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EXAMINING THE PERCEPTIONS OF INDUSTRY-ACADEMIA COLLABORATION IN INDIAN HIGHER EDUCATION INSTITUTIONS: SCALE DEVELOPMENT AND VALIDATION

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Abstract

Industry-academia collaboration (IAC) is a valuable partnership between academic institutions and industries that fosters innovation, improves educational outcomes, and drives economic growth. This research paper aims to investigate and identify the critical success factors associated with IAC in Indian Higher Education Institutions (HEIs). The study seeks to develop a reliable and valid scale for measuring and assessing these success factors within the unique context of Indian HEIs. Through analysis of engineering institutions across India, the study provides quantitative insights into the factors influencing the success of industry-academic collaboration. The constructs of IAC Strategy, Empowering Academic Ecosystem, and Alumni Engagement exhibit strong measurement properties, including reliability and convergent validity. This collaborative approach not only benefits students but also positions HEIs as leaders in emerging trends, contributes to economic growth, and addresses societal challenges in quantifiable ways.

Keywords: Industry-Academia Collaboration, Critical Success Factors, Scale Development IAC Strategy, Empowering Academic Ecosystem, Alumni Engagement.

1. INTRODUCTION

Higher education institutions (HEIs) in India play a crucial role in the nation's intellectual, social, and economic progress. With a wide range of HEIs offering diverse academic programs, they contribute to the development of a skilled workforce and drive innovation (Bhattacharya et al., 2019). However, HEIs currently face various challenges, such as access and equity, quality assurance, limited infrastructure, faculty shortages, outdated curricula, and gaps between academia and industry (Sharma & Choudhary, 2020).

To address these challenges and improve the competitiveness of HEIs, the Indian government and other stakeholders have implemented initiatives like the Rashtriya Uchchatar Shiksha Abhiyan (RUSA) and the National Institutional Ranking Framework

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(NIRF) (Mishra & Singh, 2019). These initiatives aim to foster collaboration between HEIs and industries. Industry-academia collaboration (IAC) within the Indian higher education ecosystem is essential for driving innovation, enhancing educational outcomes, and promoting economic growth (Garg & Arora, 2021).

IAC enriches educational programs by enhancing employability and contributing to the development of a skilled workforce (Kaur & Sharma, 2019). It bridges the gap between theory and practice, equips students with employability skills, and fosters a culture of lifelong learning (Mondal & Rai, 2021). However, successful implementation of IAC requires addressing challenges such as organizational differences, limited resources, and conflicting priorities (Choudhary & Garg, 2020). Overcoming these challenges necessitates effective communication, shared objectives, and streamlined processes (Khurana & Kumar, 2018). Strategies should focus on fostering meaningful partnerships and facilitating knowledge exchange to enhance the effectiveness of IAC (Mukherjee & Goyal, 2020).

The involvement of alumni is crucial for the successful implementation of IAC initiatives, as they serve as valuable resources and bridges between academic institutions and industries. By engaging alumni in IAC efforts, HEIs can tap into their practical experiences, insights into industry trends, evolving skill requirements, and market demands (Mondal & Rai, 2021). Alumni can contribute to aligning academic programs with industry needs, serving as mentors, guest speakers, and advisors to guide students and faculty members. Their involvement strengthens the link between academia and industry, enhancing the employability of graduates and fostering a culture of continuous learning and industry engagement.

The effective and successful implementation of IAC requires various strategies. These strategies include establishing collaborative platforms, offering practical training opportunities, establishing clear intellectual property rights (IPR) policies, streamlining administrative processes, and incentivizing collaborative initiatives. By adopting these strategies, stakeholders can enhance knowledge exchange, promote practical skills development, address intellectual property concerns, ensure efficient project management, and foster a culture of collaboration and innovation. Empowering the academic ecosystem for industry-academia collaboration is crucial for fostering successful partnerships and driving innovation.

To empower the academic ecosystem for industry-academia collaboration, several key strategies have been identified. Firstly, cultivating a culture of collaboration is vital. Encouraging open communication, interdisciplinary cooperation, and knowledge sharing within the academic community creates an environment where faculty, researchers, and students actively seek opportunities to engage with industry professionals and apply their academic knowledge to real-world challenges (Jones et al., 2020).Developing industry-relevant curricula is another essential strategy. Regularly reviewing and updating academic programs ensures they remain relevant, practical, and equip students with the skills and knowledge demanded by the job market. Engaging industry experts and professionals in curriculum development ensures industry relevance by incorporating

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industry case studies, projects, and internships into the learning experience (Robinson et al., 2022).

Promoting industry-driven research is crucial for fostering collaboration. Encouraging faculty members and researchers to collaborate with industry on research projects creates an environment conducive to collaboration. Establishing mechanisms to identify research areas aligned with industry requirements facilitates joint projects, research clusters, and research centers. By disseminating research findings to industry stakeholders, academic institutions ensure the practical application of research outcomes (Turner & Baker, 2020).Establishing industry advisory boards comprising professionals and experts provides valuable guidance to academic institutions. These boards advise on industry trends, emerging technologies, and evolving skill requirements. They shape academic programs, provide mentorship opportunities, and facilitate industry-academia collaborations (Anderson & Roberts, 2018). Facilitating networking and knowledge exchange is another critical strategy. Organizing seminars, workshops, conferences, and guest lectures allows industry professionals to share their expertise while academic researchers showcase their work. Encouraging interactions between students, faculty, and industry representatives through career fairs, industry showcases, and networking events builds strong connections and explores collaborative opportunities (Smith & Davis, 2019).

Providing resources and support is essential to empower the academic ecosystem. Establishing dedicated offices or centers within academic institutions that coordinate industry collaborations can provide assistance in project management, intellectual property rights, legal considerations, and administrative support. Offering grants, funding opportunities, and incentives also promotes collaborative research and innovation (Baker et al., 2021).

Fostering entrepreneurship and a start-up culture within the academic ecosystem is important for industry-academia collaboration. Supporting initiatives that encourage innovation, technology transfer, and the commercialization of research outcomes is key. Providing mentoring, incubation support, and access to funding opportunities for aspiring entrepreneurs among students, faculty, and researchers fuels an entrepreneurial spirit (Brown & Thompson, 2023).Enhancing industry-academia communication and partnerships is crucial for successful collaborations. Establishing formal mechanisms for dialogue, such as joint committees, industry forums, and partnerships, encourages ongoing collaboration. Actively seeking feedback from industry partners improves collaboration efforts and ensures mutual benefit (Jones & Turner, 2021).

By implementing these strategies, stakeholders can cultivate a collaborative culture, align curricula with industry needs, promote industry-driven research, establish advisory boards, facilitate networking and knowledge exchange, and provide resources and support. Empowering the academic ecosystem for industry-academia collaboration requires a proactive and collaborative approach from various stakeholders. It requires recognizing the importance of collaboration, fostering connections with industry, and creating an environment conducive to knowledge exchange and practical application of

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research outcomes. Through these efforts, the academic ecosystem can drive successful industry-academia collaborations, leading to mutual benefits, advancements in research and technology, and societal impact.

Moreover, streamlining administrative processes is crucial to facilitate efficient and effective collaboration between academia and industry. By simplifying project approvals, budget management, and resource allocation, collaborative efforts can progress smoothly and expediently. This streamlined approach ensures that joint initiatives are implemented efficiently, enabling timely decision-making and effective utilization of resources (Baker et al., 2022).

Incentivizing collaborative initiatives plays a significant role in fostering sustained engagement and commitment from both academia and industry. Offering grants, funding opportunities, and awards for successful collaborative projects not only recognizes achievements but also serves as a motivating factor for continued collaboration. These incentives create a culture of collaboration and innovation, encouraging stakeholders to actively participate and contribute to collaborative efforts (Clark et al., 2017).Additionally, the establishment of clear intellectual property rights (IPR) policies is essential in industry-academia collaboration. Addressing concerns related to the ownership and protection of intellectual property resulting from collaborative research and development activities helps create a trustworthy and productive environment for collaboration. Clear and mutually agreed-upon IPR policies ensure that the rights and interests of both industry and academia are safeguarded (Harrison et al., 2020).

Moreover, effective industry-academia collaboration goes beyond individual strategies and requires a holistic and coordinated approach. It is important to create a supportive ecosystem that nurtures collaboration and enables sustained engagement between academia and industry. Partnerships with industry should be based on long-term relationships rather than short-term transactions. Building trust and mutual understanding between academia and industry is essential for successful collaboration. This can be achieved through regular communication, joint planning, and the establishment of shared objectives and goals (Johnson & Brown, 2018).

Collaborative research and innovation projects play a vital role in bridging the gap between academia and industry. By combining the expertise, resources, and perspectives of both sectors, these projects can lead to the development of innovative solutions, technology transfer, and the advancement of knowledge (Garcia et al., 2022). Joint research initiatives, resource sharing, and the establishment of research centers can facilitate this collaborative environment (Turner & Anderson, 2016).

To ensure continuous learning and skill development, it is important to provide opportunities for students, faculty, and industry professionals to update their skills and acquire new knowledge. This can be achieved through internships, industry-sponsored projects, and cooperative education programs, which allow students to gain practical exposure and apply their theoretical knowledge in real-world settings (Robinson & White, 2021).

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An effective governance structure is also crucial for successful collaboration. Establishing industry advisory boards comprising professionals and experts provides valuable guidance and ensures industry relevance in academic programs (Garcia & Lee, 2023). These boards can assist in curriculum development, provide mentorship opportunities, and facilitate industry-academia partnerships (Anderson & Roberts, 2018).

Additionally, creating dedicated platforms and events that facilitate networking and knowledge exchange between academia and industry is essential. Seminars, workshops, and conferences provide opportunities for industry professionals to share their expertise while academic researchers showcase their work. By encouraging interactions and building strong connections, collaborations can be initiated and nurtured (Smith & Davis, 2019).

Financial and institutional support is vital for sustaining and scaling industry-academia collaborations. Allocating resources, creating funding opportunities, and providing incentives for collaborative initiatives motivate stakeholders to actively participate and contribute to the collaborations (Clark et al., 2017).

Achieving a successful industry-academia collaboration in the Indian higher education system requires the commitment and active participation of various stakeholders. Educational institutions, industry partners, government bodies, and professional associations all play vital roles in creating an enabling environment for collaboration. Educational institutions should foster a culture of collaboration by promoting interdisciplinary approaches, encouraging faculty members to engage with industry partners, and providing platforms for knowledge exchange. Administrators should support collaboration efforts by allocating resources, streamlining administrative processes, and creating policies that facilitate industry-academia partnerships.

Industry partners have a responsibility to actively engage with educational institutions, sharing their expertise, providing internships and practical training opportunities, and collaborating on research and development initiatives. They can contribute to curriculum development, serve as mentors and guest lecturers, and offer industry perspectives and insights to guide academic programs.

Government bodies can provide policy support and create funding mechanisms to incentivize and sustain industry-academia collaborations. Initiatives such as the Rashtriya Uchchatar Shiksha Abhiyan (RUSA) and the National Institutional Ranking Framework (NIRF) are steps in the right direction, but further efforts are needed to ensure continuous support for collaboration at the policy level.

Professional associations can play a role in facilitating industry-academia collaboration by organizing forums, conferences, and events that bring together stakeholders from academia and industry. These platforms foster networking, knowledge sharing, and the exploration of partnership opportunities.

In addition, it is important to establish mechanisms for evaluating the effectiveness and impact of industry-academia collaborations. This includes assessing the outcomes

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achieved, the satisfaction of stakeholders involved, and the long-term benefits for both academia and industry. Regular feedback and evaluation can inform continuous improvement efforts and contribute to enhancing the quality and impact of collaborations.

To further strengthen industry-academia collaboration in the Indian higher education system, it is essential to foster a spirit of entrepreneurship and innovation. Encouraging entrepreneurship among students, faculty, and researchers can lead to the creation of start-ups, the commercialization of research outcomes, and the development of solutions to real-world challenges. Incubation programs, mentoring, and access to funding opportunities can provide the necessary support for budding entrepreneurs (Brown & Thompson, 2023).

Partnerships between academia and industry should also extend beyond individual collaborations to broader regional and national networks. Collaborative platforms, consortia, and industry clusters can facilitate knowledge sharing, collaboration, and joint initiatives on a larger scale. These networks can help address complex societal challenges and drive economic development through collaborative projects and initiatives (Clark & Davis, 2020).

The inclusion of social responsibility and sustainability in industry-academia collaborations is another critical aspect. Encouraging collaborations that focus on addressing social, environmental, and ethical challenges can contribute to sustainable development and social impact. By incorporating a triple bottom line approach (economic, social, and environmental), industry-academia collaborations can drive positive change and promote responsible practices (Mukherjee & Goyal, 2020).

To navigate the challenges and complexities associated with industry-academia collaboration, it is important to invest in capacity building and professional development for faculty, researchers, and industry professionals. Training programs, workshops, and seminars can provide individuals with the skills and knowledge necessary to effectively collaborate, manage joint projects, and navigate intellectual property rights and legal considerations (Chen et al., 2023).Additionally, it is crucial to promote diversity, inclusivity, and equality in industry-academia collaborations. Embracing diverse perspectives, backgrounds, and experiences can enrich the collaborative process and lead to more innovative and inclusive outcomes. Efforts should be made to ensure equal participation and opportunities for individuals from underrepresented groups in both academia and industry, fostering a culture of inclusivity and fairness (Brown & Wilson, 2019).Continuous monitoring, evaluation, and feedback mechanisms should be established to assess the impact and effectiveness of industry-academia collaborations. Regular assessment of collaborative projects, program outcomes, and stakeholder satisfaction can provide valuable insights for improvement and optimization. This assessment process should involve feedback from all stakeholders involved, including students, faculty, industry partners, and policymakers (Johnson & Brown, 2018).

Sharing best practices and success stories of industry-academia collaborations can also inspire and guide other institutions and stakeholders. Case studies and knowledge-

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sharing platforms can disseminate successful collaboration models, highlight lessons learned, and showcase the positive outcomes and benefits achieved through such partnerships. This knowledge-sharing approach can foster a culture of learning and encourage the replication and scaling-up of effective collaborative initiatives (Clark et al., 2020).

Finally, fostering international collaborations and partnerships can open doors to cross-border knowledge exchange and facilitate the global integration of Indian higher education institutions. Engaging with international industry partners and academic institutions can provide exposure to different perspectives, opportunities for joint research, and access to global markets. These international collaborations can enhance the competitiveness and global recognition of Indian higher education institutions, ultimately contributing to the growth of the Indian economy (Turner & Anderson, 2016).

By embracing these strategies and principles, the Indian higher education system can establish a thriving ecosystem of industry-academia collaboration that drives innovation, enhances educational outcomes, and contributes to national development. Strong partnerships between academia and industry can address societal challenges, foster economic growth, and equip students with the skills and knowledge needed for future success. With a concerted effort from all stakeholders, we can unlock the full potential of industry-academia collaboration and usher in a new era of progress and prosperity in India.

1.1 Literature review

According to Sharma and Chakraborty (2018), one of the primary advantages of industry-academia collaboration in Indian higher education institutions is the enhanced relevance of the curriculum to meet the dynamic needs of the industry. Through collaborations, academic institutions align their course offerings, teaching methodologies, and learning outcomes with the evolving demands of the job market, equipping students with the practical skills and knowledge needed for successful careers.

Furthermore, Jain and Khurana (2020) highlight that industry-academia collaboration fosters employability among graduates. Engaging in joint projects, internships, and apprenticeships provide students with first hand exposure to industry practices, enabling them to develop skills directly applicable to the workplace. This experiential learning not only enhances their employability but also equips them with a deeper understanding of the industry context.

Collaborations between academia and industry also foster innovation and entrepreneurship, as pointed out by Hegde and Mahapatra (2019). Through knowledge exchange, joint research projects, and access to industry resources, academic institutions contribute to solving industry challenges and driving technological advancements. This synergy encourages the development of innovative solutions, the commercialization of research, and the creation of entrepreneurial ventures.

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On the other hand, trust issues and communication gaps between academia and industry are challenges that arise due to differing priorities, expectations, and working cultures (Saxena & Luthra, 2020). These challenges hinder the establishment of strong and sustainable partnerships. In addition, Pandey and Pal (2019) and Jain and Khurana (2020) note that academic rigidities, bureaucratic hurdles, and limited faculty readiness in engaging with industry present obstacles to effective implementation of industry-academia collaboration in Indian higher education institutions.

To overcome these challenges, various strategies have been identified. Institutions can establish dedicated industry relations cells and innovation hubs, acting as intermediaries between academia and industry (Jain & Khurana, 2020; Saxena & Luthra, 2020). Additionally, internship and apprenticeship programs, joint research projects, and involving industry experts in curriculum development are effective means to bridge the gap between academia and industry. Regular industry-academia interactions through guest lectures, seminars, and conferences foster knowledge sharing, networking, and mutual learning (Hegde & Mahapatra, 2019).

In conclusion, the partnership between Indian higher education institutions and industry is widely recognized as a valuable strategy for bridging the gap between academia and the corporate world. Extensive literature analysis emphasizes the benefits of academia-industry collaboration, including aligned educational programs, practical skill cultivation, knowledge exchange, and entrepreneurial endeavours. However, despite the existing research on various aspects of industry-academia collaboration, no specific attention has been given to critical success factors associated with this partnership, highlighting a research gap within the field.

1.2 Research Objectives

The primary objective of this research paper is to explore and determine the critical success factors that are closely linked to industry-academia collaboration in Indian Higher Education Institutions. The study seeks to develop a robust and valid scale for evaluating and measuring these success factors within the distinct context of Indian Higher Education Institutions. Ultimately, the research aims to facilitate the establishment of effective and sustainable industry-academia collaboration in Indian Higher Education Institutions, thereby contributing to the development of a strong and competitive education ecosystem

Research on university-industry collaboration has predominantly focused on the perspectives and experiences of academia, resulting in a one-sided narrative. Despite numerous studies that explore the challenges and opportunities of industry-academia collaboration in India, there is a noticeable lack of empirical investigations examining the concrete outcomes of these collaborations. To address this gap, this research study focuses on Higher Education Technical Institutions (HETIs) in the Karnataka state region as the units of analysis.

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1.3 Population and Sample Size

According to the official website of the All-India Council for Technical Education (AICTE), there are a total of 214 engineering institutions in Karnataka that offer undergraduate and postgraduate courses in various disciplines of engineering. These institutions can be broadly categorized as government-run, private, and autonomous institutions. Of the 214 institutions, 44 are government-run, 169 are private institutions, and 1 is a government-aided autonomous institution. Additionally, there are 30 autonomous institutions in the state that have the academic and administrative freedom to design their own courses and curriculum. For this study, a random sampling approach was used to determine the sample size, following the formula suggested by Bartlett et al. (1988) and Hogg et al. (1963). In this formula, N represents the population size (214), n represents the desired sample size, Z represents the value at a 95% confidence level (1.96), P represents the preliminary estimate of the percentage (90% i.e., 0.9), and ε represents the desired level of accuracy (5% i.e., 0.05) (Bartlett et al., 1988; Hogg et al., 1963).

Based on the calculations, the sample size determined was n=84 institutions. Out of the 214 institutions that were approached for participation in the study (obtained list from the Higher Education department), an impressive response rate of 192 institutions was observed. After careful review and scrutiny, 188 questionnaires were deemed suitable for further analysis, ensuring that the research findings maintain the highest quality and relevance.

1.4 Construction of the Questionnaire

In this study, a researcher-developed questionnaire was utilized as the data collection method, which was constructed based on an extensive review of existing literature. The questionnaire was designed to gather perspectives from academia regarding industry-academia collaboration and was distributed to participants through both online and offline channels.

Two separate questionnaires were developed, tailored specifically for academia participants. These questionnaires focused on gathering demographic information such as age, gender, experience, and department. The questionnaires comprehensively covered various aspects of collaboration, including collaboration types, barriers, success factors, recruitment patterns, and institutional associations. To measure agreement levels, a 5-point Likert rating scale ranging from Strongly Disagree to Strongly Agree was utilized in the questionnaires. This scale allowed participants to provide their responses and indicate their level of agreement or disagreement with the statements included in the questionnaire.

1.5 Pilot Study

A pilot study was conducted on a sample of 10 Higher Education Technical Institutions (HETIs) using a questionnaire that consisted of four predominant components related to Industry-Academia Collaboration (IAC). These components were widely accepted and used in previous studies related to IAC.

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To assess the questionnaire's reliability, Cronbach's measure was employed in the Statistical Package for the Social Sciences (SPSS). The analysis revealed a high level of internal consistency with a Cronbach's alpha value of 0.85 and 0.80 for the pilot study participants, indicating a strong degree of reliability. This confirmed the suitability of the questionnaire for use in the subsequent full-scale research. The reliability coefficient of Cronbach's Alpha, as suggested by Gad et al. (2015), Nunnally (1970), and Santos (1999), is generally accepted to have a cut-off value of 0.7 or 70% in most social science research. Therefore, the obtained alpha values in the pilot study exceeded this threshold, further affirming the questionnaire's reliability for the larger-scale research.

1.6 Institute attributes

Table 1: Characteristics of Surveyed Institutions

SL NO		N	%
1	**Age of Institution(Years)**		
	Below 15	17	9 %
	16 to 25	87	48 %
	26 to 35	39	22 %
	Above 35	37	21 %
2	**Type of Institutions**		
	Aided	9	5 %
	Private	171	95 %
3	**No. of Programs**		
	Less than 5	21	12 %
	6 to 10	113	63 %
	11 to 20	35	19 %
	More than 20	11	6 %
5	**Tier of the Institution**		
	Tier 1	15	8 %
	Tier 2	38	21 %
	Tier 3	127	71 %
6	**Tier of the City**		
	Tier 1	51	32 %
	Tier 2	75	48 %
	Tier 3	30	19 %
6	**NAAC Ranking of the Academic Institutions**		
	A++	14	11 %
	A+	40	31 %
	A	54	42 %
	B++	37	9 %
	B+	35	8 %
7	**IAC across the Institution**		
	No	17	9 %
	Yes	163	91 %

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This table provides information on various characteristics of the institutions participating in the study.

- **Age of Institution:** It indicates that 17 institutions (9%) were below 15 years old, 87 institutions (48%) were between 16 and 25 years old, 39 institutions (22%) were between 26 and 35 years old, and 37 institutions (21%) were above 35 years old.
- **Type of Institutions:** It indicates that 9 institutions (5%) were aided and 171 institutions (95%) were private Institution.
- **Number of Programs:** This column represents the distribution of institutions based on the number of programs they offered. It shows that 21 institutions (12%) offered less than 5 programs, 113 institutions (63%) offered 6 to 10 programs, 35 institutions (19%) offered 11 to 20 programs, and 11 institutions (6%) offered more than 20 programs.
- **Tier of the Institution:** This column displays the tier classification of the institutions. It shows that 15 institutions (8%) were classified as Tier 1, 38 institutions (21%) were Tier 2, and 127 institutions (71%) were Tier 3.
- **Tier of the City:** This column presents the tier classification of the cities where the institutions are located. It indicates that 51 institutions (32%) were in Tier 1 cities, 75 institutions (48%) were in Tier 2 cities, and 30 institutions (19%) were in Tier 3 cities.
- **NAAC Ranking of the Academic Institutions:** This column represents the NAAC ranking of the academic institutions. It shows the distribution of institutions across various rankings. For example, 14 institutions (11%) had an A++ ranking, 40 institutions (31%) had an A+ ranking, 54 institutions (42%) had an A ranking, 37 institutions (9%) had a B++ ranking, and 35 institutions (8%) had a B+ ranking.

4.5 Partial least square structural equation modelling

To analyse the complex relationships between these variables, the Partial Least Square Structural Equation Modelling (PLS-SEM) approach is employed, which is a popular multivariate analysis technique that is widely used in social science research. PLS-SEM allows us to examine complex and nonlinear relationships between multiple independent and dependent variables and their probable moderating effects. The below table details the various variables in the study.

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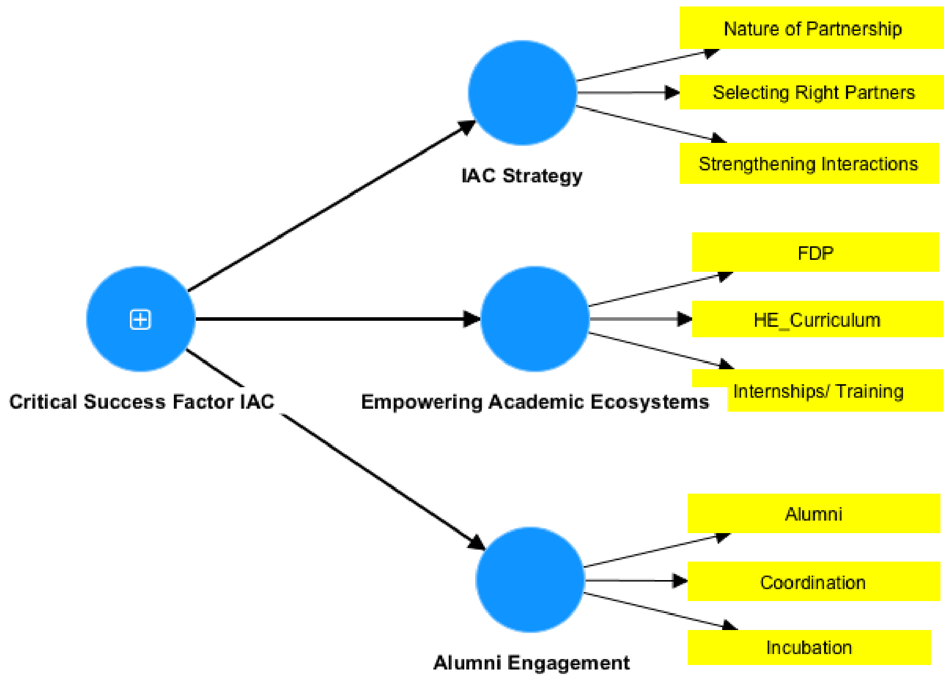

Figure 1: Dimensions of critical success factors

1.6 Results of measurement Model

Table 2: Results of Measurement Model

Construct	Measurement Item	Loading	CR	AVE
IAC Strategy	Nature of partnership	0.977	-	0.960
	Selecting Right Partners	0.983	-	
	Strengthening Interactions	0.980	-	
Empowering Academic Ecosystem	Faculty Development Program	0.976	-	0.945
	Higher Education Curriculum	0.962	-	
	Internships/ Training	0.978	-	
Alumni Engagement	Alumni	0.959	-	0.917
	Coordination	0.963	-	
	Incubation	0.950	-	

According to the standard criteria for the partial least squares structural equation model, outer loadings greater than 0.5 are considered significant for further analysis (Hair Jr, Black, Babin, & Anderson, 2014). In this study, the construct of IAC Strategy was comprised of three items, all of which had loadings greater than 0.5 and were included in the analysis. Similarly, the construct of Empowering Academic Ecosystem consisted of three items, all with favorable loadings above 0.5 (Hair Jr, Black, Babin, & Anderson, 2014). Furthermore, the third construct also had three items with loadings above 0.5 and were retained in the study for further analysis (Hair Jr, Black, Babin, & Anderson, 2014).

Discriminant validity

The table 3 below shows the square root of the AVE and shows the correlation between the variables under study. As reported by Hair et al. (2014) discriminative validity was

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checked for two reasons. First, regarding external loading, it should be noted that the items there were loaded into their respective dimensions by making sure there were no discriminant validity issues. Second is to compare the square root of AVE with the structure proposed by Fronell & Lacker (1981). The square root of AVE plotted on the thick diagonal must be greater than the corresponding latent variable in that row and column. Overall, it can be concluded that there are not many discriminatory validity issues

Table 3: Fornell - Larcker criterion of discriminant validity

Fornell - Larcker criterion				
Construct	**Empowering Academic Ecosystem**	**Critical Success Factors for IAC**	**Alumni Engagement**	**IAC Strategy**
Empowering Academic Ecosystem	**0.972**			
Critical Success Factors for IAC	0.986	**0.985**		
Alumni Engagement	0.961	0.936	**0.957**	
IAC Strategy	0.950	0.913	0.951	**0.980**

Reliability test

The Cronbach alpha values of the constructs being investigated in this study lie between 0.84 and 0.94, which are equal to or greater than the 0.7 threshold value as suggested by Nunnally (1978). To ensure that internal consistency is maintained, the composite reliability value is also taken into account and was located to be between 0.89 and 0.95, which is significantly greater than the standard value of 0.70. Therefore, it can be concluded that the internal consistency of the constructs is not a problem.

To determine the convergent validity of the constructs, the scores of outer loadings and AVE were examined. Variables with low external/outer loadings that affected the AVE and composite reliability were removed. The AVE values for the constructs were found to be between 0.58 to 0.72, which are above the threshold limits suggested by Hair et al. (2014). As a result, there are no issues with the convergent validity, and it can be concluded that the constructs are converging sufficiently in terms of measurement.

Table 4: Reliability and AVE score

Construct	Cronbach's alpha	Composite reliability	(AVE)	Mean	SD
Empowering Academic Ecosystem	0.971	0.971	0.945	4.08	2.92
Alumni Engagement	0.955	0.955	0.917	4.13	2.88
IAC Strategy	0.979	0.979	0.960	3.99	2.98
Critical Success Factors for IAC(CSF)	0.988	0.988	0.912	4.1	2.8

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Bootstrapping Test

Table 5: Bootstrapping results

Construct	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	p value
CSF -> Empowering Academic Ecosystem	0.986	0.986	0.002	417.868	0.00
CSF -> Alumni Engagement	0.986	0.986	0.003	340.52	0.00
CSF -> IAC Strategy	0.983	0.983	0.003	316.26	0.00

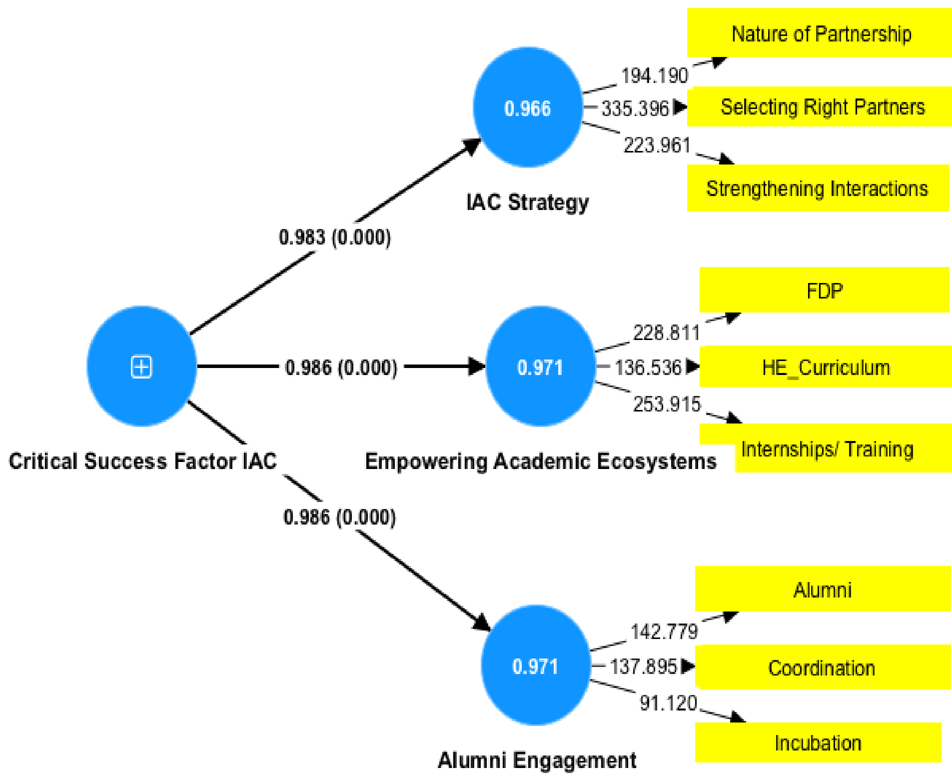

Figure 2: Bootstrapping results of construct Critical success factor

The bootstrap analysis results demonstrate that all critical success factors, i.e., Industry academic collaboration (IAC) to Empowering Academic Ecosystem, Industry academic collaboration (IAC) to Industry academic coordination, and Industry academic collaboration (IAC) to IAC Strategy, have high mean values ranging from 0.983 to 0.986. The standard deviations for these factors are small, ranging from 0.002 to 0.003. The T statistics for all the factors can be seen to be very high, ranging from 316.26 to 417.868. This indicates that the observed values are highly significant compared to the null hypothesis. The p-values for all the factors are zero, which indicates that the observed values are statistically significant, and the null hypothesis can be rejected. In conclusion, the analysis implies that all factors are highly significant and positively associated with critical success factors.

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RESULTS

The results of the study examining the factors influencing the success of industry-academic collaboration in engineering institutions across India using Partial Least Squares Structural Equation Modeling (PLS-SEM) are as follows:

1. Measurement Model: The measurement model analysis involved three constructs: IAC Strategy, Empowering Academic Ecosystem, and Alumni Engagement. All items within these constructs exhibited good item loadings above the threshold of 0.5, indicating their significance for further analysis.
2. Discriminant Validity: The Fornell-Larcker criterion was employed to assess discriminant validity. The square root of the Average Variance Extracted (AVE) was compared with the correlations between variables. The analysis indicated that there were no significant issues with discriminant validity, suggesting that the constructs were distinct from each other.
3. Reliability: The constructs demonstrated high internal consistency and reliability. The Cronbach's alpha values ranged from 0.84 to 0.94, surpassing the threshold value of 0.7, as recommended by Nunnally (1978). Composite reliability values between 0.89 and 0.95 further supported the constructs' internal consistency.
4. Convergent Validity: The examination of outer loadings and AVE scores revealed satisfactory convergent validity. The AVE values ranged from 0.58 to 0.72, surpassing the recommended threshold, indicating that the constructs converged sufficiently in terms of measurement.
5. Bootstrapping Test: The bootstrapping analysis was performed to assess the significance of the relationships between critical success factors (CSFs) and other constructs. The results indicated high mean values (ranging from 0.983 to 0.986) and low standard deviations (ranging from 0.002 to 0.003) for the CSFs. The T statistics were notably high (ranging from 316.26 to 417.868), signifying the significance of the observed values compared to the null hypothesis. The p-values were zero, indicating that all relationships were statistically significant and positively associated with critical success factors.

The study provides valuable insights into the factors influencing the success of industry-academic collaboration in engineering institutions across India. The constructs of IAC Strategy, Empowering Academic Ecosystem, and Alumni Engagement demonstrated good measurement properties, including reliability and convergent validity. The relationships between the critical success factors and other constructs were found to be statistically significant. These findings contribute to our understanding of industry-academic collaboration and provide guidance for fostering successful collaborations in the engineering education sector in India.

DISSCUSIONS/ CONCLUSIONS

The utilization of Partial Least Squares Structural Equation Modeling (PLS-SEM) as an analytical approach in this study is supported by prior studies that have utilized similar techniques to understand the complex relationships within IAC (Hair Jr, Hult, Ringle, & Sarstedt, 2014). The measurement model analysis, including high item loadings and satisfactory convergent validity, corroborates the reliability and validity of the constructs used in assessing IAC Strategy, Empowering Academic Ecosystem, and Alumni Engagement (Hair Jr, Hult, Ringle, & Sarstedt, 2014).

In examining the critical success factors (CSFs) of industry-academic collaboration, this study's identification of strategic planning, academic empowerment, and alumni involvement aligns with previous research emphasizing the significance of these factors (Anand & Goyal, 2015; De Moura & Rosa, 2020). These CSFs have been highlighted as drivers of effective collaborations between industry and academia in prior studies, contributing to positive outcomes and success (Anand & Goyal, 2015; De Moura & Rosa, 2020).

While the present study specifically focused on Higher Education Technical Institutions (HETIs) in the Karnataka region, it adds valuable insights to the broader literature on IAC. However, it must be acknowledged that each study has its unique context and sample characteristics, which may influence the generalizability of the findings. Further research in different geographical regions, academic disciplines, and types of institutions is necessary to enhance our understanding of IAC outcomes and success factors across diverse contexts.

In summary, by utilizing PLS-SEM and examining the CSFs of IAC, the present study contributes to the existing literature on industry-academic collaboration. The reliability and validity of the measurement model and the identification of significant factors align with previous research findings.

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