurship education improvements should develop holistic approaches through creative education plans and real-world education methods together with strong network collaborations and entrepreneurial character development. Through hands-on practical learning and network creation, along with sustainable and responsible entrepreneurial training, these strategies help individuals master the necessary skills they need to excel in current business competition.

Success in modern businesses depends fundamentally on the abilities entrepreneurs acquire through education to innovate their approaches alongside enhanced resource utilization and long-range strategic planning and risk mitigation strategies.

Long-term business success relies on entrepreneurs who grasp sustainability while using their expertise to lead innovation, minimize costs, and support wider societal missions. Companies that want to develop entrepreneurial cultures via sustainability need to implement multiple strategies focusing especially on supporting creative thinking as well as enabling workforce empowerment, offering educational resources, and giving rewards to encourage sustainable innovation. These action plans help organizations develop entrepreneurial momentum that generates enhanced innovation output along with superior problem-solving capabilities to create sustained organizational growth opportunities and competitive market advantages. For businesses aiming to thrive within a sustainable economy, there is a need to teach entrepreneurial skills together with sustainability principles in our educational systems.

Government support creates substantial real-world benefits for improved business sustainable performance. Through financial incentives, regulatory standards enforcement, and funding assistance, governments develop an enabling environment that drives businesses toward sustainable choices. These solutions help businesses achieve lower environmental impact while strengthening their social responsibility and position them as profitable competitive entities over the long term. Government support forms an essential framework that allows businesses worldwide to achieve sustainability targets while sustaining economic development and stability. A society depends on strong social support to develop healthy cohesiveness alongside resilience. Through strategic approaches including community network development along with expanded mental health services and voluntary participation and safeguards for vulnerable groups governments and associations can ensure overall social support. The implementation of these support systems creates positive effects on individual health alongside increased social connection, strengthened economic activity, and total societal fitness.

The development of leading technologies in sustainable digital innovation mandates that these innovations produce lasting positive impacts on both human welfare and environmental health. The improvement of sustainable digital innovation depends on systematic joint actions by organizations and governments. Governments establish enabling conditions through their support of incentives together with investment in research and development as well as collaborative networks and green procurement requirements. Through sustainable integration into digital strategies, organizations can optimize their investments in green technologies as they develop innovative solutions while transitioning toward circular economic models. Together, governments and organizations can build a sustainable future that uses technology to fuel economic development while resolving critical environmental and social issues through sustainable digital innovation.

5.2 Limitations

The present study has more strength compared to previous relevant studies but it points out several limitations as well in addition to its strong results and theoretical/practical

implications. The study is being carried out in Gilgit-Baltistan, a self-governing region administered as part of Pakistan. That is why it makes a difference if the same theoretical framework works out in different economic and cultural contexts. In particular, this study treated the entrepreneurship ecosystem as a dimensional study; however, future work could make use of these dimensions into a single construct. The methodology employed in this research is PLS-SEM (partial least squares structural equation modeling), a sound statistical method. Still, using different methods would have made the results a bit more confirmation. Future studies might take a mixed-methods approach, combining meaningful quantitative results with qualitative understanding to more fully examine the phenomenon of interest. The study is limited because it has concentrated only on SMEs future research can explore the potential of large companies.

5.3 Conclusion

An extensive examination of the entrepreneurial ecosystem, sustainable digital innovation, and business sustainable performance took place within Gilgit-Baltistan. Empirical research alongside a solid methodological framework allowed us to enhance the current scholarly literature while generating actionable insights that benefit academic scholars together with professionals. Empirical research showed that entrepreneurial ecosystems and sustainable digital innovation drive improved business sustainable performance in small and medium enterprises. The conducted study demonstrated powerful positive correlations between these factors, which affected business sustainable performance. The results emphasize the crucial role of the entrepreneurial ecosystem in driving productivity improvements and facilitating organizational changes in today's digital age. Additionally, our research supports the idea that sustainable digital innovation serves as a mediator between the entrepreneurial ecosystem and business sustainable performance. The findings highlight how innovation and digitalization practices foster improved productivity outcomes in SMEs, as well as the importance of cultivating culture through the support of various stakeholders.

Our study builds upon existing theoretical frameworks and empirical data, offering concrete evidence to support key assertions and introducing new insights into the interplay between entrepreneurial ecosystems and business sustainable performance in SMEs. By providing empirical backing for theoretical claims, this research enriches the literature on entrepreneurial ecosystems, and sustainable digital innovation, while shedding light on the underlying processes that drive business sustainable performance. We emphasize the importance of improving entrepreneurship education, culture, government, and social support, fostering sustainable digital innovation to increase productivity concerning sustainability in SMEs.

To sum up, an active entrepreneurship ecosystem supports the resources, networks, and opportunities required for fostering environmental as well as economically sustainable digital innovations. These unique process and construction

innovations enhance business performance by reducing waste, saving cost operations parameters to match global standards, and demand for regulation from the consumer end, and in general from an ecological perspective. By incorporating these digital benefits into enterprises, entrepreneurs can not only enhance operational efficiency and competitiveness in the market but also support larger sustainability objectives. Hence, the relationship between entrepreneurship and sustainable digital innovation is symbiotic for fostering business sustainability performance where managers must strategically integrate them to enhance long-term value creation and overarching resilience.

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found in the article/Supplementary material.

Ethics statement

All participants provided formal written consent under the Helsinki Declaration. The employee councils and the Xi'an University of Technology, P. R. China's Ethics Committee, granted approval for this research.

Author contributions

SJ: Conceptualization, Investigation, Methodology, Software, Writing – original draft. JJ: Formal analysis, Supervision, Writing – review & editing. MI: Conceptualization, Data curation, Investigation, Methodology, Software, Writing – review & editing. AR: Writing – review & editing. MN: Writing – review & editing. TB: Writing – review & editing.

Funding

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/frsus.2025.1485680/full#supplementary-material

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