Developing a reflective-formative-formative scale for measuring University Entrepreneurial Ecosystem from students' viewpoints

Abstract

University Entrepreneurial Ecosystem (UEE) provides students and academic staff with the resources and environment where they are supported to take up entrepreneurship. Studies have indicated that student and academic staff-run entrepreneurship contributes to regional development through university spinoffs and knowledge spillover. However, the complete framework of developing UEE has not been discussed in the literature, and scholars have focused on examining the impact of certain aspects of UEE, like entrepreneurial education and technology transfer. The measurement scale for the dimensions of UEE are scarce. We address this gap by conceptualizing the UEE as analogous to the ecology ecosystem and identifying the dimensions of UEE as Entrepreneurial Skill Development, Entrepreneurial Resources, and Entrepreneurial Culture. Moreover, we strengthen the UEE framework by finding out the components and sub-components. Finally, we develop measurement scales for UEE by following a rigorous four-step methodology followed by ensuring the nomological validity of the scale. The paper not only contributes to the entrepreneurial ecosystem literature by conceptualizing UEE and developing a way to measure UEE, but it also helps managers by suggesting a tool for comparison of performance of various UEEs.

Keywords: entrepreneurial ecosystem; university entrepreneurial ecosystem scale; formative scale development; PLS-SEM

Managerial Relevance Statement

Our research offers significant managerial insights for policymakers and academic administrators striving to cultivate vibrant University Entrepreneurial Ecosystems (UEEs). By delineating the

dimensions and sub-components of UEE and providing measurement scales for evaluation, our study furnishes a practical blueprint for enhancing entrepreneurial environments within universities. Extant literature explored only select components of UEE and did not provide a comprehensive idea about the performance drivers of UEE. Extant literature also did not have any scale to measure various components of UEE. Policymakers can utilize this framework to identify areas of improvement within their UEEs, enabling targeted interventions to bolster entrepreneurial skill development, resource availability, and cultural support. Moreover, our findings underscore the importance of tailored strategies for different types of universities: technical institutions may benefit from enhancing entrepreneurial culture and resource infrastructure, while management schools could focus on integrating practical skill-building opportunities. Such a finding is new in comparison to extant literature which has not compared the drivers of UEE performance based on type of the university. Encouraging cross-disciplinary collaborations between these institutions further enriches the entrepreneurial ecosystem, fostering knowledge exchange and innovation. Ultimately, our research empowers stakeholders to make informed decisions, optimize resource allocation, and cultivate a fertile ground for entrepreneurial success within academic settings.

1. Introduction

University as the source of entrepreneurship and new ventures has gained enormous interest over the years [77], [37], [20]. Thus, policymakers and researchers have shown a growing interest in exploring and developing the University Entrepreneurial Ecosystem (UEE) [72], [67]. UEE can be defined as a systematic framework for fostering entrepreneurship and increasing entrepreneurial activities on campus through a holistic approach [38], [2]. UEE plays a significant role in developing the entrepreneurial behaviour of the students and academics [40] and therefore, academicians and policymakers have given a great deal of importance to studying UEE. While

some examined the interrelationships among the components of UEE [2], others have explored the role and impact of university entrepreneurial ecosystem on the spinoff companies [70], [76] and in facilitating technology transfer and industry connect [29], [57]. Another branch of research exploring UEE has focused on the impact of entrepreneurial education and development of entrepreneurial intention among students [39], [27]. Using case-based analysis, some focused on how UEE is formed and its effect on forming new ventures [61]. Although these studies are important, they primarily focus on the effects of specific components of UEE instead of focusing on how the components themselves are developed. There is no generalizable model or framework that can be used to develop the UEE that policymakers can use. Moreover, a validated measurement scale of how the various components of UEE lead to the development of UEE is not available. While some studies in extant literature have tried to measure UEE, the scales used are too simple, not complete, and ignore several important dimensions of UEE [79]. Our study addresses this gap by providing a comprehensive framework that not only identifies and measures the components of UEE but also examines their development within various university settings. The above research gap leads to the following research questions:

(a) What are the components and sub-components of UEE?

(b) How can we measure UEE through its components and subcomponents?

(c) What is the relative importance of such components and sub-components towards entrepreneurial intentions and how does that vary contextually?

We have also added the relative position of our paper in comparison to other extant papers on UEE in Table S0 of supplementary file.

We answer the above-mentioned research questions by following a rigorous scale development approach developing a new hierarchical three-level Reflective-Formative-Formative

scale for measuring the three dimensions of UEE, namely, Entrepreneurial Skills, Entrepreneurial Resources, and Entrepreneurial Culture. The three dimensions have been conceptualized as an analogy of the ecological ecosystem. We further found the relative importance of the dimensions, components and subcomponents on entrepreneurial intention and found the contextual variations of the above. During our research, we kept our conceptualization of UEE targeted to students only and did not include academic staff. Not only the above choice is in sync with extant literature [86], but this is also practical for the following reasons: (a) academic-staff-run entrepreneurship often creates conflict of interest and (b) there is no common rule over various universities all over the world which allows academic-staff-run entrepreneurship.

The remaining part of this article is as follows: We start by providing the theoretical background of the scale. In the next section, we discuss our research methodology. Then we discuss each step of the scale development process. Finally, we end our study with the discussion section.

2. Theoretical Background

The term "entrepreneurial ecosystem" combines “entrepreneurship” and “ecosystem,” referring to a region comprising factors that foster entrepreneurship [74], [77]. This concept has gained significant interest from policymakers and scholars as a systematic way to boost regional entrepreneurship [16], [66]. Special policies now emphasize students, seen as crucial innovation agents, prompting universities to support student entrepreneurship and develop robust UEEs [16].

Studies on universities' roles in student entrepreneurship often focus on individual factors, such as entrepreneurial education [2], [68], [53] or specific micro-entrepreneurial ecosystems like incubation centers and innovation hubs [12], [59]. This fragmented approach has hindered the development of comprehensive frameworks and measurement scales for analyzing UEE quality.

Existing studies, while attempting to measure UEE, lack completeness and robustness, often overlooking crucial components [63]. We aim to fill this gap by providing a more holistic approach.

The concept of an entrepreneurial ecosystem is derived from ecology, where an ecosystem is a community of interacting organisms and their environment [62]. Ecological systems consist of biotic components (living organisms) and abiotic components, which are divided into climatic (e.g., temperature, humidity) and edaphic (e.g., soil type, pH) factors [62]. These components interact and impact the ecosystem's dynamics and sustainability [82].

We use the concept of organizational ecology to develop a UEE framework, drawing an analogy to natural ecosystems. This structured approach models the UEE by highlighting interactions, dependencies, and adaptation mechanisms [4]. In this analogy, student entrepreneurs represent the biotic components, driving the system's dynamics. Just as biotic components in an ecosystem include diverse organisms with varying roles, student entrepreneurs bring diverse skills, motivations, and behaviors to the entrepreneurial environment. This analogy finds support in scholarly works such as [44] and [52], emphasizing the pivotal role of student entrepreneurs in driving innovation and economic growth within the UEE. Edaphic abiotic components in the form of entrepreneurial resources, as described by [84] and [8], provide the foundational elements including funding, infrastructure, and mentorship crucial for supporting and sustaining student entrepreneurial endeavors, like how soil quality affects plant growth. Correspondingly, entrepreneurial culture within the UEE acts as climatic abiotic components, shaping the environment's conduciveness for entrepreneurship. The significance of fostering an entrepreneurial culture that encourages risk-taking, innovation, and resilience among student entrepreneurs has been well advocated in literature [48]. This holistic framework, drawing

parallels between biotic, edaphic abiotic, and climatic abiotic components, offers a comprehensive understanding of the UEE's dynamics.

While the ecological analogy emphasizes the structural and interactional aspects of the UEE, it also implicitly encompasses the development of entrepreneurial mindset through adaptation, interdependence, and dynamic interactions. Just as organisms in an ecosystem adapt to their environment, student entrepreneurs develop and refine their entrepreneurial mindset in response to the resources and culture available to them. This process of adaptation and evolution mirrors the development of entrepreneurial skills, resilience, and innovative thinking. The entrepreneurial mindset thrives in environments where there is synergy between resources, culture, and individual aspirations. This interconnectedness fosters a collective mindset geared towards entrepreneurship, where collaboration and mutual support are pivotal. The dynamic interactions within an ecosystem reflect the continuous learning and growth experienced by student entrepreneurs. Their mindset is shaped by interactions with peers, mentors, and the broader entrepreneurial community, leading to the development of critical entrepreneurial traits such as perseverance, opportunity recognition, and strategic thinking.

3. Scale Development Methodology

To ensure that our scale has high reliability and validity, we followed a four-step scale development procedure adapted from [19], [88], [18], [58] as depicted in figure 1. We first generated the items for our study through a combination of literature, expert interview and Delphi method. In the scale purification step, we performed the exploratory factor analysis. The scale finalization step consisted of confirmation of the first-order reflective scale and the higher-order factors using Smart PLS. Finally, we validated our developed scales using nomological validity. Moreover, we found

the relative importance of the dimensions, components and sub-components along with the contextual variation of the above.

<Insert Figure 1 here>

4. Item Generation via literature review, secondary analysis, and Delphi-method.

A university entrepreneurial ecosystem refers to the interconnected network of resources, programs, and support mechanisms within a university that fosters and encourages entrepreneurial activities among students, faculty, and the broader community [37], [38]. Thus, university acts as an ecosystem consisting of various components that facilitates entrepreneurship. To provide a framework of the UEE we draw analogy to the ecology ecosystem and identify the three dimensions of the university entrepreneurial ecosystem are Entrepreneurial Skill Development, Entrepreneurial Resources and Entrepreneurial Culture.

Our identifying of the items consists of three steps, first we found the components and sub-components of each of the three UEE dimensions via literature review [19]. Secondly, we identified the items of the scale by understanding how each of the sub-components are developed by analyzing secondary data from various reports and by taking personal interviews with stakeholders. Finally, we used Delphi method to finalize the items of our scale [51].

4.1. Identifying the dimensions and sub-components of UEE using Literature Review

4.1.1 Components and sub-components of Entrepreneurial Skill Development

Entrepreneurial skills are fundamental to the success and viability of entrepreneurship [75]. Individuals with strong entrepreneurial skills are more likely to identify and capitalize on opportunities, navigate challenges effectively, and drive innovation within their ventures [9], [16]. Moreover, entrepreneurial skills are essential for fostering a proactive and forward-thinking mindset, enabling entrepreneurs to stay competitive and agile in dynamic business environments.

Therefore, the development and cultivation of entrepreneurial skills are crucial in nurturing a thriving entrepreneurial ecosystem and increasing the likelihood of entrepreneurial success. Entrepreneurial skills are developed through entrepreneurial education and fostering advanced technical skills [68], [20].

Entrepreneurial Education

Entrepreneurial education empowers individuals with the knowledge and skills needed for venture formation [40]. It plays a crucial role in developing students' entrepreneurial abilities [46], [40]. [68] note that entrepreneurial literacy boosts students' self-efficacy and confidence, influencing their intentions to pursue entrepreneurial careers. This education includes both theoretical knowledge and practical skills relevant to entrepreneurship. Entrepreneurial literacy, provided through coursework, equips students with the know-how to navigate their entrepreneurial journeys [55]. Additionally, hands-on experiences and simulations enhance entrepreneurial intention and readiness. [27] emphasize that simulations offer a risk-free environment for experimenting with business ideas, fostering problem-solving, decision-making, and risk assessment skills. This approach also nurtures an entrepreneurial mindset and motivation, shaping students' confidence in their abilities [52].

Advanced Technical Skill

Developing technical skills among students significantly enhances entrepreneurial intention and capability. Universities focusing on technical excellence foster a strong entrepreneurial ethos, producing innovative and ambitious entrepreneurs [20]. Technical skills are developed through literacy and exposure to technological advancements. A robust curriculum and experiential learning heighten entrepreneurial intentions [53]. [26] highlight the crucial role of technical

prowess, especially in technology and data analytics, as drivers of innovation. Technical abilities sharpen problem-solving and fuel creativity, essential for entrepreneurial success. [68] assert that entrepreneurship education fostering technical skills boosts students' confidence and belief in their entrepreneurial capacities. Exposure to technological advancements is pivotal, influencing students' entrepreneurial intentions by cultivating innovation and enhancing perceived feasibility [52]. Familiarity with advanced technologies correlates with a heightened entrepreneurial mindset and the ability to identify market opportunities [73], [9].

4.1.2 Components and sub-components of Entrepreneurial Resources

Edaphic abiotic components in ecology are non-living elements like water, wind, minerals, and soil. In a university entrepreneurial ecosystem (UEE), analogous resources include money, technical support, product development centers, and advisors. Universities should provide these resources to support student entrepreneurs. Entrepreneurial ecosystem literature highlights the importance of both social and material resources.

Social resources

Universities prioritize developing social resources such as support services, mentors, and networks within their entrepreneurial ecosystem due to their significant impact on entrepreneurial intention [74]. These resources empower students, enhance their confidence, and facilitate their entrepreneurial aspirations by providing guidance, advice, and access to valuable networks [21]. Mentorship offers practical insights, encouragement, and networking opportunities crucial for success [22]. Support services and networks create a conducive environment for exploring opportunities and collaboration [17]. Founders, especially student entrepreneurs, often lack essential skills, and networks help bridge these gaps [56]. Effective networking allows students to

exploit opportunities before others [5]. Prioritizing these social resources nurtures a vibrant entrepreneurial culture within universities.

Material Resources

Material resources are the tangible things that entrepreneurs need to set up their businesses. These resources comprise financial support, infrastructure, and general facilities. When you ask, "what is the most important thing needed to start a business?" the first answer that comes to mind is money [67]. Universities have prioritized developing material resources such as financial support, specialized infrastructure (e.g., incubation centers, centre of excellence), and general facilities (e.g., co-working spaces, high-speed internet) in their entrepreneurial ecosystem. Research by [84] underscores the pivotal role of financial resources in influencing entrepreneurial intention, facilitating venture initiation and growth. [8] emphasize the significance of specialized infrastructure, like incubation centers, in providing essential resources and opportunities crucial for entrepreneurial success. Additionally, general facilities, such as co-working spaces and reliable internet connectivity, foster collaboration, idea sharing, and innovation among students [31]. These material resources empower students, reduce barriers to entrepreneurship, and enhance the overall entrepreneurial ecosystem within universities, as demonstrated by [38] and other scholars in the field.

4.1.3 Components and sub-components of Entrepreneurial Culture

Entrepreneurial culture is a factor that has been studied extensively in the literature to understand the impact it has on entrepreneurs and their decision to take up entrepreneurship [49]. Literature has provided evidence that a supportive culture of entrepreneurship immensely encourages entrepreneurs and helps to develop their entrepreneurial intention and motivation [49], [59].

Entrepreneurial culture is analogous to the climatic abiotic component of the ecological system. Unlike edaphic (resource) components of the ecosystem that provide the resources for doing an activity, the climatic abiotic components impact the execution and efficiency of the activity. The university creates a supportive entrepreneurial culture where the students feel comfortable and are encouraged to indulge in entrepreneurial activities. A supportive entrepreneurial culture can be developed through Incentivizing Entrepreneurship, Sensitizing Entrepreneurship and Encouraging Entrepreneurial Traits.

Incentivize Entrepreneurship

The university needs to give some incentives so that the students take up entrepreneurship because it is not the ideal path for students to follow. Universities have provided the following incentives to students. The incentives could be in the form of incentives in placement or coursework to be done. Our education system has taught us that education aims to get good marks in exams and get a job after completing the coursework. The prospect of getting a job is given so much emphasis that, often, the students suppress their desire and dream to start something of their own and take up entrepreneurship. This load of coursework and preparing for exams consumes so much energy that students are left with little to no time to indulge in the hardships of entrepreneurship.

Sensitize Entrepreneurship

Entrepreneurship, for some students, comes naturally [25]. However, the conventional career path for students is to get placed in a company, go for higher studies, or prepare for government jobs. Very few people dare to walk on the risky and uncertain path of Entrepreneurship. One reason behind this is the lack of motivation and unawareness of the benefits one can reap from being an entrepreneur. Sensitizing the students about the bright side of entrepreneurship is necessary.

Universities also prioritize showcasing and celebrating role models within their entrepreneurial ecosystem to foster a supportive environment conducive to entrepreneurial action [26], [46]. Research by [26] and [46] demonstrates that exposure to successful entrepreneurs inspires students, increases self-efficacy, and makes entrepreneurship more relatable and attainable. Role models provide tangible examples of success, instill a culture of entrepreneurship, encourage innovative thinking, and offer guidance and mentorship [13], [64].

Encourage Entrepreneurial Traits

In times of chaos, entrepreneurs embrace uncertainty and seek opportunities [39]. Encouraging traits such as embracing failure and fostering innovation is crucial for shaping entrepreneurial intention among students. Society often views failure negatively [48], but successful entrepreneurs see it as a steppingstone to success. This mentality is being fostered among all university ecosystem stakeholders, including entrepreneurs, faculty, mentors, friends, family, and investors. Universities emphasize developing these traits to cultivate a conducive entrepreneurial mindset. Embracing failure encourages resilience and risk-taking [48], [15], while fostering innovation promotes creativity and problem-solving [7], [23], [43]. By nurturing these qualities, universities inspire students to think entrepreneurially, take calculated risks, and drive innovation, fostering a thriving entrepreneurial ecosystem within their institutions. Table 1 summarizes the dimensions, components, and sub-components of UEE scale along with relevant literature.

<Insert Table 1 here>

4.2 Identifying the items for Scale Development

To create and clean the items of the sub-dimensions, we collected data from two distinct sources. The first set, termed "Entrepreneurial Activity Data," comprises archival information detailing various initiatives undertaken by university bodies to support and cultivate entrepreneurship on

campus. Entrepreneurial Activity Data encompasses reports from the institute's entrepreneurship cells, documented activities on official websites, and compliance with the National Institute Startup Policy (NISP). Additionally, this category includes ARIIA (Atal Ranking of Institutions on Innovation Achievements) reports from the institution, providing insights into entrepreneurial and innovative activities and measures. Using the ARIIA report is very relevant for studying university entrepreneurial ecosystems as it offers standardized measures to assess innovation infrastructure, startup support, funding mechanisms, industry collaboration, and entrepreneurial culture of the university in India.

The second set, labeled "Interview Data," was acquired through interviews with diverse stakeholders associated with the University of Entrepreneurial Excellence (UEE). Interview Data was obtained through semi-structured interviews conducted online by the author between April 2022 and September 2022. The respondents belonged to reputed professional education universities/institutes of India with national ranking in top 10. These institutes had global repute and well-established entrepreneurial ecosystem. Respondents were afforded the freedom to elaborate on the measures implemented by UEE to support student entrepreneurs. Field notes, generated during and immediately after each interview, formed the basis for inductive analysis. Respondents were selected from various UEE stakeholders, including student entrepreneurs, members of the entrepreneurship cell, and professors of entrepreneurship. The dataset comprised 15 respondents, and their demographic details are outlined in Table S2 in supplementary file.

Based on the content analysis of the reports and the interview data, we identified a total of 89 items that were considered in the scale development. The list of the items is provided in the supplementary data.

4.3 Delphi Method to finalize the Items of Scale

The Delphi method was systematically employed to refine and finalize the items for the university entrepreneurial ecosystem scale. A carefully selected panel of experts—comprising academics, industry leaders, and policymakers with expertise in university entrepreneurship—participated in this iterative process [47], [14]. In the initial round, the experts evaluated a pool of 85 items derived from a thorough literature review and expert interviews [14]. Each item was assessed for relevance, clarity, and importance in capturing the multifaceted dimensions of the university entrepreneurial ecosystem. Qualitative feedback and suggestions for additional items were solicited to ensure comprehensive coverage [32].

Items not meeting predefined consensus criteria were flagged for potential exclusion or revision based on expert feedback and statistical analysis [32]. Subsequent Delphi rounds presented a revised set of items, incorporating expert feedback for reevaluation. Experts provided final ratings, focusing on achieving consensus and selecting the most salient items for inclusion [14].

The Interquartile Range (IQR) was used to assess consensus among experts, as it is robust to outliers and easy to interpret. The IQR is calculated by determining the difference between the 75th percentile (Q3) and the 25th percentile (Q1) of the experts' ratings for each item. Small IQRs indicated strong consensus, highlighting the items' significance, while larger IQRs prompted further scrutiny. This consensus-based process led to the rejection of 12 items that did not meet the criteria, resulting in a final scale of 77 items [47], [32]. The final items are listed in the Figure S1 in supplementary file.

5. STEP-2: Scale Purification*:* Exploratory Factor Analysis

To evaluate the items of 1st order reflective scale of the components of UEE, we followed the exploratory factor analysis (EFA) method. EFA is a method for factor reduction through which

many observed variables are clustered into latent variables. We used a principal component analysis with varimax rotation for EFA analysis [88].

5.1 Data

We collected samples from UEEs where startups thrive, supported by funding, infrastructure, networks, culture, and policies. Using a questionnaire, we surveyed Entrepreneurship Cell members, student entrepreneurs, and faculty involved in entrepreneurship. This targeted approach enhanced data significance and reliability [35]. Responses were collected on a Likert scale from 1 (Totally Disagree) to 5 (Totally Agree). Based on literature review, expert interviews, and the Delphi method, the questionnaire assessed entrepreneurial skill development, resources, and culture. Data from 30 Indian universities yielded 479 valid responses, split into two samples for exploratory factor analysis and scale finalization (see Table S3).

5.2 Results

The Kaiser-Meyer-Olkin (KMO) statistic assesses the adequacy of a sample for factor analysis, indicating whether the data is suitable for this type of statistical procedure ([10]. KMO values above 0.8 are deemed satisfactory for factor analysis [19]. In this study, the KMO values for three dimensions—Entrepreneurial Skill Development, Entrepreneurial Resources, and Entrepreneurial Culture—were 0.892, 0.870, and 0.875, respectively, suggesting that the samples were appropriate for factor analysis. Additionally, Bartlett's Test of Sphericity evaluates whether the correlation matrix displays significant correlations among its components [42], [19]. For all dimensions, Bartlett's test results were significant, with chi-square values of $\lambda(n=153) = 948.598$ (Entrepreneurial Skill Development), $\lambda(n=406) = 1748.841$ (Entrepreneurial Resources), and $\lambda(n=435) = 2059.449$ (Entrepreneurial Culture). These results, presented in Table S4 of the supplementary file, confirm that the data is suitable for factor analysis.

The Communalities Test measures how well each item correlates with other items, with values above 0.5 being desirable for significant factor loading [83]. Our analysis showed communalities above 0.5 for all three dimensions. The total variance explained by the derived factors was 72.828% for Entrepreneurial Skill Development, 73.363% for Entrepreneurial Resources, and 68.178% for Entrepreneurial Culture. Ideally, the scale should account for at least 60% of the variance [42].

Exploratory Factor Analysis (EFA) determines the strength and direction of relationships between observed variables and extracted factors, with higher loadings indicating stronger associations [19], [41]. Items with factor loadings above 0.50 were retained. Items with loadings below 0.5 or cross-loadings above 0.4 were excluded. In the initial EFA, items EL4 and ATL1 from the Entrepreneurial Skill Development dimension were removed due to cross-loadings. The revised EFA explained 73.21% of the variance, with KMO value of 0.889 and Bartlett's test chi-square of $\lambda(n=105) = 672.585$.

For the Entrepreneurial Resources dimension, items FS2, GF2, SS4, FS5, and MEN4 were removed due to cross-loadings or low factor loadings (check table S5 and S5.1 in supplementary file). The final EFA explained 74.96% of the variance, with KMO value of 0.869 and Bartlett's test chi-square of $\lambda(n=276) = 1322.864$. In the Entrepreneurial Culture dimension, items GE4, SRF5, IC2, and PIC5 were excluded for similar reasons. The final EFA explained 70.72% of the variance, with KMO value of 0.882 and Bartlett's test chi-square of $\lambda(n=325) = 1698.506$.

Reliability was assessed using item-to-total correlations and Cronbach's alpha values. All item-to-total correlations were above 0.5 [10], and Cronbach's alpha values ranged from 0.745 to 0.897 across the three scales, indicating good reliability. Consequently, out of the original 75 items, 66 were retained for the development of the UEE scale.

6. STEP-3: Scale Finalization

In the first step, we assessed the validity and reliability of our first-order reflective scale. All first-order factors were reflective in nature. Then we tested our higher-order hierarchal structure of our model. Both these steps of scale finalization are discussed in the following sections.

6.1 Confirmation of First-Order Reflective Scale

We use Smart PLS to confirm the validity and reliability of the first-order reflective scale. Smart PLS, as a method to confirm the reliability and validity of the model, has recently gained immense popularity [60]. We checked our scale's model fit, reliability, convergent validity, and discriminant validity [19]. The results of the confirmatory analysis of the first-order reflective scale for the Entrepreneurial Skill Development, Entrepreneurial Resources, and Entrepreneurial Culture scales are depicted in figure 2.

To analyze the model-fit of the scale, we used SRMR values, which should be less than 0.1 [60]. The SRMR values for Entrepreneurial Skill Development, Entrepreneurial Resources and Entrepreneurial Culture dimensions are 0.061, 0.054, and 0.088, respectively. We performed reliability analysis to check the consistency of the scale. We checked the reliability using Cronbach's alpha and Composite reliability [41]. The range of Cronbach's alpha value of three dimensions of the scale ranged between 0.732-0.888, 0.741-0.911, and 0.778-0.896, and thus are greater than the acceptable value of 0.7 [65]. The composite reliability (rho_c) value for the dimensions of scale showed values greater than 0.7 [65]. Thus, based on Cronbach's alpha and composite reliability results, our scale has good reliability.

We checked for convergent validity by analyzing the average variance extracted (AVE) values. The AVE values, which should be greater than 0.50 [60] or all the dimensions of the scale, ranged between 0.554-0.749, 0.523-0.763, and 0.585-0.759. To establish discriminant validity, we

used the Fornell and Larcker (1981) criterion that states that the square root of the AVE should be more than any correlation with another factor. To fulfill the Fornell-Larcker Criteria**,** the square root of AVE for one factor should be greater than the correlation of that factor with all other factors. The condition was met for all the sub-components of the scale. We also used Heterotrait-Monotrait Ratio of Correlations (HTMT ratio). The HTMT ratio for all sub-components of the scale was less than the acceptable value of 0.9 [42]. Thus, our scale also passed the discriminant validity test.

<Insert Figure 2 here>

6.2 Test of the hierarchical factor structure

The higher-order factors consist of dimensions and sub-components. Using PLS, we further tested whether the higher-order factors could be formulated as a third order which comprises of second-order dimensions. We used the repeated indicator technique to specify the hierarchical structure in PLS in accordance with [11]. For this method, underlying first-order latent variables and all manifest variables of the underlying lower-order constructs served as representations for a higher-order latent variable [85]. As a result, in the case of third-order models, the elements were used three times. The results of the hierarchical third-order measurement model for each scale are shown in figure 3.

We checked the significance of the 2nd order dimensions and 3rd order factor by checking the factor weights. All factor weights for each scale were significant. To check if our 3rd order measurement scale was good or not, we checked the t-statistics of higher-order factors. The t-statistics were greater than 1.96 for 2nd order and 3rd order factors. We also checked the multicollinearity of our scale. In the case of formative models, the lower order and higher order variable's relationship strength need not be strong. Thus, the indicator reliability and convergence test may not hold good in case of formative models. So, we used the variance inflation factor (VIF)

of the 2nd order dimensions to ensure there was no multicollinearity problem in our model. The VIF values for all the dimensions were between 1.578 - 3.354 (scale-1), 1.927 - 3.128 (scale-2), and 1.403 – 2.905 (scale-3), which is below the critical limit of 10 [42].

Finally, we checked the discriminant validity of the formative measures. However, unlike reflective constructs, AVE cannot be used to check discriminant validity in the case of the formative construct [19], [41]. To assess the discriminant validity of the formative measures, as in the case of formative constructs, the items might not converge [28]. Thus, we analyzed the item-to-construct and item-to-item correlations for formative constructs. We used latent variable scores and found that the correlations between a particular higher-order factor and its sub-components were more in comparison to the correlation between that higher-order factor and sub-components of other higher-order factors.

Thus, our higher-order hierarchical measurement models present a suitable approach for the measurement of the dimensions of UEE, namely Entrepreneurial Skill Development, Entrepreneurial Resources, and Entrepreneurial Culture.

<Insert Figure 3 here>

7. STEP-4: Scale Validation

Nomological Validity: Nomological validity tests are used to check the degree to which a pre-established theory is confirmed by a model. If our model confirms nomological validity, then our model should produce results in accordance with the relationship that has been established theoretically [83], [58]. Scholars of entrepreneurial research have frequently suggested that the components of UEE positively affect the entrepreneurial intention of the students [53], [68]. Thus, to test nomological validity, we used the hypothesis that Entrepreneurial Skills, Entrepreneurial

Resources, and Entrepreneurial Culture will positively impact the entrepreneurial intention among the students [34], [46]. We, therefore, used an additional four-item measure for entrepreneurial intention: (a) The career aspiration of students of university is to become an entrepreneur (b) Students of University Seriously consider starting their own firm (c) Students of your university have firm intention to start their firm someday (d) Students of your University will make every effort to start and run their business, adapted from [1] in our questionnaire.

In our study, we used the PLS model to test the nomological validity of our scales. We used one-tailed significance test as our hypothesis indicated the direction between factors [88]. The significance of parameter estimates of each scale was analyzed, and the t-scores were also noted. As assumed, results show that the dimensions, i.e., Entrepreneurial Skill Development, Entrepreneurial Resources, and Entrepreneurial Culture, showed a highly significant influence (β=.650, t=9.932 for scale-1; β=.536, t=5.018 for scale-2; β=.591, t=13.429 for scale 3) on the entrepreneurial intention of the students. Thus, we can say that our scale confirms the nomological validity test. We also performed multigroup analysis between technical and management students, the results of which are shown in figure 4.

<Insert Figure 4 here>

8. Discussion

8.1 Measurement Scale

We developed the measurement scale for each component of UEE. We started our analysis with a pool of 77 items. After the scale purification step, some items from the scale that did not meet the inclusion criteria were deleted. After that, in the scale finalization step, we found that all the retained items passed all the tests for inclusion in the scale. Our scales also stood the nomological

validity test, thus completing our scale development process. The final scale is in Figure S1 in supplementary file.

8.2 Theoretical Implication

This paper makes a significant contribution to the University Entrepreneurial Ecosystem (UEE) literature, which has traditionally concentrated on the relationships between select UEE components and their effects on spinoff companies, technology transfer, and entrepreneurial intentions [70], [29], [39], [84]. Our research addresses this gap by presenting a comprehensive framework that not only identifies and measures various UEE components but also explores how these components evolve across different university contexts—a dimension that has been largely overlooked in previous studies [2].

Furthermore, the absence of a widely accepted and validated measurement scale to evaluate UEE components remains a critical limitation in existing research. Prior measurement attempts have often been incomplete, omitting essential dimensions of UEEs [79]. By emphasizing the key determinants of UEE and introducing robust, validated measurement scales, this study offers a vital resource for policymakers and academic administrators who seek to develop, evaluate, and enhance entrepreneurial ecosystems within universities [43], [87].

Ultimately, this work advances both theoretical and practical understanding of how entrepreneurial ecosystems within universities can be developed, measured, and sustained, offering valuable insights that policymakers can use to foster entrepreneurship in academic institutions [61], [76], [57].

Our measurement scales enable scholars to analyze the impact of UEE components on various aspects of student entrepreneurship, such as entrepreneurial behavior and the success of student ventures. The sub-components of our scale can serve as foundational elements for

establishing new UEEs and will pave the way for similar studies in different countries. This approach not only advances UEE literature but also contributes to the broader entrepreneurial ecosystem literature [66], [74]. By identifying components and sub-components of different entrepreneurial ecosystems, similar scales can be developed to measure and track their development. Such a finding is new in comparison to extant literature which has not compared the drivers of UEE performance based on type of the university [70], [29], [39], [84].

In technical universities, where innovation and technical expertise are highly valued, entrepreneurial culture emphasizes risk-taking, experimentation, and applying technical knowledge to solve real-world problems. These environments encourage creativity, collaboration, and interdisciplinary thinking, fostering an entrepreneurial mindset. Access to resources such as laboratories, research facilities, and technology transfer offices provides tangible support for entrepreneurial endeavors.

Conversely, management universities focus on developing specific entrepreneurial skills such as strategic thinking, market analysis, financial management, and leadership. These skills are essential for identifying business opportunities, formulating viable business models, and navigating business complexities. The entrepreneurial culture in these institutions may be more structured, emphasizing business-oriented strategies and practices.

This variation highlights the contextual nature of entrepreneurial intentions and underscores the need for tailored approaches in entrepreneurship education based on the specific characteristics and goals of academic institutions. It enriches the literature by providing insights into how different educational environments shape students' entrepreneurial aspirations and behaviors.

Our study also promotes cross-disciplinary collaborations between technical and management universities, facilitating knowledge exchange and co-creation of innovative solutions, thereby enriching the entrepreneurial ecosystem in both types of institutions. The scale we have developed is thus suitable for different university types, including technical and management.

8.3 Managerial Implication:

The focus on developing the UEE to foster entrepreneurship among the students has got a lot of traction over the years [37]; [24]. Our study provides policymakers with a blueprint to develop an understanding of how to develop different components and sub-components of UEE. Our scales can also be used to assess the quality of the UEE and to get on comparing one's ecosystem with respect to other universities. Policymakers can identify the areas in which they are lacking and will also have an indication of what activities and initiatives should be considered for developing specific dimensions of the UEE and thus can make more informed decisions. Our study indicated that there is much more to the ecosystem than just arranging the resources required for entrepreneurship. The measurement scales identify and validate different dimensions and sub-components of ecosystem in addition to common factors like finance, infrastructure, and support services. Such a scale of measurement and such clarity of various components of UEE was unavailable to academicians and policymakers based on extant literature.

Using our scale, policymakers and university ecosystem managers could develop a Dynamic Entrepreneurial Readiness Index (DERI). This index would assess the current entrepreneurial climate across universities at different stages of development and innovation. It could be used as a benchmarking tool to compare universities at local, national, or even international levels. The index would dynamically adjust based on real-time feedback, ensuring

that universities continuously track progress and adapt their ecosystems accordingly. Additionally, this could serve as a ranking system that motivates institutions to enhance their entrepreneurial infrastructure and culture to achieve better standings in the index.

From our research we have also realized that technical universities may benefit from enhancing their entrepreneurial culture and resource infrastructure to further stimulate entrepreneurial intentions among students. On the other hand, management universities could focus on integrating practical skill-building opportunities into their entrepreneurship programs to better prepare students for entrepreneurial endeavours in the business world. Additionally, fostering cross-disciplinary collaborations between technical and management universities could facilitate knowledge exchange and the co-creation of innovative solutions, enriching the entrepreneurial ecosystem at both types of institutions.

In Table S19 in the supplementary file, we discuss how our scale can be used in different university contexts providing differential focus on various dimensions based on the objectives of the university contexts. This provides administrators with valuable insights for strategic planning (identifying strengths and opportunities for improvement to develop targeted strategies related to entrepreneurial outcome from universities), resource allocation (allocating resources in weaker areas), policy development (strategizing action points for better efficiency of resource allocation), and continuous improvement (regularly assessing the entrepreneurial ecosystem to monitor progress and adapt strategies based on feedback).

8.4. Limitations and Future Scope

The above study has a few limitations too. Our study was conducted within the context of Indian universities, which may limit the generalizability of its findings. To address this limitation, future studies should expand their scope by examining the University Entrepreneurial Ecosystem (UEE)

in various entrepreneurial universities worldwide. This study doesn't examine how university entrepreneurial ecosystems affect social enterprises, highlighting the university's role in civic and community empowerment, which is crucial area that future scholars should explore. Moreover, demographic characteristics of students may influence the data provided by them, but this aspect was beyond the scope of the current study. Future research could explore the influence of demographic factors, such as gender, ethnicity, and socioeconomic background, on entrepreneurial intentions within the university context. Another aspect that warrants attention in future studies is the temporal dimension of the UEE. This study adopted a static approach, overlooking the origin and self-sustainable development process of the entrepreneurial ecosystem (EE). Given that the UEE is in a continuous state of evolution, understanding its temporal dynamics is crucial. Research should consider the dynamic nature of the EE, acknowledging its phases of emergence, development, maturity, and even decline over time.

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Tables

Table 1: Source of components and subcomponents

Dimension 1: Entrepreneurial Skill Development		
Components	**Sub-Components**	**Reference**
Entrepreneurial Education (EE)	Entrepreneurial Literacy (EL)	[39], [69], [84]
	Entrepreneurial Simulation (ES)	[50]
Advanced Technical Skills (ATS)	Technical Literacy (TL)	[20]
	Exposure to Technological Advancements (ETA)	[81], [33]
Dimension 2: Entrepreneurial Resources		
Social Resources (SR)	Support Services (SS)	[6]
	Network (NET)	[17], [21]
	Mentors (MEN)	[22]
Material Resources (MR)	Financial Support (FS)	[54], [55], [67]
	Specialized Infrastructure (INF)	[71], [36]
	General Facilities (GF)	[31], [3]
Dimension 3: Entrepreneurial Culture		
Incentivize Entrepreneurship (IE)	Incentives in Placements (IP)	[45]
	Relaxation in Coursework (IC)	[13]

Sensitize Entrepreneurship (SE)	Glorify Entrepreneurs (GE)	[13], [64], [80]
	Awareness & Motivation (AM)	[30]
Encourage Entrepreneurial Traits (EET)	Support Failure & Risk Taking (SFR)	[48], [15]
	Promoting Innovation & Creativity (PIC)	[78] [23] [7]

Table 2: Effect on entrepreneurial intentions: Nomological validity through Multigroup Analysis between technical and management students

	Total Sample	Technical Univs	Management Univs
Entrepreneurial Skill	0.650 (t=9.932)	0.486 (t=11.287)	0.784 (t=8.34)
Entrepreneurial Resources	0.536 (t=5.018)	0.652 (t=7.321)	0.438 (t=9.752)
Entrepreneurial Culture	0.591 (t=13.429)	0.663 (t=7.906)	0.504 (t=9.813)

Figures

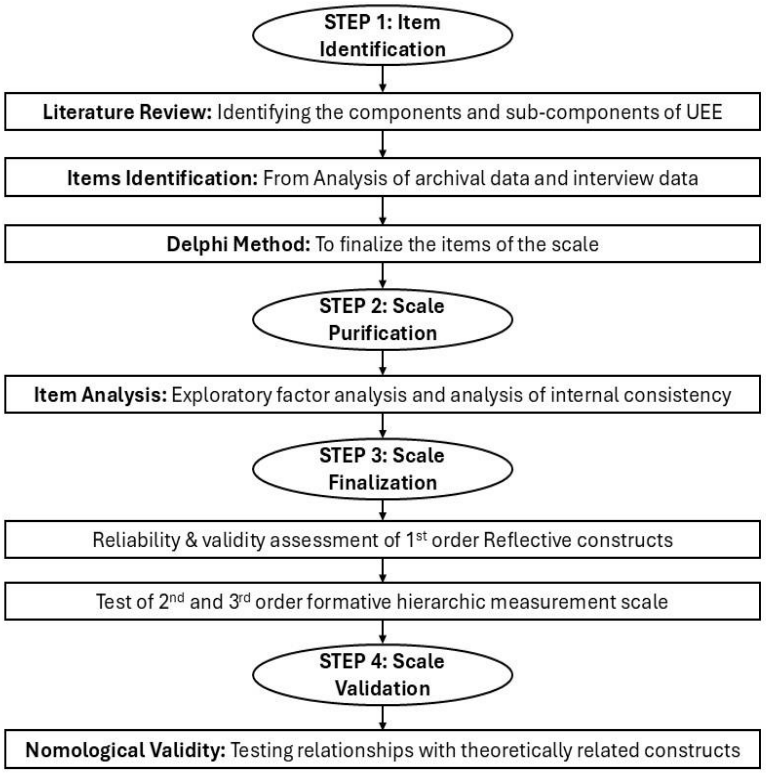

Figure 1: Steps of Scale Development

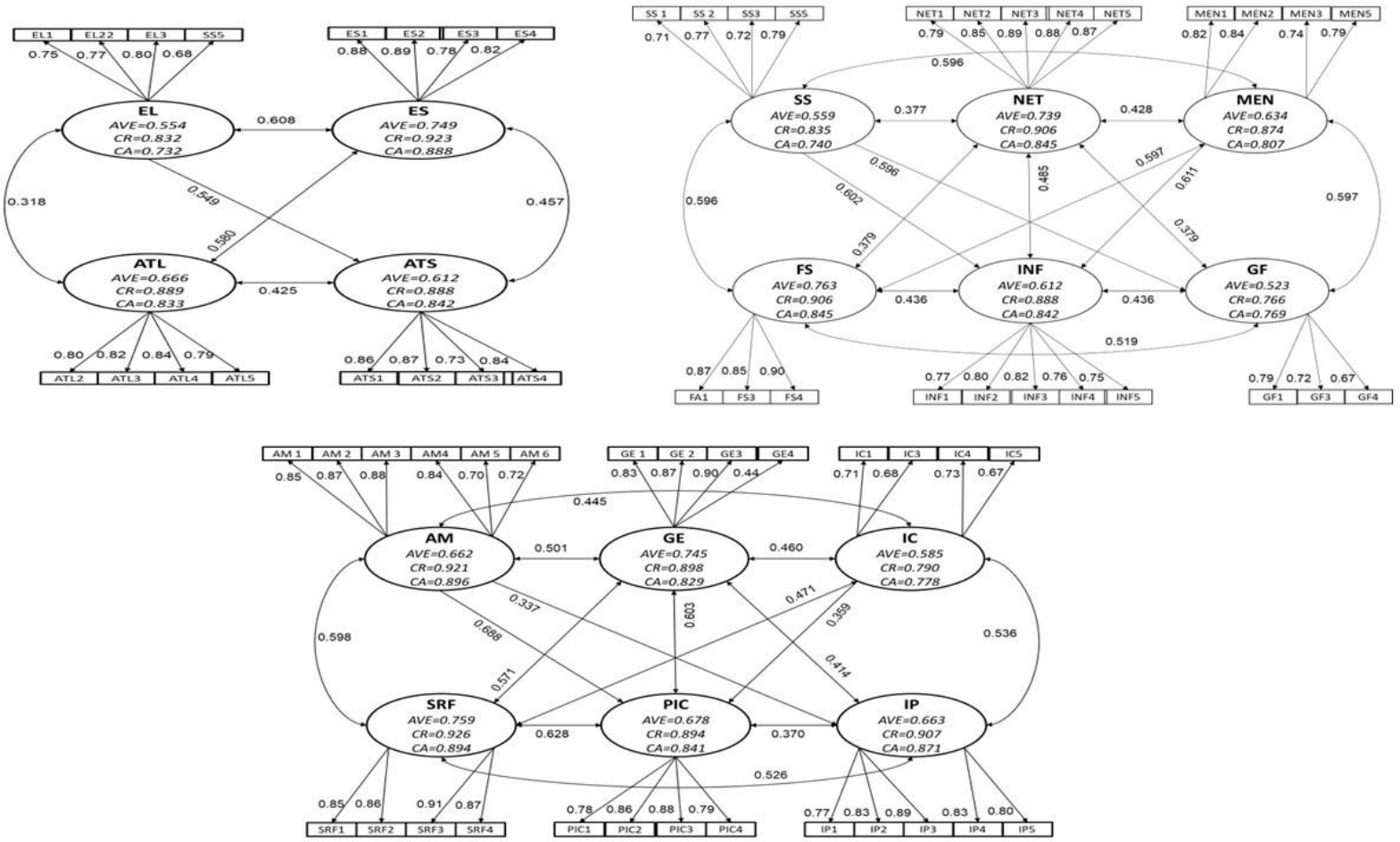

Figure 2: Confirmatory first-order measurement model results for the subscales

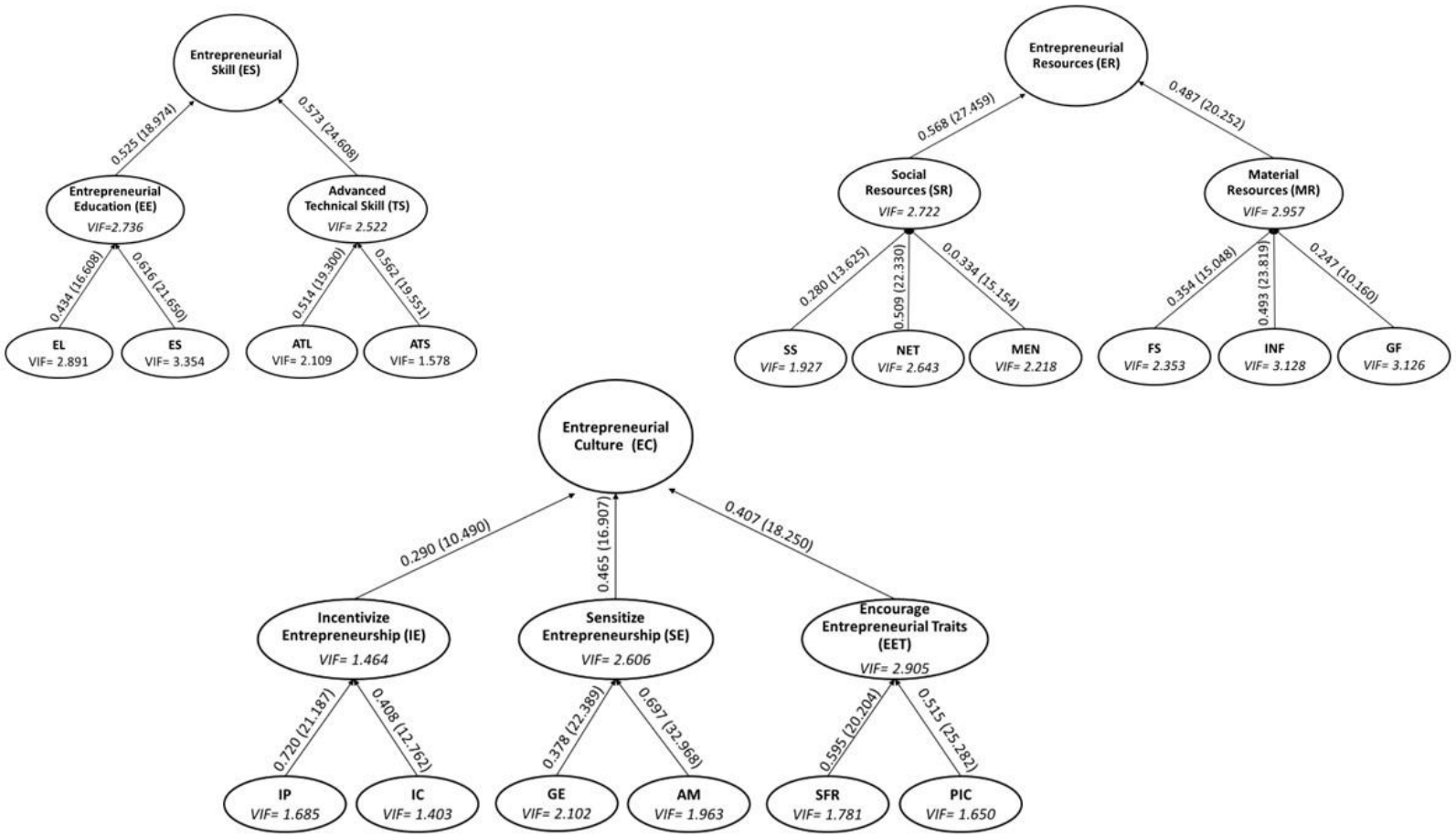

Figure 3: Hierarchical Third-Order Measurement Model Results