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The strategic role of higher education in promoting entrepreneurship and managing innovation complexities: a conceptual framework analysis

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Abstract
This study critically explored the interconnected themes of entrepreneurial potential, sustainable entrepreneurship, and the evolving role of higher education. It highlighted the intellectual responsibility of universities in confronting two pressing entrepreneurial challenges: the insufficient preparation of individuals for future entrepreneurial roles and the overemphasis on market-driven behaviours. Using a descriptive-analytical approach, the findings revealed that higher education faces substantial barriers in fulfilling its societal mission. These obstacles stem from diverse learning methodologies, individual experiences, and varying levels of creative capacity, all of which complicate the measurement and management of innovation. Positioned within the broader regulatory frameworks of higher education institutions, these challenges underscore the need for systemic reform. Grounded in the triple helix model, the research proposed a decision-making framework that bridges theory with practice. This framework emphasizes capacity building and encourages collaborative partnerships between academia and society, while integrating data science to address persistent difficulties in assessing innovation within higher education.

Keywords Entrepreneurial Potential, Sustainable entrepreneurship agenda, Data science, Higher education, Triple helix model

Introduction

Entrepreneurship is a phenomenon that continues to attract global interests given its impact on society. In the developing and emerging economies, the need to address stuttering economic growth could not but necessitate blueprint and strategies that cultivate massive employment than what the entrepreneurship phenomenon offers. In many of these countries, there are growing adoptions of Short and Medium and Scale Enterprise (SMEs) as a makeshift agenda for industrialisation, while governments on its part, incentivize through favourable regulatory policies, short-funds and loans for aspiring

and early-stage entrepreneurs. It was touted that the competition, emanating from both creation and commercialisation of products and services would inevitably generate the required productivity and investment that signals self-sufficiency and as well the defined trajectory for economic growth and development (Rodrik, 2007). As such, the achievement of the lofty targets of government is assured by aggregating the entrepreneurial willingness and ability of the citizens of the country (Chrysostome, 2019). There is further leverage on the demographic transition; most importantly, the youthful age, as it signals a potential for skilled and unskilled labours, natural and material resources in the country can put to profitable use (Quak, 2021). Thus, many governments in the developing countries are keen on extending their labour input and economic growth interest to academia; mostly leveraging on its role of knowledge and skills transfer to individuals.

Entrepreneurship is central to the objectives of advanced economies. Even if its role appears only moderately elevated compared to developing countries, true economic freedom is driven by innovation, knowledge, and technology. Significant investments in research and development are warranted only when they produce products and services that deliver stronger comparative advantages in the global marketplace (Quak, 2021). Global competitiveness depends on the extent to which an individual, firm, or country can explore and exploit resources to its advantage. Entrepreneurship serves this foundational basis, linking opportunities with individuals; and producing actions that can advance the course of individual and national wealth (Cabrita et al., 2015; Kent et al., 2022). However, despite the immense gains, innovation-driven entrepreneurs and advanced economies are constantly concerned in many ways. Over centuries, several unprecedented successes in technologies, science medicine and the ensued outcomes of globalisation, heavy industrialisation, and improved commercialisation were complimented by challenges in unemployment, poverty, diseases, war, etc. and the situations could only sum up general anxiety that projects into a possibility for future crisis. Over all, the problems continue to force the need for rationing how economic values are created and recreated; and particularly in a way that seeks to assure social, environmental and economic interests are considered while business opportunity are pursued. Most importantly, scholars have found the phrase in entrepreneurship sustainability to explain this reconciliatory agenda (Pinna, 2020; Shepherd & Patzelt, 2011), and the means to achieve the goal may not subsist without recourse to the management of the innovation process. Today, intellectualisation of the phenomenon of sustainability and entrepreneurship has renewed interest in the theoretical-academic paradigm upon the realisation that intellectual capital is an absolute function of economic and social development.

How, then, can the dual objectives of entrepreneurship be realized? The literature underscores the pivotal role of higher education in this process (Marshall, 2018; OECD, 2015; Diaconu & Duțu, 2015). It is touted that post-secondary education can play a significant impact on the overall entrepreneurial behaviour, not just by raising awareness and attitudes but through training on the means of identifying opportunities for exploitation (Fredriksson, 2011; Kirkley, 2017; Valerio et al., 2014). Importantly, stronger attention accorded to higher education is in the view of its capacity-building role: leveraging on its educating function for future decision-making (Civera et al., 2020). The university's function of teaching and researching connect to the goals of development for an entrepreneurial role; and scientific knowledge and technological development. The Triple Helix Model explains university as an innovative hub, a centrally positioned

intellectual capital for both the government-led and industry-led economic systems (Etzkowitz & Leydesdorff, 2000). For the government-led economies, the university is the source of knowledge and local technologies to harness products and services for consumption and to a certain extent, trade with other countries. It serves a major objective of the government in massive employment through creative business ideas generation. Similarly, the industry-led economic system placed on university the task of developing cross-cutting knowledge and leading technologies for global consumption. While the two economic sources possess differentiated characteristics to make a clear categorisation of countries at macro-level, at micro-level such as academic institutions, it is posited there are no differences except policy-drives that capture the social, economic and cultural dynamics of every country (Lemarchand, 2015).[1]

Higher Education responds to the triple helix model of innovation—which emphasises the dynamic interaction between universities, industry, and government—through two primary pathways: Entrepreneurship Education and Entrepreneurial University (Davey et al., 2016). It is believed that individuals taking up the entrepreneurial role would need no less competence in venturing into uncertainty as to the world of entrepreneurship. As a consequence, the scholarly field of entrepreneurship education (EE) emerged and quickly grew with institutional support. In many tertiary-level educations, EE became the hallmark of creative thinking and business idea formation. Students are exposed to both content and process as this is believed would maximise their potential in becoming entrepreneurs. Although the outcome of the experimentation has had its fair share of successes, it is not without some monumental challenges. The disproportionate ratio of aspiring entrepreneurs to actual start-ups continues to challenge advocates of entrepreneurial education (EE). According to OECD (2023), the high incidence of short-term business failures among start-ups further underscores the sobering limitations of the programme. These concerns, being both genuine and pressing, demand intensified efforts toward practical solutions that reflect the realities of the entrepreneurial landscape (Hahn et al., 2017).

On the other side is an entrepreneurial university, a designed academic model linking entrepreneurial activities with the commercialisation of university research (Etzkowitz & Leydesdorff, 2000; Compagnucci & Spigarelli (2020). The traditional role of university in teaching and research is in the shadow of its newly adopted role of knowledge and technology transfer. Today, top universities continue to design an effrontery approach towards innovation processes, while showcasing products and services that are direct outcomes of their teaching and theorizing (Amry et al., 2021). This role has made their function to be both broad and visionary. Universities do not only need to deliver several complex projects that capture the needs of the society but have to do so as quickly as possible to attract funds from private organisations and State grants before others (Kliewe et al., 2019; Peters & Weber, 2020). These tasks indicate that there are more engaging collaborations among faculties than before, with the intense goal to compete at a global level. In the realm of sustainability agenda, the ignited practices in patenting, licensing, spin-offs and most importantly, eco-parks became the emblem of university's efforts at addressing a social and economic problem of the society (Schmitz et al., 2017). Despite this, several challenges lay bare for the success of university in its line of

[1] According to UNESCO Science Report (2015), the significant differences in innovation rate and typologies observed among developing countries that otherwise have comparable levels of income are of distinct policy interest (p.35).

achieving the third mission. As pointed out by Erdil, Meissner, & Chataway (2018), the contribution of universities towards innovation remains hidden even within its defined task of detecting and solving problems affecting society. This situation might have also dovetailed into the ensued complexity that exists between university-industry partnerships. In the end, it is still held that the eco-park initiatives have barely been successful beyond its policy implications; as most firms or industries do not find the need for its implementation beyond legal requirements.

The tracking effort of scholarship may have yielded a significant outcomes in the defined existing relationship between university function and societal condition. Besides its traditional role of teaching, it has been argued that university has struggled to exert its influence and regulatory control on innovative behaviour, a condition that have bearing on knowledge and technology transfer to the public domain. Our coinage of 'inadequacy' is justified in that many universities lack the quantifying mechanism to track possession of genuine entrepreneurial ideas, ability or mindset, that merit government's support to transit from aspiring to start-up and finally to the scale-up entrepreneurs. This is much evident especially in many of developing and emerging economies as they have at point in time, come up with certain self-employment stimulating programmes with minimal successes. Similarly, universities appear unable to assess the maladaptive forms of creativity that emerge and diffuse into society—an interpretative phenomenon we describe as 'excess'**.** There is no doubt some ideas are not only unsustainable, they are malicious, dangerous and as simply put by Kirzner (1999) destructive. As such, it holds little meaning finding a balance without recourse to the source of innovation itself.

Scholars have traced innovation itself to two distinct sources: education and intuition (Müller, 2021; Sadler-Smith & Shefy, 2004). Education is considered conscious rationality, a data-driven source, a defined trajectory for success that is based on known information, or an established system or model of the education process that maximises desirable output (Lackeus, 2015). Within the context of innovation complexity, it explains why the products of entrepreneurial education can be challenging, given the volumes of processes in contents, methodology, and pedagogical means by which information is transferred to students and or means by knowledge acquired (by students) are evaluated to denote academic excellence. The issue is further exacerbated by the widened boundary of faculties or disciplines in the university. Today, many universities are creating fields and sub-fields; differentiating knowledge is contrary to highly interdependent reality. This has had a major impact on the decisional outcome that might be needed to advance the human course. Intuition, by contrast, represents an unconscious mode of emotional cognition that frequently resists the structures of scientific inquiry and analytical reasoning. Sometimes, people tend to use experience or patterns to predict possible future occurrences. Such thinking becomes a window by which people develop new insight into a phenomenon (Samier, 2015; Malewska, 2018). In the university, the ambiguity that follows 'constructed' ideas or scenarios in recourse to real-life 'uncertainties' underscores genuine innovation complexity (Petrakis & Konstantakopoulou, 2015). However, in a situation where a university lacks such quantifying means by which thoughts or ideas can be evaluated with its possibilities or associated contingencies, its role is inhibited.

Literature review

Conceptual entrepreneurship

The definition of entrepreneurship is very fuzzy. It holds for both entrepreneurial intention and active efforts to push through a business venture (Zięba, 2015). This distinction also emerges from disciplinary perspectives and appears to be corroborated across major theoretical fields. To elaborate, psychologists conceptualize opportunity as a construct conceived within the mind of the individual. For the entrepreneurial potential to form its full circle, it takes a person to undertake a process of identifying opportunity and this is understood by having the desire, possessing the efficacy and willingness to pursue the opportunity conceived. Based on their arguments, the entrepreneurial potential comes before the entrepreneurial intention, as there is a possibility of individuals having high potential and yet failing to consider the entrepreneurial activity. However, since entrepreneurial intention only defines psychological predispositions and tendency to act entrepreneurially, efforts to underscore potential entrepreneurs are therefore geared towards exploration of some of its defining psychological traits. On the basis of the foregoing discussion, variables such as the need for achievement, locus of control, risk propensity, problem-solving ability, assertiveness, tolerance of ambiguity, and emotional stability are frequently advanced to explain who may or may not become entrepreneurs (Santos et al., 2013). Yet, despite the valuable insights these variables provide and their relevance to defining entrepreneurial potential, they remain limited. One key limitation lies in the multiplicity of traits, which often makes it difficult to clearly distinguish potential entrepreneurs from non-entrepreneurs (Mitchell et al., 2002). This situation makes a whole lot of difficulties and therefore pushes for an alternate means to explain the entrepreneurial potential phenomenon.

Economists' interpretation of entrepreneurial potential depicts an intelligentsia—risk-taker; an individual imbued with the quality of rational choice and decision-making. For such individuals, it is said that the gain of starting a business enterprise significantly outweighs the decision not to venture into it. Entrepreneurs therefore constantly seek to pounce on profitable opportunities that lay (empty) in the disequilibrium environment (Gunning & Kirzner, 1981). The economics paradigm of the entrepreneurial phenomenon lays more emphasis on the environment and defines a potential entrepreneur as being ready to take a risk before any others (individual). However, questions lie stark for the proponents of the economic explanation of potential too. As Ács and Audretsch (2003) observe, it is difficult to disentangle risk aversion from other determinants of choice. Moreover, critics of absolute economic rationality argue that wealth itself complicates the model: greater wealth tends to increase risk aversion, while lesser wealth may encourage risk-taking (Tversky & Kahneman, 1974). Thus, the overwhelming impact of risk-taking views of entrepreneurial potential can be said to be limited by the mind of the prospective entrepreneur himself. Of course, the readiness of an economic agent to quickly identify the lying opportunity in the environment cannot easily be comprehended without recourse to psychologically defined intention.

The overlap between economic and psychological paradigms has been well documented, particularly in efforts to define potential entrepreneurs within the literature addressing the practical dimensions of the entrepreneurial phenomenon. In essence, this convergence necessitates a meaningful reconciliation of the two disciplines in advancing

our understanding of entrepreneurship and entrepreneurial potential. To date, most attempts at integration have emerged within the domain of cognition.

The importance of the field of cognition to the definition of entrepreneurial potential can be seen as evident from this all-important reconciliatory views that emerged out of the knowledge that both psychological and economic viewpoints are inseparable in the trajectory of entrepreneurship process. Cognition combines individual psychological profile: affect, behaviour with individuals' perception of the environments. The development also aligned well with the two contrasting theoretical views, i.e. Schumpeter, (1934) and Kirzner, (1979) from where individualism/collectivism perspectives emerge.[2] However, scholarships have found little practical implication for the relativity and realism-based views of Schumpeter and Kirzner; and this continues to intensify a centralised body of enquiry through human cognition in modelling entrepreneurial individuals and action (Braun, 2007; Hattwick, 1979; Loasby, 2007). More importantly, it is quite anticipated how such ontological perspectives can integrate into the compendium of entrepreneurial knowledge and practices, and thereby connect into social policies and development agenda.

Higher education in the web of process and structure

Higher education marks the stage of learning beyond secondary school, encompassing universities, colleges, and professional institutions that award degrees, diplomas, and certificates. Career development specialists emphasize its critical role as the foundation for skill acquisition, career progression, and long-term professional stability. Yet, its deeper significance emerges through the interaction of two distinct but interdependent dimensions: process and structure.

Process refers to the dynamic sequence of actions aimed at achieving specific outcomes, while structure denotes the organized arrangement of components within a system. The distinction is evident: process is fluid, continuous, and concerned with how things happen, whereas structure is relatively stable, enduring, and concerned with how things are organized—even though it evolves over time. As Kravchenko et al. (2020) note, in higher education, process is most visible in capacity development. This involves the dynamic procedures through which students are taught, mentored, and assessed, ultimately strengthening their entrepreneurial and innovative capabilities. It highlights the how—the pedagogies, instructional methods, and evaluative mechanisms that cultivate independent thinkers and creative problem-solvers. By contrast, structure provides the framework within which these processes unfold. Monat and Gannon (2023) explain that structure encompasses institutional hierarchies, organizational arrangements, and formal systems that allocate roles, responsibilities, and resources. A useful lens for interpreting this is the Triple Helix Model, where universities, industry, and government coexist in a structured system designed to foster innovation.

Thus, while process drives the transformation of students' abilities through teaching and evaluation, structure ensures the order and stability necessary for those transformations to occur. Structure organizes the environment; process transforms individuals within that environment into capable, innovative graduates. This duality frames our

[2] Schumpeter strongly holds on to the importance of creative destruction, stressing the instrumental factors in individuals' traits and personality to brings about new waves of economic development, while Kirzner (1979) rejected the individual creative impact and attribute a discovering function to individual for finding entrepreneurial opportunities.

understanding of entrepreneurial phenomena. Both entrepreneurial potential and the sustainability agenda (eco-innovation park) fall within the scope of process, yet they simultaneously shape—and are shaped by—the structural arrangements of the Triple Helix Model (Etzkowitz & Leydesdorff, 2000; Zakaria et al., 2023). In this way, process and structure remain inseparably intertwined, each reinforcing the other in the ongoing evolution of higher education and its role in innovation.

Methodology

This study employs a descriptive–analytical approach, integrating systematic observation of phenomena with critical interpretation to uncover their underlying causes and broader implications. As Loeb et al. (2017) note, while descriptive analyses often serve as foundational elements in research, they can also stand alone when they reveal previously undocumented phenomena, highlight hidden patterns within large datasets, or identify pressing real-world needs that demand policy or intervention. In this work, two key datasets were examined: the GUESSS Survey (2023), which provides insights into entrepreneurial potential, and the International Survey on Eco-Innovation Parks compiled by Jacquet, Massard, and Zurcher (2018), which sheds light on the sustainable entrepreneurial agenda. Together, these sources form the basis for generating insights into the relationships among interconnected dynamics.

Entrepreneurial potential in higher education

The interconnections between entrepreneurship, the environment, and learning highlight the pivotal role of higher education. Fayolle (2008) emphasizes the ongoing dialogue among these three elements as an essential mechanism for fostering an entrepreneurial culture within nations. This dynamic is further reinforced by the increasing imperative in many countries to combat unemployment through policies that encourage self-employment, particularly among the expanding population of university graduates. Achieving such ambitious goals requires governments to strengthen institutions, provide adequate infrastructure, and cultivate individual capacities in ways that advance national development objectives effectively, participatorily, and sustainably (Kioupi & Voulvoulis, 2020). However, more explicit is the role of higher education in achieving the needed synergy of the micro–macro system. The microsystem, generally, saddled with capacity building is the individual level development and it is all about developing the skills, experience, and knowledge that allow each individual to achieve (entrepreneurially) through resilience and innovative thinking. In essence, the potential for entrepreneurship defines the needed synergy between university and society; with the former tasked with producing entrepreneurially ambitious and competent individuals, who could at best, utilise the available resources and opportunities in the State and turn them into useful and commercially satisfying products and services for people in the community or society at large.

To realize this objective, many developing and emerging nations have embraced entrepreneurship as a central strategy, owing to its capacity to stimulate job creation. This project, among other initiatives, is also consistent with the template of international organisations such as the World Economic Forum (WEF) and the Economic Commission (EC), through the strategic university entrepreneurial capacity building (OECD,

2012).[3] The two entrepreneurial typologies, education and training in universities and other tertiary institutions (TVET) became key instruments to achieving such lofty objectives (Van Der Sijde, Ridder, Blaauw, & Diensberg, 2008). In many universities in Asia and Africa and some parts of Europe, entrepreneurship education is a popular instrument for capacity development, with its curriculum focusing majorly on information that seeks to change the mindset of the learners towards new business formation (Sieger, Fueglistaller, Zellweger, & Braun, 2018). Gradually, the strategy is fast yielding positive outcomes. Today, university students are at the locus of entrepreneurial initiatives; aspiring to become self-employed and creating new ventures in a different capacity that reflect their interests and educational exploits (Sieger et al., 2018). Nevertheless, despite these anticipated potentials, significant challenges persist in relation to the ambitious targets and goals set for entrepreneurship. To frame these challenges more clearly, statistical data is provided to highlight the modest progress made to date in strengthening entrepreneurship education and training within tertiary institutions, especially regarding their capacity to foster entrepreneurial potential.

Table 1 depicts the share of nascent and active entrepreneurs[4] for developed and developing countries. It explains that many developing rather the developed countries have a higher number of nascent and active entrepreneurs. This implies that developing countries are gaining momentum by enhancing the delivery of Entrepreneurship Education—both in terms of content and teaching methods—to a growing number of aspiring students. Nations such as Nigeria, Pakistan, and Indonesia are capitalizing on their large populations to drive this progress. However, significant challenges remain, as the gap between nascent and active entrepreneurship in these regions is still wider compared to developed countries. This implicates that as optimism continue to grow among the teaming youth populace, many of these initiatives are not sustained; thus taking many business aspiring youths back to the trance of unemployment. Similarly, in the Table 2 (below), the phenomenon of impactful entrepreneurial training was underlined, especially for developing nations as they exhibit significantly higher entrepreneurial aspirations and direct engagement compared to developed nations (Sieger et al., 2021).

Based on statistics, the average statistics of participation in entrepreneurial activities directly is close to those that took up activities 5 years after their study for developing countries compared to their developed counterparts. This reflects greater enthusiasm or necessity-driven involvement, possibly tied to emerging opportunities, social mobility, or demographic factors like younger populations.

While these statistics may have perhaps presented good evidence for human capital theory through entrepreneurial capacity development (Muthsam & Becker, 1965); conversely, several important questions are raised, most especially on the need to move away from the theoretical knit to the practical side of entrepreneurship, especially within the concomitant business failure in developing countries. It also entails the strategic means to bridge an existing gap between nascent entrepreneurs and those with the potential to become actively engaged[5] (Jayawarna et al., 2014; Ul Hassan & Fatima, 2013). The

[3] The OECD developed a guiding framework for entrepreneurial universities. This framework attempts to develop ideas for the effective management of institutional and cultural change.

[4] Nascent entrepreneurs are students currently trying to start their own business, while Active entrepreneurs are students already own and run their own business.

[5] GUESSS survey data (2023) emphasised that education and ecosystems must evolve to better support students in becoming entrepreneurs.

Table 1 Share of active and nascent entrepreneur for developed and developing countries. *Source*: GUESSS 2023 Global Report

Developed Nations			Developing Nations		
Country	**Active**	**Nascent**	**Country**	**Active**	**Nascent**
Japan	1.0	1.1	China	8.4	2.2
Austria	8.8	4.8	North Macedonia	19.3	9.4
Switzerland	9.6	3.7	Brazil	21.8	10.1
Slovenia	10.6	7.9	Uruguay	25.4	12.5
Germany	10.7	6.5	Costa Rica	28.2	15.7
Portugal	11.2	4.3	Chile	28.7	15.2
Belgium	12.0	5.0	Russia	30.2	11.8
Sweden	13.6	7.9	Bulgaria	30.3	10.3
Croatia	13.8	2.7	Dominican Rep	30.7	19.9
New Zealand	15.0	7.0	India	36.0	4.8
Ireland	15.7	3.6	Argentina	36.3	18.2
Czech Republic	17.2	7.9	Puerto Rico	36.6	25.4
Spain	17.5	7.7	Mexico	38.6	15.2
Greece	19.0	8.7	Ukraine	40.8	9.9
Italy	20.6	8.3	Indonesia	41.3	24.2
Canada	23.2	8.3	Colombia	42.5	27.3
Slovakia	23.2	7.4	Ecuador	43.7	28.5
Netherlands	25.2	16.3	Jordan	45.5	19.8
Lithuania	26.3	13.0	Iran	46.4	7.1
Korea	26.4	3.3	Paraguay	47.6	25.6
Hungary	27.2	7.3	Morocco	51.1	2.2
Liechtenstein	30.6	9.7	Bolivia	53.6	29.8
UAE	36.1	12.0	Pakistan	54.0	7.1
Qatar	38.6	11.4	Tunisia	54.3	8.6
England	41.8	16.7	Kazakhstan	56.7	22.1
Saudi Arabia	44.3	14.1	Iraq	58.3	18.0
Panama	45.1	19.6	Nigeria	69.1	28.9
USA	63.8	54.6			
Average Nascent	10.0		Average Nascent	16.6	
Average Active	24.0		Average Active	39.1	

challenge is particularly evident in the contrast between developing and developed economies, where entrepreneurship tends to be perceived as an occupation-driven path in the former, often pursued out of necessity, and as opposed to the functional, innovation-driven endeavour in the developed countries. Some key areas for examination for entrepreneurial potential concerns are highlighted below:

Academic background

Academic background plays a pivotal role in shaping how individuals engage with entrepreneurship. However, when an entrepreneurial ecosystem is concentrated within only a few disciplines rather than drawing from diverse fields, it often signals a fragile environment—what might be described as a nascent–active divide. This dynamic may help explain why developing countries tend to exhibit stronger entrepreneurial intentions, as their ecosystems often operate primarily within occupational capacity modes. As shown in Table 3, business-related disciplines—such as business and management, economics, art, and design—remain the dominant sources of both intentional founders (Direct/5 Years) and entrepreneurs (nascent/active). Thus, framing entrepreneurship education

Table 2 Share of intentional founders within 5 years and direct across countries. *Source*: GUESSS 2023 Global Report

Country	Direct (%)	In 5 Years (%)	Country	Direct (%)	In 5 Years (%)
Lithuania	38.6	38.4	Indonesia	62.2	57.9
Netherlands	34.8	30.7	Nigeria	43.1	60.8
Slovakia	31.7	30.3	Guinea	57.9	57.9
Slovenia	31.4	30.2	Tunisia	48.3	53.6
Liechtenstein	30.4	28.2	Dominican Republic	53.0	52.1
Canada	25.4	20.6	Puerto Rico	51.8	51.3
Czech Republic	22.8	17.5	Mexico	50.2	49.3
Brazil	23.2	26.2	Paraguay	48.9	47.0
Portugal	21.4	26.0	Colombia	46.4	46.2
Belgium	22.8	25.8	Ukraine	44.2	42.2
England	20.0	24.7	Bolivia	42.1	41.7
Ireland	18.2	23.6	Ecuador	41.5	40.9
Spain	20.1	22.7	Iran	39.8	39.3
New Zealand	18.5	20.8	Panama	39.0	38.6
Austria	21.9	20.5	Morocco	37.9	37.4
Germany	21.4	20.1	North Macedonia	35.7	36.7
Switzerland	14.4	18.1	Qatar	35.6	36.3
Korea	36.3	14.7	Russia	35.2	36.1
Sweden	17.8	15.2	United Arab Emirates	34.9	36.0
Japan	36.1	8.2	Pakistan	32.9	30.6
China	36.0	9.4	Jordan	31.4	28.7
USA	36.6	7.3	Bulgaria	30.1	27.2
			Uruguay	30.1	26.4
			Costa Rica	30.0	26.3
			Argentina	28.5	25.7
			Greece	28.3	25.4
			Chile	27.2	25.2
			Hungary	26.4	23.2
			Italy	26.3	23.2
			India	25.7	21.8
			Saudi Arabia	25.1	19.3
			Croatia	24.2	19.0
			Kazakhstan	20.3	17.2
			Iraq	18.4	24.8
Direct	**26.35%**		Direct	36.84%	
5 Years	**21.78%**		5 Years	36.04%	

and training within a list of specific academic background raise significant a serious concern for entrepreneurial potential.

Table 3 highlights the need to clarify the strategic direction universities should pursue in fostering entrepreneurial potential. This involves addressing critical decisions regarding which student groups are most likely to initiate ventures after graduation—whether those with a business-oriented background, current management students, individuals taking entrepreneurship as an elective, or students engaging in entrepreneurship education through extra-curricular activities (Hägg & Kurczewska, 2021a, 2021b; Sieger et al., 2021).

Pedagogy

The question of how to teach has long been intertwined with the broader challenge of cultivating entrepreneurial potential across nations. This inquiry extends to the

Table 3 Entrepreneurial intentions and activities by field of study. *Source*: GUESSS Survey (2023)

Field of Study	Intentional Founders (DIRECT)	Intentional Founders (5 YEARS)	Nascent Entrepreneurs	Active Entrepreneurs
Business and management	18.7%	32.2%	11.4%	8.4%
Economics	14.6%	27.6%	9.2%	6.2%
Science of art (art, design, etc.)	13.4%	22.2%	10.4%	7.3%
Engineering	12.8%	24.4%	8.1%	5.7%
Computer sciences / IT	12.7%	24.3%	8.3%	5.9%
Other	11.6%	22.6%	7.9%	5.4%
Law	11.3%	21.4%	7.3%	5.0%
Human medicine / health sciences	10.6%	20.2%	6.6%	4.6%
Social sciences	10.3%	19.6%	6.6%	4.6%
Arts / humanities	9.9%	18.6%	6.7%	4.7%
Natural sciences	9.4%	17.8%	6.1%	4.3%
Mathematics	8.6%	16.4%	5.6%	3.9%

GUESSS (2023) data show that most university students still view entrepreneurship as a career path. Business and Management students lead in entrepreneurial intention, nascent activity, and active ventures, followed by those in Economics and the Arts (e.g., design, fine arts)

Table 4 Entrepreneurial intentions and activities by field of study

Entrepreneur Category	Female (%)	Male (%)
Actives	9.1	13.8
Nascent	21.5	31.6
Intentional Founders (5Y)	27.1	34.4
Intentional Founders (D)	13.4	19.0

integration of entrepreneurship into every discipline. A wide range of approaches—spanning traditional classroom instruction, experiential learning, embedded or transformative models, collaborative methods, and digital integration—have emerged as innovative strategies for navigating the increasingly complex entrepreneurial landscape. While these approaches present exciting opportunities, the enduring dilemma lies in determining which pedagogical methods are most suitable and what content should be prioritized to effectively shape students' entrepreneurial mindset. This remains a critical point of reflection in achieving the academic objectives of entrepreneurship education (Hägg & Kurczewska, 2021a, 2021b).

Gender

Another critical factor influencing the gap between nascent and active entrepreneurs is gender. A growing body of evidence suggests that the male–female dichotomy presents a significant challenge to unlocking entrepreneurial potential, particularly in developing economies. While entrepreneurship is often heralded as a pathway to economic empowerment, women entrepreneurs consistently lag behind their male counterparts in terms of both participation and progression.

Table 4 demonstrates that female entrepreneurs consistently trail their male counterparts across all measures of entrepreneurial potential. Although the extent of the gender gap varies by country, the overarching pattern highlights the enduring need to foster greater aspirations and entrepreneurial engagement among women (Siegrist, 2022).

Inclusive entrepreneurial ecosystems

A major challenge undermining entrepreneurial potential lies in the limited capacity to effectively engage key stakeholders such as government, industry, and civil society. Weak collaboration across ecosystems that span both public and private actors has been repeatedly highlighted, particularly in developing countries where institutional frameworks are often fragile, fragmented, or misaligned. In such contexts, entrepreneurs frequently encounter barriers to accessing supportive policies, infrastructure, and financing mechanisms due to insufficient dialogue with government agencies. Likewise, industry players often remain disconnected from emerging ventures, constrained by mistrust, inadequate incentives, or the absence of robust platforms for partnership.

Encouragingly, some governments in developing economies are beginning to renew their commitment to fostering innovation and entrepreneurship through targeted policies and incentive programmes designed to support aspiring entrepreneurs. Yet, as Adeyemo & Ogunsola (2020) observe, while these initiatives have significantly inspired entrepreneurial aspirations, the absence of pragmatic mechanisms that translate financial support into tangible entrepreneurial capacity underscores the urgent need for solutions that bridge theory and practice.

Measurement complexity

A key trajectory that emerged in the outcomes of entrepreneurial education and training within universities, with significant implications for society is the need to prove entrepreneurial ability or competence beyond ideation. Central to this trajectory is the measurement of students' entrepreneurial and innovative capacity, which is closely linked to elements of the broader ecosystem. Research shows that not all individuals are able to identify and organize available resources in their environment to create viable business opportunities. This limitation does not necessarily reflect a lack of knowledge; rather, the challenge often lies in connecting disparate ideas, which can generate genuine ambiguities that are difficult for students to articulate. Some students may successfully recognize and structure opportunities but struggle to communicate them effectively. At the early stages, ideas often exist only as patterns, making them difficult to measure or assess—especially given the diverse knowledge backgrounds of learners.

In higher education, the challenge of achieving genuine measurement has been consistently highlighted, particularly in view of the heavy and fragmented nature of instructional content. The inherent complexity of curricula often requires students to navigate diverse and sometimes disconnected domains of knowledge and experience, thereby complicating the design of assessments capable of capturing the full scope of intended learning outcomes. Even among advocates who argue for embedding entrepreneurial content across all disciplines, critical questions remain regarding the extent to which a field can be dissected without undermining its intellectual coherence. This tension not only complicates the training of students but also hinders the evaluation of outcomes, as facilitators are frequently constrained to judgments that reflect only their limited cognitive capacity to process such multifaceted learning experiences (Schmitz et al., 2017).

To address these challenges, scholars have increasingly advocated for assessment strategies that move beyond traditional examinations and standardized measures. Competency-based assessment, for instance, emphasizes the demonstration of skills and capacities in authentic, real-world contexts rather than the rote reproduction of content

knowledge. Similarly, portfolio-based evaluation enables students to curate their learning trajectories, highlighting creativity, problem-solving, and entrepreneurial thinking in ways that resist reduction to a single metric. Experiential approaches—such as project-based learning and community engagement—further expand opportunities to evaluate innovation capacity through tangible outputs and collaborative processes. All these cannot without integration of a viable process in data science to resolve the complexity involved in towards the goal of entrepreneurial learning assessment.

In summary**,** the obstacles identified here underscore the inherent complexity of decision-making in higher education. This complexity, rooted in the intangible nature of human thought and creativity, necessitates comprehensive systems and methodologies. Only through such frameworks can universities fulfil their responsibility to drive societal transformation and cultivate innovative ideas.

Sustainable entrepreneurship agenda

Sustainable entrepreneurship has only recently entered academic discourse, introducing novel perspectives in both its theoretical approach and methodological framework (Shepherd & Patzelt, 2011; St Flour & Bokhoree, 2021). Coming out of the shadow of the parent idea: general sustainable development goal (SDG), the term became a foundational concept for practical entrepreneurship (Urbaniec, 2018). Conceptually, it occupies a position on the spectrum opposite to entrepreneurial potential, though it carries its own unique implications. Although the concept has been used in different ways by several authors, the general idea seems to be converging on new solutions or sustainable innovations that aim at the mass market and provision of products that are in tune with the value to society (Weidinger, Fischler & Schmidpeter, 2014; Amaeshi et al., 2019). Concerns about humanity's welfare and the sustainability of future generations are, of course, longstanding. Yet the moral evaluation of human activity cannot be overstated, particularly in light of historical evidence suggesting that the collapse of past civilizations was linked to inadequate foresight and poor planning for the future (Ehrlich & Ehrlich, 2013).

The lessons drawn from the collapse of past civilizations underscore the necessity of rational foresight in guiding business and economic activities. Scholars have long argued that inadequate resource management and the absence of long-term planning contributed to societal decline, offering a cautionary framework for contemporary systems. These historical insights have been transposed into modern discourse as compelling reasons to embed rationality and sustainability into entrepreneurial practice. As Greco and Jong (2017) observe, the motivations underpinning sustainability can be framed along two distinct dimensions: internal and external. Internal drivers stem from personal beliefs and values—such as the pursuit of safety, commitment to environmental stewardship, and the aspiration for self-employment as a means of autonomy. External drivers, in contrast, arise from broader systemic forces and societal challenges, including land degradation, social inequality, unemployment, and public health crises. Taken together, these dimensions underscore the dynamic interaction between individual conviction and structural imperatives in advancing sustainability.

In the realm of entrepreneurship, sustainability is built on the need for exploration and development of a new business paradigm that fosters social-economic and ecological values simultaneously (Weidinger, Fischler & Schmidpeter, 2014). Dal Mas, (2018)

provided an all-encompassing definition for sustainable entrepreneurship as a concern that revolves around three major themes: finance, society (culture), and environment. Financial sustainability entails dynamics that surround financial matters such as economic growth, investment, company reporting, business value, industry, and corporate production. On the other side, issues such as human rights, social media, local support, national situation, etc. dominate the concerns for social sustainability. Lastly, environmental sustainability deals with diverse issues such as waste management, natural resources, green, etc.

Today, a prominent threat attributed to entrepreneurial activities is climate change (Tanner et al., 2019). This issue continues to surface in several ecopreneurship paradigms, and the recent of them is the 'Greening' agenda that has largely pushed for the remodelling of the traditional entrepreneurship into the frontline of socio-political and economic propaganda (Muo & Azeez, 2019; Schaper, 2010). With the increasing need to take a rational approach to coordinated entrepreneurial activities, orientation efforts are strongly moved for entrepreneurs to be more aware of the impending impact of their activities. Moreover, there are also strong calls for entrepreneurs to pursue some opportunities that can help solve the social and environmental problems arising from global socio-economic systems (Hanohov & Baldacchino, 2018). However, whether much has been achieved to this effect remains a strong question that continues to raise arguments from many sides.

#Case Study: Patagonia

Company Objective: Patagonia is a private benefit corporation engaged in the design and sale of outdoor apparel and equipment. The company is distinguished by its explicit commitment to environmental activism and sustainability, embedding ecological responsibility into its core business model. Its mission extends beyond profit generation to include the promotion of systemic environmental solutions through business practices

Achievements: Patagonia has emerged as a global exemplar in sustainable enterprise, demonstrating that environmental stewardship and commercial success are not mutually exclusive. The company has pioneered advancements in ethical sourcing, circular economy initiatives, and climate advocacy. Key achievements include:

Utilization of over 90% preferred materials in its product lines, including recycled, organic, and regenerative fibres

Recognition that 92% of its carbon emissions originate from the supply chain, prompting a strategic redesign of products to reduce upstream environmental impact

Implementation of the Worn Wear program, which promotes product longevity through repair and resale, thereby minimizing textile waste

Transition of all company-owned facilities toward 100% renewable energy usage

Establishment of an ownership structure that allocates all non-reinvested profits to climate change mitigation efforts, ensuring long-term alignment with environmental objectives

Key Challenges: Despite its accomplishments, Patagonia faces several persistent challenges:

Reducing greenhouse gas emissions across a complex and globally dispersed supply chain

Balancing the imperatives of business growth with the constraints of environmental sustainability

Effectively educating consumers about sustainability without resorting to superficial or misleading messaging (i.e., greenwashing)

Managing the inherent tension between promoting durable, long-lasting products and maintaining consistent revenue streams in a competitive retail environment

Culled from Patagonia website (https://www.patagonia.com/our-footprint/?msockid=354123ebc86a6b0c08953086c92a6a0c)

Every pursuit of sustainability has consistently encountered resistance, often equal in scale if not greater. This raises a profound question: what makes sustainability such a distinctive measurement challenge that it warrants higher education response or intervention? For numerous reasons, it is essential to examine key indicators within the economic and business spheres to better understand the obstacles that encumber the sustainability agenda. Among the leading initiatives in this regard, is the eco-innovation

and eco-industrial parks which stand out as pivotal strategies for advancing sustainability worldwide (Halonen & Seppänen, 2019).[6]

The data indicated in the case studies (Table 5) predominantly emphasize waste management, energy efficiency, and water management as priorities of eco-innovation parks, reflecting their central role in advancing sustainable practices and mitigating environmental challenges. In contrast, criteria such as biodiversity, land use, and environmental management systems receive comparatively limited attention, suggesting their marginal status within mainstream sustainability frameworks. This asymmetry reflects entrenched societal priorities that may resist integration due to structural or institutional constraints. As such, it is easy to identify this structural factor itself in the mould of technology. Technology, by virtue of its intuitive design and pervasive diffusion, subtly shapes perception and behaviour, often guiding choices without conscious deliberation. In the context of social entrepreneurship across Africa and Asia, many initiatives have emerged in response to the availability of advanced operational technologies. As pointed out by Ogundiani (2023), this tech-driven orientation frequently overshadows the foundational ethos of social enterprise—namely, its collectivist socio-cultural and economic vision rooted in community empowerment and inclusive development. In a simple terms, many entrepreneurial initiatives and countries become laggard to existing knowledge and technology. The other important factor is trust (institutional factor), which will be addressed later.

Table 6 presents the sustainability standards applied to eco innovation parks, while Fig. 1 illustrates compliance to the defined criteria. The figure illustrates that most initiatives comply with only two to five criteria, while a smaller proportion adopt a more holistic approach by meeting eight or more. Only a few parks achieve all eleven standards, and just a handful fall below four, signalling partial compliance with the overarching sustainability objectives. A key factor identified in the literature for the uneven performance of eco innovation initiatives is their reliance on advanced technologies and scientific processes. The alignment of technological solutions with specific market demands is frequently difficult to achieve, and such innovations may inadvertently redistribute environmental burdens across different stages of the production chain (Bozeman,Fay

Table 5 Environmental activities of eco-innovation park. *Source*: Massard, Jacquat and Zürcher (2014)

Eco-Criteria	Frequency
Waste Management	120
Energy Efficiency	100
Water Management	99
Materials Flow	94
Renewable Energy	77
Cultural / Social / Health (CSH)	45
Mobility / Transportation	40
Land Use Optimization	36
Biodiversity	29
Air Pollution Prevention	26
Environmental Management System	23
Noise Prevention	13

[6] Eco-Industrial Park (EIP) is a form of business collaboration within the local community in an effort to reduce waste and pollution, and to efficiently share resources and contribute to long-term development in order to boost economic gains as well as improve environmental quality.

Table 6 Core Eco-criteria for eco-industrial parks

	Criterion	Description
1	Waste Management	Efficient handling, reduction, reuse, and recycling of industrial waste
2	Energy Efficiency	Minimizing energy consumption through optimized processes and technologies
3	Water Management	Sustainable use, treatment, and recycling of water resources
4	Materials Flow Optimization	Enhancing resource productivity and reducing raw material input
5	Renewable Energy Use	Integration of solar, wind, biomass, or other renewable sources
6	Pollution Prevention	Measures to reduce air, water, and soil pollution from industrial activities
7	Biodiversity and Land Use	Preserving natural habitats and optimizing land use planning
8	Mobility and Transportation	Promoting low-emission transport and efficient logistics
9	Environmental Management Systems (EMS)	Adoption of ISO 14001 or similar frameworks for continuous improvement
10	Social, Cultural, and Health Aspects	Ensuring worker safety, community engagement, and cultural sensitivity
11	Noise and Emission Control	Reducing industrial noise and harmful emissions

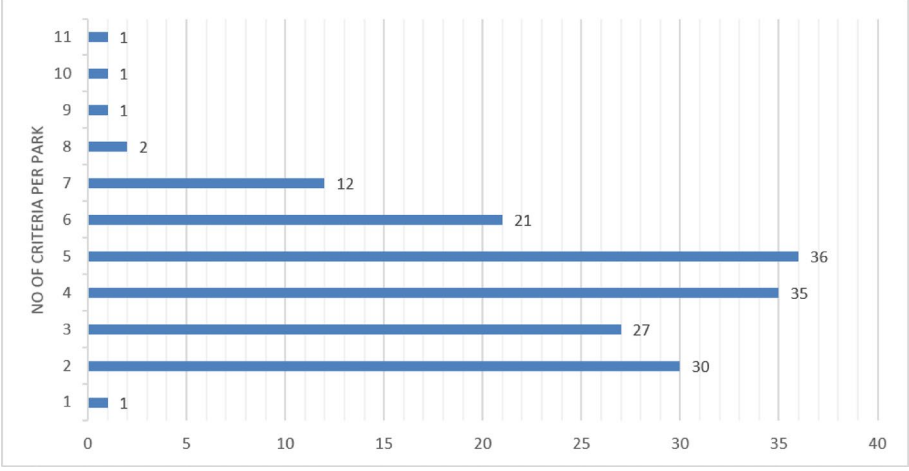

Fig. 1 Distribution of eco-innovation parks according to the number of eco-criteria met. *Source*: Adapted from Jacquet, Massard and Zurcher (2018)

& Slade,2013; Chattaraj, 2017). Moreover, university–industry collaborations, though widely promoted, have not consistently delivered on their intended goals (Kemp & Oltra, 2011; Steinmo & Rasmussen, 2016). The discourse surrounding their potential benefits frequently outpaces the evidence of tangible achievements, underscoring the complexity of the eco innovation agenda. Kemp and Oltra (2011) further emphasize the absence of reliable statistics on eco technologies and the lack of a robust framework for evaluating their performance, both of which hinder systematic assessment and progress. Again, it is worth examining the recorded success factors for eco-industrial parks (Table 7 and Fig. 2).

Based on the data, *coordinators* (109) are the most decisive identified success factor, underscoring the primacy of structured leadership. Collaboration mechanisms—*cooperation in science and technology* (81) and *eco-innovation parks* (78)—form the next tier, highlighting the importance of collective environments. Contextual enablers such as *value added* (69), *policy* (55), and *location* (55) provide the necessary framework, while *incentives* (46) and *diversity* (41) act as complementary enhancers. In parsimonious

Table 7 Success factor for eco-industrial parks

Success Factor	Occurrences
Coordination bodies	109
Cooperation in S&T	81
Eco-innovation parks	78
Value added	69
Policy	55
Location	55
Incentives	46
Diversity	41

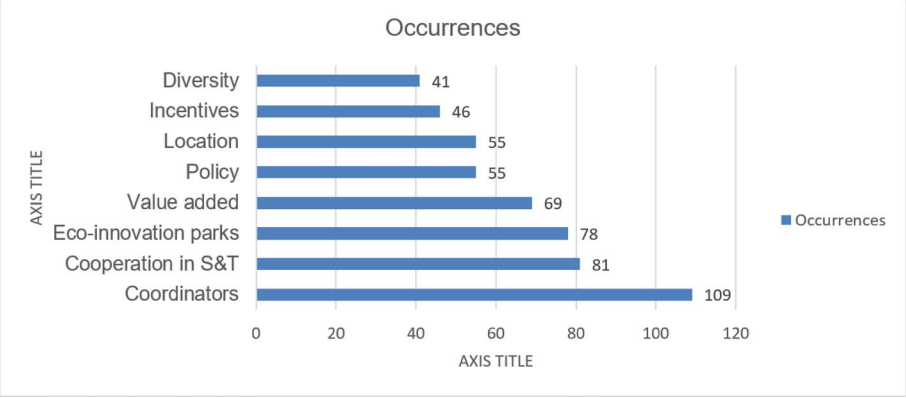

Fig. 2 Distribution of eco-innovation occurrences across policy and innovation categories. *Source*: Jacquet, Massard and Zurcher (2018)

terms, the distribution of success factors is unbalanced, with predominant emphasis on coordination mechanisms and collaboration in science and technology.

Massard, Jacquat, & Zürcher, (2014) distinguish two principal types of coordination bodies: public–private partnership entities that act as facilitators at the industrial park level, and public institutions that operate across broader geographic scales. These arrangements reflect a management structure that sustains synergy between state governance and eco-industrial park initiatives. Within innovation systems, coordination functions typically encompass business model development, project design and management, risk control, communication strategies, awareness-raising, social networking, and engagement with public administration. Coordination bodies thereby serve as institutional mechanisms that define the nexus between government and industry. Empirical evidence indicates that these arrangements are particularly prevalent in developed economies, where innovation driven partnerships underpin industrial competitiveness in global markets.[7] Yet, several factors continue to threaten the effectiveness of

[7] For practical illustrations of the of organised Triple Helix model, see:

a. Silicon Valley in the United States, where Stanford University collaborates with technology firms and government agencies to foster start-ups and global technology leaders (https://cfr.stanford.edu/corporations/engagement-opportunities).
b. Sweden, where the model is embedded in national innovation policy and drives competitiveness in biotechnology and clean energy (https://clean-energy-islands.ec.europa.eu/countries/sweden/legal/other-clean-energy-supporting-policies/rdd-policies-bio-scheme);
c. the Netherlands, particularly Kennispark Twente, known for science parks and incubators that enable joint projects between universities, government, and industry (https://kennispark.nl/en/);
d. Japan, where the Ministry of Economy, Trade and Industry (METI) launched the "Connected Industries" initiative to strengthen collaboration in robotics and advanced manufacturing (https://www.meti.go.jp/english/policy/mono_info_service/connected_industries/index.html).

this collaboration, particularly within the context of the entrepreneurial sustainability agenda. For clarity, these factors will therefore be examined under few headings as follow:

Trust, governance and politics of collaboration

A significant challenge to the entrepreneurial sustainability agenda arises from the intuitive–emotive dimension of decision-making, which can at times overshadow systemic priorities in favour of narrow interests. In the spirit of coordination, it is known that every government operates within the constraints of distinct political agendas, and this may shape the dimensions in which priorities are set for sustainability within the university–government arrangement. In fact, political dynamics often clash with the long-term strategic imperatives of industry and academia, thereby undermining the possibility of sustained, coordinated action (Jackson & Peters, 2022). The rationality with which governments approach coordination tasks—such as funding allocation, regulatory alignment, and innovation policy—varies widely across contexts and is frequently influenced by institutional inertia or short-term political gains. This is where trust, political manoeuvring, and strategic alliances become critical. In many cases, governments must mask political interests behind neutral policy instruments to gain legitimacy and foster cooperation. The success of coordination efforts often hinges on the strength of informal networks and the credibility of public institutions, which can either facilitate or obstruct collaboration with higher education.

Trust, knowledge and entrepreneurial sustainability

The second most critical success factor—cooperation with science and technology institutions—carries significant weight in the context of this study. Higher education institutions, as primary generators of knowledge and intellectual capital, occupy a central role in the innovation ecosystem. They serve as the driving force behind creative ideas, which often evolve into the leading edge of technological advancement and entrepreneurial activity within society. By virtue of these responsibilities, they are expected to coalesce with industry to make a progress in the line of sustainability. Although, evidence abound that this partnership is theoretical sound, and as have been seen or taken off in many advanced countries, they are not without concerns, especially those pressing to the genuine concern of entrepreneurial sustainability. At first, some universities often face difficulties in managing ideas or newly initiated large research projects, particularly those not grounded in established knowledge frameworks or lacking clear organizational structures (Kravchenko et al., 2020). Such challenges exacerbate complications and pose significant threats to the sustainability of UIC. However, this knowledge management inability is less compared to concern of trust that pervade the closure between the industry and higher education.

Like the parable of two intertwined roots, the pervasive distrust harboured by industries toward the university system also remains a critical obstacle to fostering cooperative relationships. No organisation is willing to relinquish the ideas that underlines its dominance and profiteering in the public domain to the perceived abstractions of

e. Germany, where the Fraunhofer Institutes act as a bridge between academia and industry, supported by government funding, positioning the country as a leader in applied research and industrial innovation (https://www.fraunhofer.de/en/about-fraunhofer.html).

academia. Kahneman and Tversky (1979) would sum this up in loss aversion and confirmation bias! Aside from the influence of powerful allies and the constraints of political correctness, evidence suggests that industries are often reluctant to engage with universities and research organizations when developing new products or improving processes (Compagnucci & Spigarelli, 2020; Rybnicek & Königsgruber, 2019). This reluctance arises from concerns that sharing essential knowledge could erode their competitive advantage in highly contested markets.

The productivity paradox: publications versus creative collaboration

Ferguson and Fernández (2015) emphasise that universities are distinguished by their collective commitment, clarity of purpose, and the autonomy that supports rational decision-making. Conceptually, they are often regarded as institutions of rationality, founded upon principles of reason, systematic inquiry, and the pursuit of knowledge. Yet, as institutional theorists such as Habermas and Scott remind us, universities are not insulated from the influence of emotion, politics, activism, and faith, all of which have decisively shaped their historical trajectory and organizational evolution.

The question of what constitutes true productivity—particularly in knowledge creation—has often been cast as a paradox within the university system, with significant implications for entrepreneurship and innovation. Planells-Aleixandre et al. (2025) argue that universities' foundational mission has been eroded by political intrusions that displace rational judgment and compromise institutional integrity. This erosion is reinforced by the prevailing view of universities as spaces of unrestricted inquiry, detached from applied imperatives. While this orientation has historically safeguarded academic freedom, it has also weakened incentives for industry collaboration, limiting opportunities for innovation and societal impact. The tension between pure research and applied knowledge underscores the need to recalibrate autonomy and utility if universities are to remain rigorous and socially relevant in the knowledge economy (Gibson et al., 2019; Mochizuki & Yarime, 2016). Actions taken without reference to the university's foundational role risk becoming wasteful or even futile. Moreover, the tendency to equate productivity with publication volume—rather than with creative ideas and innovation—remains a major obstacle to effective university–industry collaboration (UIC).

Sustainability measurement complexity

The challenges limiting entrepreneurial sustainability within the triple helix framework often stem from fragile trust relations between university and industry. Yet, an even greater obstacle lies in the inherent complexity of measuring sustainability itself, since contested metrics undermine accountability and erode trust further. While universities undeniably play a central role in advancing eco-innovation parks and promoting sustainable entrepreneurship, effectiveness depends not only on the scale of these initiatives but also on their contextual alignment with regional ecosystems and stakeholder priorities. As several studies highlight, no condition carries more profound implications for sustainability than its epistemic nature—the way knowledge is defined, validated, and operationalized within institutional contexts (Leydesdorff, 2012; Galvao et al., 2019; Nwaichi et al., 2025). The epistemic framing of sustainability—whether conceived as ecological resilience, social equity, or economic viability—determines which policies are prioritized and which entrepreneurial models gain legitimacy. Moreover, fragile trust relations and

contested measurement practices reinforce one another, creating a cycle that obstructs entrepreneurial sustainability.

The question erstwhile is that how best should sustainability agenda be approached? The answers tend to lean to role of higher education. Rather than awaiting the full manifestation of sustainability challenges, Higher Education Institutions are often more effective when these issues are addressed at the level of intention. As argued by Valencia-Arias et al. (2025), educational experience and context play a crucial role in the formation of sustainable entrepreneurial intentions. Higher education serve as incubators of sustainable mind-sets, for which impact is maximized when embedded within broader societal partnerships. However, this task of foreseeing sustainable mindset through budding ideas and entrepreneurial and innovative practices may not be easily achieved without recourse to a defined process. We define this process within the purview of data science which will be fully developed and discussed later. In essence, while innovation – a by-product of intuitive thinking – is often celebrated for its being an enabler, it needs to be subjected to rigorous, objective scrutiny that accounts for all possible contingencies, particularly when weighed against its broader social, economic, and cultural cost–benefit implications (Saiz-Santos, de la Mata, & Hoyos-Iruarrizaga, 2017; Orji et al., 2019).

Higher education, innovation and data science

There is little doubt that higher education faces the formidable challenge of fostering innovation—both as a forward-looking catalyst of entrepreneurial potential and as a foundational mechanism for sustaining entrepreneurship over time. A central question, therefore, is why higher education remains so critical to these dual innovation imperatives. The answer lies in its pivotal role within the broader trajectory of human development. As Trinh (2023) underscores, through the integration of teaching and assessment, higher education institutions occupy a strategic position at the core of innovation, shaping national development and advancing capacity building. Yet, the complexities inherent in this role demand the adoption of targeted tools, instruments, and frameworks that can more effectively define and strengthen developmental capacities. In an increasingly entrepreneurially driven world, demonstrable learning outcomes and acquired competencies must serve as credible bases for state funding and incentivization. Only under such conditions can financial allocations from the state be directly and legitimately tied to individual capability.

In simple terms, addressing these complexities increasingly depends on the tools and methods of data science. As an emerging and rapidly evolving field, data science involves the systematic collection, storage, and processing of data to generate meaningful insights into diverse problems and phenomena. It draws upon multiple disciplines—including statistics, artificial intelligence (AI), scientific methodologies, and computational data analysis—to extract value from information and to support more informed, evidence-based decision-making (Sahay, 2021). Data, in turn, are generated through human efforts or machines and also come in different formats. Data science has fascinating algorithms features which include domain-specific, data management and computation, knowledge discovery among others that facilitate a deep understanding of experiences of mathematical analysis, story-telling or business scenario, and intuitive thinking.

Importantly, it applies to entrepreneurship in that it offers the opportunity to know the existing situation and forecast the future while making smarter existential or anticipated entrepreneurial decisions. It also helps an entrepreneur to improve innovation and business performance for competitive advantage while synthesizing data from internal and external sources into insights, and actionable future events (Cao, 2018). In recent times, several theoretical applications of data science to entrepreneurial training and opportunities have evolved in different forms and their integration into the discipline has renewed the task of bridging the theories and practices; and generally, the improvement of entrepreneurial decision-making (Guan et al., 2020). Some of the highlighted theoretical applications of data science are explained below:

Data science and its applications (Table 8) have been widely praised for their usefulness, contributing significantly to the pursuit of both theoretical insights and practical outcomes within the entrepreneurial domain. Yet, despite this encouraging progress, an important caution remains: technologies such as artificial intelligence are often mistakenly regarded as inevitable solutions to the complex challenges confronting universities (Chen & Hitt, 2021; Venters, 2006). Marshall (2018) recalled that such distraction stems from the flawed model of transformative thinking and technocratic motivations that pervades the idea of a modern university system. The constant demand for divergent thinking, often framed around the promise of technological improvement, does not necessarily cultivate the university's deeper mission of fostering critical reflection, civic responsibility, and holistic human development. Instead, it risks reducing academic inquiry to a utilitarian exercise, where innovation is measured primarily by efficiency gains or market competitiveness. Such a trajectory overlooks the essential role of universities as custodians of cultural heritage, ethical reasoning, and the pursuit of knowledge for its own sake (Peters, 2020).

Kahneman and Sibony (2021) underscore this line of thought, noting that while the reduction of system noise may at times justify substituting human judgment with rules or algorithms, such measures cannot be regarded as definitive solutions. The application of technological tools within entrepreneurship education and sustainable entrepreneurship is defensible in principle; however, algorithms remain constrained by the rules upon which they are constructed, rules that may fail to adequately capture the complexity of users' interests and needs. Nevertheless, the academic calling extends beyond the deployment of technical instruments. Scholars must continue to serve as generators of innovative ideas—an endeavour that constitutes the very essence of their intellectual identity. Importantly, the processes through which such ideas are cultivated are as consequential as the substantive problems they aim to address.

The overarching implication is that data science is necessary only insofar it advances entrepreneurial capacity building. Its value does not lie in indiscriminate application, but in its ability to strengthen how entrepreneurship is taught, assessed, and practiced. A range of tools—predictive analytics among others can effectively enhance the teaching and evaluation of entrepreneurial learning at the national level. These tools enable educators to monitor progress, diagnose knowledge gaps, and assess competencies with greater precision, while equipping entrepreneurs with evidence-based insights to inform strategy, optimize resource allocation, and improve risk management. In the subsequent analysis, we outline an ideal regulatory process for managing innovation complexity that incorporates these capabilities.

Table 8 Data science applications for entrepreneurship training and opportunities

References	Applications	Details	Areas of Relations	Statistical Methods/ Techniques	Objectives
Peña-Ayala (2014); Romero et al. (2010); Vijay Gaikwad, Chaugule, & Patil (2014); Yang et al. (2020)	Educational Data and Text Mining	Educational data mining (EDM) is concerned with developing methods for exploring the unique types of data that come from educational settings, and using those methods to better understand students, and the settings which they learn in	Computer Science, Education, Statistics *Sub areas* E-learning Datamining Artificial Intelligence Learning Analytics	*Prediction* Regression classification Density Estimate *Clustering* Hard Clustering Soft Clustering *Relationship Mining* Association rule mining Sequential pattern mining Correlation mining Causal data mining *Social Network Analysis (SAN)* One-Mode Networks Two-Mode Networks Ego-centred and Special Dyadic Networks *Process Mining* Conformance checking Process model discovery Process model extension *Text Mining* Term Based Method (TBM) Phrase Based Method (PBM) Concept Based Method (CBM) Pattern Taxonomy Method (PTM) *Others*: Discovery with models; Outlier Detection, Knowledge Tracing, Matrix Factorization etc	*Learners* EDM supports learner's reflections on the situation Provides adaptive feedback or recommendations to learners Help respond to student's needs, to improve learning performance, etc *Educators* Help in understanding students' learning processes as well as reflection on their own teaching methods; Improve teaching performance by facilitating understanding of social, cognitive and behavioural aspects of entrepreneurial learning etc *Researchers* Help in developing and comparing data mining techniques to be able to recommend the most useful one for each specific educational (entrepreneurial) task or problem Evaluate learning effectiveness when using different settings and pedagogical methods of imparting entrepreneurial instructional contents etc *Administrators* Help in evaluating the best way to organize institutional resources, i.e. human and material, and their educational offer

Table 8 (continued)

References	Applications	Details	Areas of Relations	Statistical Methods/ Techniques	Objectives
Calvo, D'MelloS, Gratch, Kappas (2015); Paiva, Prada, & Picard (2007); Tao and Tan (2005); Wolfe (2006); Yusupova et al. (2021)	Affective Computing	Affective Computing is the study and development of systems and devices that recognizes, interprets, processes, and simulates human affects. It aims to give computers human-like abilities such as observation, interpretation, and generation of affective features	Computer Science, Psychology, Engineering, Neuroscience Education, Cognitive Science Other Disciplines *Sub areas* Recognition of emotions Expression of emotions Having emotions Emotional intelligence	*Affect Generation* Wavelet Packet Analysis *Affect Detection* Neural Networks EEG analysis models multimodal analysis Cluster analysis Linear Discriminant Analysis	*Students* It aids in the regulation of emotions by improving both meaning and memory *Educators* It enables simulations, role plays, and other highly engaging experiential activities *Administrators* It aids in the resolution of real-life problems by increasing emotional and motivational states, thus bridging the gap between the gown and the town

Table 8 (continued)

References	Applications	Details	Areas of Relations	Statistical Methods/ Techniques	Objectives
Mohan et al., (2021); Popenici & Kerr, 2017)	Artificial Intelligence (AI)	AI is a collection of computations that can help users perceive, reason, and act at any time. It is a designed technology that to recognizes speech, improve learning, planning and aid problem solving	Computer Science, Biology, Psychology, Linguistics, Mathematics, and Engineering	*Prediction* Linear regression *Understanding* Data frame Descriptive statistics etc *Causality* Neural network Data Visualization Charts, Graphs, Maps	*Students* Help students in personalizing their learning especially those in line with own unique experiences and preferences outside of the classroom, it assists in sharpening skills and improving weak points makes learning available to all students, at any time and from any location *Educators* Helps in analysing the students' learning abilities and by so doing identify those at-risk and needing improvement through specific learning programme or pedagogy By minimizing students meeting with the educator, AI frees up time for them to focus on lesson planning, curriculum research, and improving student engagement *Administrators* Supports administrative decision in times of financial aid and grants for students or academics

Table 8 (continued)

References	Applications	Details	Areas of Relations	Statistical Methods/ Techniques	Objectives
Bourdot, Interrante, Nedel, Magnenat-Thalmann, & Zachmann (2019); Ma et al. (2011)	Virtual Reality (VR) and Augmented Reality (AR)	VR means a fully computer generated, three-dimensional environment, in which engineers can interact with and manipulate a realistic representation of the product in real time Augmented reality(AR) is an experience where designers enhance parts of users' physical world with computer-generated input	Remote-control operations and robotics Mechanics, optics, and acoustics Computer science *Sub areas* Experimental psychology Behavioural sciences Ergonomics Cognitive psychology Physiology, Neurobiology	cluster analysis, data mining predictive modelling methods spatial analysis	*Students* AR/VR help students grasp abstract concepts and gain hands-on experience in low-risk virtual environments *Educators* AR/VR solutions have the potential to improve collaborations as well as blended learning models AR/VR allows educators to practice their skills with simulated, virtual students before applying them in a classroom setting. *Administrator* Using immersive solutions for collaboration, communication, and community engagement may also be beneficial to administrators

Table 8 (continued)

References	Applications	Details	Areas of Relations	Statistical Methods/ Techniques	Objectives
Brownlee, (2013, 2019); Holloway & Mengersen, 2018)	Machine Learning	Machine learning is a set of algorithms that can detect patterns in data and predict outcomes. The primary goal of machine learning is to improve the behaviour of computers using empirical data	Same as AI	Pattern recognition, Natural language processing, Ensemble learning Sentiment analysis	Same as AI

Table 8 (continued)

References	Applications	Details	Areas of Relations	Statistical Methods/ Techniques	Objectives
Aldowah, Ul Rehman, Ghazal, & Naufal Umar, (2017); Mircea et al., (2021)	Internet of Things (IOT)	The Internet of Things (IoT) refers to frameworks in which web connectivity combines processing capabilities and enables everyday objects to generate, imbibe, and exchange data with the help of sensors, even without human intervention. It is simply based on the idea of integrating everyday smart objects equipped with sensors to the Internet	Scalability Reliability Robustness	*Sensors* Temperature Sensor Thermistors Thermocouples Hair Tension Moisture Sensor Light Sensor Smart Acoustic Sensor Image Sensor Optical Sensor Motor Sensor *Actuators* Linear Actuators Motors Relays Solenoid	*Students* Help in finding study materials such as assignments, quizzes, and presentations, as well as any other study materials that are available on the internet Assist with communication either student-to-students or student-to-lecturer *Educators* Educators can quickly and efficiently transmit lecture material and live video streams of lectures to students anywhere on campus Support global peer-to-peer professional training tools that allow educators from all over the world to share best practices and tips *Administrators* Ensure security and safety of students is become easy task through tracking system Helps with documentation, keeping track of supply management, and properly distribution of funds Enables the simultaneous processing of gigabytes of data, opening up a plethora of application domains for schools and colleges

Framework for integrating data science within higher education capacity development

Although the scope of this analysis, higher education, encompasses a range of postsecondary institutions, this paper focuses on universities, which are the primary drivers

of research and innovation. University is an organisation of its own with a unique mix of academic goals, human resources, infrastructures, cash flow, and changing environment (Bess & Dee, 2008a, 2008b; Saiti, 2010). It is at the heart of innovation complexity through entrepreneurial agents. As pointed out by Bess and Dee (2008a, 2008b) universities are combinations of rational organization and polity. The rational attribute of higher education reflects its hierarchical role in pursuing collective goals, while the polity dimension captures behaviours that advance individual or sub-unit interests. Importantly, the politics of university policy planning often arises internally, as academics balance disciplinary needs with personal or departmental ambitions. When these political interests overshadow rational objectives, institutions risk fragmenting into competing interest groups. The relentless publication race exemplifies polity dominance: academics and departments prioritize visibility, citation counts, and performance metrics over the broader institutional purpose of nurturing intellectual growth and social responsibility (Cortis-Sánchez, 2017; Peters & Besley, 2020). The rot may have equally infiltrated the measurement of learning outcomes, where entrepreneurial ability and student success are defined within the weakest and most simplistic processes. Instead of encouraging creativity, resilience, and ethical leadership, universities often reduce learning to quantifiable outputs—grades, standardized assessments, or employability statistics—that fail to capture the tapestry of human capability. Such reductive measures not only impoverish the educational experience but also perpetuate a narrow vision of what it means to be "productive" in academia.

An ideal university must resist the pitfalls of reductionism by embracing the full complexity of entrepreneurship and innovation, while maintaining control through a holistic and integrative framework. In line with its mission of societal transformation, the university is tasked with bridging and clarifying the relationship between theoretical knowledge and practical realities. Recognizing this complexity further requires universities to adopt predictive approaches that foster social balance, employing technologies to evaluate emerging ideas and to initiate organized entrepreneurial activities within the campus environment. Acknowledging that data science offers a critical solution, we envision a framework that organizes data science thinking (Cao, 2018). This rationalizing process for managing innovative ideas parallels the concept of sensemaking. Weick (1995) visualized organizations as entities bound together either through systems of control—such as incentives and measures—or through the languages and symbols that sustain collective meaning.

As such, the question arises: how can this rationalizing process be effectively organized within the university system? The first step is to define the need for a centralized structure entrusted with the responsibility of coordinating creativity and innovation across the institution. Such a structure would serve as the nucleus for entrepreneurial thinking, ensuring that disparate initiatives are not fragmented but instead integrated into a coherent framework. By centralizing oversight, the university can establish clear policies, allocate resources strategically, and create mechanisms for evaluating and scaling promising ideas or initiated entrepreneurial activities on campus. Although, there is an 'assumed' structure of this thinking within many universities in the frame of University technology transfer offices (TTOs),[8] this capacity may not suffice for every possible

[8] TTO's is in charge of intellectual property protection, technology transfer to companies, and the formation of spin-offs in accordance with the Regulation regarding ownership, protection, and transfer of research results obtained

policy direction and entrepreneurship indicators. University's task at transforming society comes only through numbers of individuals whose own thinking is to achieve their individual goal through the attainment of several competencies. It lies in the midst of trajectory of both individual and societal growth and development. This is key since the goal of individuals may not necessarily allude to the goal of society, necessitating intervention of university in establishing balance (Kahneman & Tversky, 1979).

Although universities cannot assume full responsibility for the historical experiences that have shaped present inadequacies—such as the limited entrepreneurial potential of graduates—nor for the socio-economic, political, and ideological preferences that have sustained systemic shortcomings, they remain accountable for how they respond to these realities. In line with their transformational agenda, universities can foster synergy and cooperation across disciplines and faculties to coordinate and guide innovation, while State or institutions provide the necessary incentives and policy frameworks upon which universities can act. This process includes identifying and supporting potentially valuable and socially acceptable innovative ideas through funding and institutional backing, while simultaneously curbing destructive or unsustainable ideas through stringent policies that prevent their proliferation. Again, this assures that only employees with sustainable ideas are linked with industries.

We recognize the potential of a well-equipped Career and Professional Development Centre within the university to fulfil this crucial organizing role. Why emphasize the Career Development Centre? Because it serves as a harmonious bridge between mind and body, fostering an understanding of both the individual and society. A career—conceived as the totality of one's experiences—functions as a vital interface between government and industry. Career development theorists, particularly Donald Super and John Holland, highlight the vital role of higher education by emphasizing the intertwined significance of self-concept and environment–person fit. Together, these dimensions not only frame the understanding of career trajectories but also serve as catalysts for entrepreneurial and innovative thinking (Wilson & Hutchison, 2014).

For government, the goal is to attract entrepreneurially motivated individuals who can advance its development agenda through creativity and innovation. For industry, the goal is to employ individuals whose personality traits align with established organizational structures.[9] Thus, the Career experts are not only trained to facilitate the transfer of multiple skills—such as interpersonal, organisational, research competencies, cognitive ability, communication skills, and enterprising skills (OECD, 2004), they have the potential to organise the process by which knowledge and innovative ideas are measured with the standard need of the university and the society. Importantly, the Career and Professional Development Centre as a capacity captures several elements that extend entrepreneurship, innovation and commercialisation, patenting and knowledge transfer to a more encompassing function, keyed into a large process that manages innovation- inadequacy, and excess – through synergy and cooperation with academics and professionals of various disciplines in the tune of the need of societies (Kettunen, 2021).

within the University.

[9] Holland's career framework posits that individuals can be classified into six personality types—Realistic, Investigative, Artistic, Social, Enterprising, and Conventional—which inform both occupational choices and functional roles in self-employment and traditional job settings.

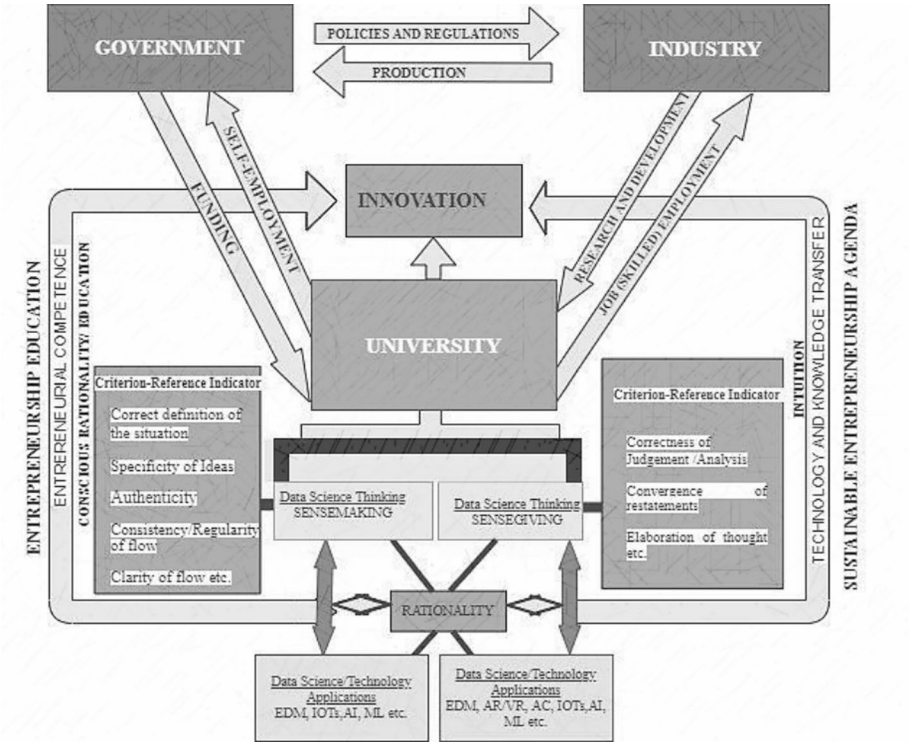

Fig. 3 The capacity development framework combining entrepreneurial potential, sustainable entrepreneurship agenda and integration of data science (authors' impression)

Finally, the present work developed a framework for university capacity to monitor and regulate innovation and knowledge transfer to the tune of policy directions of countries.

Universities serve as dynamic hubs of innovation, responding to societal needs through knowledge creation and entrepreneurial activity. Entrepreneurship, in this context, is not merely about producing marketable products and services—it is deeply rooted in the university's capacity to foster innovation through structured processes. At the core of this framework is the Triple Helix Model, which emphasizes the collaborative interplay between government, industry, and academia. This triangulated relationship is depicted in the upper section of the Fig. 3, representing the external forces that shape and support university-led innovation.

Beneath this, the framework captures the internal innovation process within the university, driven by knowledge management functions—specifically, sensemaking (interpreting complex information) and sensegiving (disseminating insights). These processes require interdisciplinary collaboration across faculties and departments to enable informed and strategic decision-making. To navigate the inherent complexity of innovation and decision-making, the framework incorporates data science technologies. These tools enhance the university's ability to perceive opportunities accurately and interpret entrepreneurial potential, thereby reducing uncertainty and improving outcomes.

Finally, the criterion-referenced layer (tentative) of the framework highlights the role of career and professional development experts. It reflects their nuanced understanding of the balance between individual capabilities and environmental conditions, and how this balance evolves across life stages and educational experiences. This criterion are significant window to which entrepreneurial ideas and innovation are flagged for

incentivisation or de-incentives, transferable or non-transferable for both government and industry respectively.

Implications

Our framework outlines implications that provide strategic contributions of higher education in the following capacities:

a. *Interpretation of Entrepreneurial Ideas and Initiatives*: Career and professional development experts assess how individual capabilities align with environmental demands, identifying viable entrepreneurial ideas.
b. *Signal for Incentivisation or De-Incentivisation*: These experts act as filters, flagging ideas that merit support from government (e.g., policy incentives) or investment from industry—or conversely, signalling ideas that may not align with strategic priorities.
c. *Feedback Mechanism to Government* Insights from this layer inform government decisions on educational reforms, innovation funding, and inclusive policy development.
d. *Alignment with Industry Needs* Experts help shape talent pipelines by matching individual competencies with industry innovation agendas, ensuring workforce readiness and relevance.
e. *Human-Centred Innovation Strategy* The criterion-referenced layer ensures that entrepreneurship is not only market-driven but also responsive to human development across life stages and educational experiences.
f. *Operationalising the Triple Helix* This layer becomes a diagnostic interface that translates individual developmental insights into actionable signals for government and industry, activating the Triple Helix collaboration.

Limitations

The present study is constrained by its reliance on descriptive analyses of GUESSS Survey and Eco-Innovation data, which primarily provided inference for the authors' judgments rather than deeper causal insights. Future research could extend this work by employing more robust survey methods and advanced statistical techniques at country, regional, and global scales to examine the dynamics of entrepreneurial phenomena, particularly those that enrich current understanding of entrepreneurial potential and sustainability.

Conclusion

The paper explores the challenges confronting entrepreneurship, framed through two distinct innovation pathways and their societal implications. The first, "inadequacy," highlights the pressing need for certain nations to strengthen innovation capacity through knowledge creation. This, in turn, fosters employment opportunities, drives regional development via industrialisation, and ultimately supports self-sufficiency. The second, "excess," underscores the necessity of constraining certain forms of knowledge, given the environmental risks and societal dangers they may generate.

The interplay between these opposing challenges produces a complex landscape that demands a system of innovation diffusion, cultivated through reasoning and critical reflection. Within this context, the university—traditionally a hub of teaching and research—must reconsider its theorising role and operational processes. By refocusing

its mission, the university can serve as a steward of innovation destined for societal benefit. Key mechanisms for achieving this include effective knowledge management and technological integration.

In particular, the incorporation of data science and analytics is essential to navigating the complexities inherent in innovation. These tools enhance the clarity, efficiency, and predictive capacity of entrepreneurial innovations, ensuring their relevance to both current and future needs and aspirations.

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Declarations

Competing interests
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