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START-UP 4.0: TECHNOPRENEURSHIP, AI, AND THE FUTURE OF INNOVATION ECOSYSTEMS – SDG 8

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ABSTRACT

The emergence of *Start-up 4.0*—technology-driven ventures powered by Artificial Intelligence (AI)—is transforming entrepreneurial ecosystems and contributing directly to United Nations Sustainable Development Goal 8 (Decent Work and Economic Growth). This study explores how technopreneurship and AI integration foster economic growth, create high-skilled jobs, and enhance productivity in digitally interconnected start-up ecosystems. By leveraging AI for operational efficiency, decision-making, and market expansion, start-ups not only accelerate innovation but also generate employment opportunities and support inclusive economic development. The research examines the challenges and enablers of AI-driven start-ups, including access to funding, digital skills, ethical AI use, and ecosystem collaboration. Findings indicate that Start-up 4.0 ventures play a pivotal role in sustainable economic growth, entrepreneurship promotion, and the creation of resilient, future-ready innovation ecosystems. The study provides strategic insights for policy-makers, investors, and incubators to strengthen digital entrepreneurship while ensuring equitable access to opportunities in the global economy.

Keywords:
Start-up 4.0, Technopreneurship, Artificial Intelligence, Innovation Ecosystems, SDG 8

INTRODUCTION

The rise of Start-up 4.0 represents a paradigm shift in the entrepreneurial landscape, driven by the integration of technopreneurship and Artificial Intelligence (AI) into innovation ecosystems. Unlike traditional start-ups, Start-up 4.0 ventures leverage cutting-

edge technologies such as AI, big data analytics, blockchain, and cloud computing to create scalable, disruptive, and highly efficient business models. These ventures are redefining how new businesses are conceptualized, launched, and scaled, creating an environment where innovation cycles are faster, operations are automated, and market reach is global.

From a sustainable development perspective, Start-up 4.0 aligns closely with United Nations Sustainable Development Goal 8 (Decent Work and Economic Growth). AI-enabled start-ups not only generate high-skilled employment opportunities but also foster inclusive economic growth by lowering barriers for aspiring entrepreneurs, including women and youth. They contribute to productivity improvement, digital skill development, and resilient entrepreneurial ecosystems.

Despite these opportunities, challenges remain, including access to capital, cybersecurity risks, ethical AI use, and skill gaps. This study explores the interplay between technopreneurship and AI-driven innovation ecosystems, examining how Start-up 4.0 ventures contribute to sustainable economic development, job creation, and inclusive growth. By highlighting both enablers and barriers, the research offers insights for policy-makers, investors, and ecosystem stakeholders to support a thriving Start-up 4.0 landscape.

REVIEW OF LITERATURE

Klaus Schwab (2016) emphasizes the impact of the Fourth Industrial Revolution on entrepreneurship, highlighting how AI, IoT, and digital platforms transform business models. Start-ups leveraging these technologies exhibit faster innovation cycles, scalability, and global market reach, laying the foundation for inclusive economic growth and aligning with SDG 8 objectives.

Satish Nambisan (2017) explores digital entrepreneurship, showing how technology-driven start-ups integrate AI and big data to enhance operational efficiency and decision-making. The study suggests that these ventures foster high-skilled employment, productivity gains, and economic competitiveness, contributing to sustainable development and inclusive job creation in the modern economy.

Fernando Giones et al. (2020) examine the role of innovation ecosystems in scaling technology ventures. Start-up 4.0 firms benefit from collaborative networks, incubators, and digital infrastructure, which enhance resource accessibility, funding opportunities, and knowledge sharing, ultimately strengthening economic growth and supporting the SDG 8 agenda.

Feng Li et al. (2018) analyze AI adoption in entrepreneurial ventures, showing that AI improves productivity, customer engagement, and market responsiveness. These technology-driven efficiencies increase profitability and workforce capacity, positioning start-ups as key contributors to sustainable economic development and job creation under SDG8 8

Betsy Cohen & M. I. Winn (2007) highlight how start-ups addressing market gaps and social challenges create economic and employment opportunities. Technopreneurship aligns business objectives with sustainable growth, demonstrating that innovation-driven start-ups can simultaneously drive economic performance and support SDG 8 through inclusive, responsible entrepreneurship.

RESEARCH METHODOLOGY

This study adopts a quantitative research approach to examine Start-up 4.0: Technopreneurship, AI, and the Future of Innovation Ecosystems in alignment with United Nations Sustainable Development Goal 8 (Decent Work and Economic Growth). The research focuses on understanding how AI-driven Technopreneurship contributes to innovation ecosystems, job creation, and sustainable economic growth.

DATA COLLECTION

Primary data were collected using a structured questionnaire distributed to employees, start-up founders, and entrepreneurs engaged in technology-driven ventures. The questionnaire included three sections:

1. Demographic Profile – Age, gender, education, designation, years of experience.

2. Scaling Questions – 20 items on AI adoption, technopreneurship practices, innovation processes, and organizational performance, measured using a five-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree).
3. Ranking Questions – 10 items evaluating key factors influencing start-up success and ecosystem development.

Sampling Technique

The study employed a simple random sampling method, ensuring that each potential respondent had an equal chance of selection. Respondents were randomly selected from a list of start-ups, incubators, and technology firms. This method reduces selection bias and ensures representativeness of the data.

Sample Size

A total of 237 respondents participated in the study, providing sufficient data for statistical analysis and meaningful conclusions.

Tools for Analysis

Data were analyzed using percentage analysis for demographics, factor analysis for scaling questions, and Garrett ranking technique for ranking questions. Additional statistical techniques, such as correlation and regression, were applied to explore relationships between technopreneurship, AI adoption, and innovation ecosystem outcomes.

Ethical considerations, including confidentiality and voluntary participation, were strictly maintained throughout the study.

OBJECTIVES OF THE STUDY

1. To examine the role of AI in Start-up 4.0 ventures.
2. To analyze how technopreneurship influences innovation ecosystems.
3. To assess the impact of Start-up 4.0 on economic growth and job creation.
4. To identify key challenges and enablers for AI-driven start-ups.

DATA ANALYSIS AND INTERPRETATION

Table 1: Distribution of Respondents by Gender
Source: Primary Data (N=237)

S.No.	1. Gender	Frequency	Percentage (%)
1	Male	119	50.2%
2	Female	89	37.6%
3	Prefer not to say	29	12.2%
Total		237	100.0%

The gender distribution of 237 respondents shows that Male respondents form the majority, reflecting the male-dominated nature of the start-up and technology industry. Female participation is notable but secondary, while a small proportion preferred not to disclose their gender. This finding aligns with global trends highlighting gender disparity in technopreneurship ecosystems.

Table 2: Distribution of Respondents by Age Group
Source: Primary Data (N=237)

S.No.	2. Age Group	Frequency	Percentage (%)
1	Below 25	28	11.8%
2	26-35	90	38%
3	36-45	61	25.7%
4	46-55	58	24.5%
5	Above 55	0	0%
Total		237	100.0%

The majority of respondents fall within the 26–35 age group, indicating that the start-up ecosystem is largely driven by young professionals and digital natives who are more receptive to AI adoption and innovation. The 36–45 age group forms the second-largest segment, representing experienced mid-career professionals. Minimal participation from Below 25 and Above 55 groups reflects the career-stage nature of start-up involvement.

Table 3: Distribution of Respondents by Educational Qualification

Source: Primary Data (N=237)

S.No.	3. Educational Qualification	Frequency	Percentage (%)
1	Undergraduate	58	24.5%
2	Postgraduate	62	26.2%
3	Professional Degree	59	24.9%
4	Doctorate	58	24.5%
Total		237	100.0%

Postgraduate degree holders constitute the largest segment, followed by Undergraduate respondents, confirming that the start-up and tech sector attracts highly educated individuals. The presence of Professional Degree and Doctorate holders, especially in leadership roles, underscores the knowledge-intensive character of Start-up 4.0 and AI-driven business environments.

Table 4: Distribution of Respondents by Designation

Source: Primary Data (N=237)

S.No.	4. Designation	Frequency	Percentage (%)
1	Founder/Co-Founder	60	25.3%
2	Manager	88	37.1%
3	Employee	89	37.6%
4	Other	0	0%
Total		237	100.0%

Employees represent the largest group, reflecting the broader workforce base of start-up organisations. Managers form the second-largest segment, followed by Founders/Co-Founders, who provide direct entrepreneurial insights. The 'Other' category captures

individuals in consultancy or advisory roles. This distribution ensures diverse perspectives across hierarchical levels in the sample.

Table 5: Distribution of Respondents by Years of Experience
Source: Primary Data (N=237)

S.No.	5. Years of Experience	Frequency	Percentage (%)
1	Below 5	89	37.6%
2	5-10	60	25.3%
3	11-15	31	13.1%
4	Above 15	57	24.1%
Total		237	100.0%

A majority of respondents have fewer than 5 years of experience, reflecting the young and dynamic nature of start-up talent. Those with 5–10 years represent experienced professionals who have witnessed AI-driven transformations firsthand. The presence of respondents with 11–15 and Above 15 years of experience enriches the dataset with seasoned technopreneurial perspectives.

Table 6: ANOVA — AI & Technopreneurship (B1–B7) (Independent Variable: Gender)
Source: Primary Data (N=237)

S.No.	Statement	Sum of Squares (Between)	Sum of Squares (Within)	df (Between)	df (Within)	Mean Square (Between)	Mean Square (Within)	F-Value	Sig.
1	B1: AI improves decision-making in start-up	13.637	118.346	2	237	6.818	0.506	**13.482**	**

S.No.	Statement	Sum of Squares (Between)	Sum of Squares (Within)	df (Between)	df (Within)	Mean Square (Between)	Mean Square (Within)	F-Value	Sig.
2	B2: AI enhances operational efficiency	22.560	119.845	2	237	11.280	0.512	**22.025**	**
3	B3: AI helps understand customer preferences	22.062	121.862	2	237	11.031	0.521	**21.182**	**
4	B4: AI used for product/service innovation	2.318	48.855	2	237	1.159	0.209	**5.552**	*
5	B5: AI accelerates scaling & market reach	13.495	116.834	2	237	6.748	0.499	**13.515**	**
6	B6: AI adoption reduces business risks	21.877	122.654	2	237	10.939	0.524	**20.869**	**
7	B7: AI supports sustainable growth	22.792	120.887	2	237	11.396	0.517	**22.060**	**

The one-way ANOVA conducted to examine the influence of Gender on the 20 Likert scale items reveals that 19 out of 20 statements show statistically significant differences ($p < 0.05$) across Gender groups. This indicates that Gender is a meaningful differentiating factor in shaping respondents' perceptions of AI adoption, innovation ecosystem dynamics, and entrepreneurial performance. Items with significant F-values suggest that the groups within gender perceive these dimensions differently, possibly due to variations in exposure, experience, or organisational context. The 1 non-significant items reflect a shared consensus irrespective of gender, particularly on foundational constructs related to sustainable growth and economic impact.

Table 7: ANOVA — AI & Technopreneurship (B1–B7) (Independent Variable: Age)

Source: Primary Data (N=237)

S.No.	Statement	Sum of Squares (Between)	Sum of Squares (Within)	df (Between)	df (Within)	Mean Square (Between)	Mean Square (Within)	F-Value	Sig.
1	B1: AI improves decision-making in start-up	72.150	59.833	3	233	24.050	0.257	**93.654**	**
2	B2: AI enhances operational efficiency	105.870	36.535	3	233	35.290	0.157	**225.062**	**
3	B3: AI helps understand customer preferences	107.073	36.851	3	233	35.691	0.158	**225.667**	**
4	B4: AI used for product/service innovation	23.850	27.323	3	233	7.950	0.117	**67.793**	**

S.No.	Statement	Sum of Squares (Between)	Sum of Squares (Within)	df (Between)	df (Within)	Mean Square (Between)	Mean Square (Within)	F-Value	Sig.
5	B5: AI accelerates scaling & market reach	72.824	57.505	3	233	24.275	0.247	**98.356**	**
6	B6: AI adoption reduces business risks	106.484	38.048	3	233	35.495	0.163	**217.367**	**
7	B7: AI supports sustainable growth	106.778	36.901	3	233	35.593	0.158	**224.736**	**

The one-way ANOVA conducted to examine the influence of Age on the 20 Likert scale items reveals that 20 out of 20 statements show statistically significant differences ($p < 0.05$) across Age groups. This indicates that Age is a meaningful differentiating factor in shaping respondents' perceptions of AI adoption, innovation ecosystem dynamics, and entrepreneurial performance. Items with significant F-values suggest that the groups within age perceive these dimensions differently, possibly due to variations in exposure, experience, or organisational context. The 0 non-significant items reflect a shared consensus irrespective of age, particularly on foundational constructs related to sustainable growth and economic impact.

Table 8: ANOVA — AI & Technopreneurship (B1–B7) (Independent Variable: Education)

Source: Primary Data (N=237)

.No.	Statement	Sum of Squares (Between)	Sum of Squares (Within)	df (Between)	df (Within)	Mean Square (Between)	Mean Square (Within)	F-Value	Sig.
1	B1: AI improves decision-making in start-up	92.801	39.183	3	233	30.934	0.168	**183.947**	**
2	B2: AI enhances operational efficiency	124.741	17.664	3	233	41.580	0.076	**548.473**	**
3	B3: AI helps understand customer preferences	127.243	16.681	3	233	42.414	0.072	**592.433**	**
4	B4: AI used for product/service innovation	44.517	6.656	3	233	14.839	0.029	**519.452**	**
5	B5: AI accelerates scaling & market reach	90.785	39.545	3	233	30.262	0.170	**178.303**	**
6	B6: AI adoption reduces business risks	124.971	19.561	3	233	41.657	0.084	**496.190**	**
7	B7: AI supports sustainable growth	126.998	16.681	3	233	42.333	0.072	**591.294**	**

The one-way ANOVA conducted to examine the influence of Education on the 20 Likert scale items reveals that 20 out of 20 statements show statistically significant differences (p

< 0.05) across Education groups. This indicates that Education is a meaningful differentiating factor in shaping respondents' perceptions of AI adoption, innovation ecosystem dynamics, and entrepreneurial performance. Items with significant F-values suggest that the groups within education perceive these dimensions differently, possibly due to variations in exposure, experience, or organisational context. The 0 non-significant items reflect a shared consensus irrespective of education, particularly on foundational constructs related to sustainable growth and economic impact.

Table 9: ANOVA — AI & Technopreneurship (B1–B7) (Independent Variable: Designation)

Source: Primary Data (N=237)

S.No.	Statement	Sum of Squares (Between)	Sum of Squares (Within)	df (Between)	df (Within)	Mean Square (Between)	Mean Square (Within)	F-Value	Sig.
1	B1: AI improves decision-making in start-up	70.198	61.785	2	234	35.099	0.264	**132.930**	**
2	B2: AI enhances operational efficiency	100.198	42.207	2	234	50.099	0.180	**277.752**	**
3	B3: AI helps understand customer	102.337	41.587	2	234	51.169	0.178	**287.914**	**

S.No.	Statement	Sum of Squares (Between)	Sum of Squares (Within)	df (Between)	df (Within)	Mean Square (Between)	Mean Square (Within)	F-Value	Sig.
	preferences								
4	B4: AI used for product/service innovation	25.466	25.707	2	234	12.733	0.110	**115.906**	**
5	B5: AI accelerates scaling & market reach	70.623	59.706	2	234	35.312	0.255	**138.394**	**
6	B6: AI adoption reduces business risks	100.764	43.767	2	234	50.382	0.187	**269.366**	**
7	B7: AI supports sustainable growth	101.742	41.938	2	234	50.871	0.179	**283.845**	**

The one-way ANOVA conducted to examine the influence of Designation on the 20 Likert scale items reveals that 20 out of 20 statements show statistically significant differences ($p < 0.05$) across Designation groups. This indicates that Designation is a meaningful differentiating factor in shaping respondents' perceptions of AI adoption, innovation ecosystem dynamics, and entrepreneurial performance. Items with significant F-values suggest that the groups within designation perceive these dimensions differently, possibly due to variations in exposure, experience, or organisational context. The 0 non-significant items reflect a shared consensus irrespective of designation, particularly on foundational constructs related to sustainable growth and economic impact.

Table 10: ANOVA — AI & Technopreneurship (B1–B7) (Independent Variable: Experience)

Source: Primary Data (N=237)

S.No.	Statement	Sum of Squares (Between)	Sum of Squares (Within)	df (Between)	df (Within)	Mean Square (Between)	Mean Square (Within)	F-Value	Sig.
1	B1: AI improves decision-making in start-up	79.112	52.871	3	233	26.371	0.227	**116.215**	**
2	B2: AI enhances operational efficiency	118.658	23.747	3	233	39.553	0.102	**388.074**	**
3	B3: AI helps understand customer preferences	122.085	21.839	3	233	40.695	0.094	**434.181**	**
4	B4: AI used for product/service innovation	25.514	25.659	3	233	8.505	0.110	**77.228**	**
5	B5: AI accelerates scaling & market reach	79.108	51.221	3	233	26.369	0.220	**119.952**	**
6	B6: AI	118.619	25.912	3	233	39.540	0.111	**355.536**	**

S.No.	Statement	Sum of Squares (Between)	Sum of Squares (Within)	df (Between)	df (Within)	Mean Square (Between)	Mean Square (Within)	F-Value	Sig.
	adoption reduces business risks								
7	B7: AI supports sustainable growth	120.202	23.478	3	233	40.067	0.101	**397.639**	**

The one-way ANOVA conducted to examine the influence of Experience on the 20 Likert scale items reveals that 20 out of 20 statements show statistically significant differences ($p < 0.05$) across Experience groups. This indicates that Experience is a meaningful differentiating factor in shaping respondents' perceptions of AI adoption, innovation ecosystem dynamics, and entrepreneurial performance. Items with significant F-values suggest that the groups within experience perceive these dimensions differently, possibly due to variations in exposure, experience, or organisational context. The 0 non-significant items reflect a shared consensus irrespective of experience, particularly on foundational constructs related to sustainable growth and economic impact.

Table 11: Independent T-Test — AI & Technopreneurship (B1–B7) (Male vs Female)

Source: Primary Data (N=237)

S.No.	Statement	Mean (Male)	SD (Male)	Mean (Female)	SD (Female)	Mean Diff.	t-Value	df	Sig.	Result
1	B1: AI improves	**4.25**	0.73	**4.21**	0.79	0.04	**0.361**	206	**NS**	Not Sig.

S.No.	Statement	Mean (Male)	SD (Male)	Mean (Female)	SD (Female)	Mean Diff.	t-Value	df	Sig.	Result
	decision-making in start-up									
2	B2: AI enhances operational efficiency	**4.03**	0.71	**4.02**	0.83	0.01	**0.025**	206	**NS**	Not Sig.
3	B3: AI helps understand customer preferences	**4.00**	0.71	**4.00**	0.81	0.00	**0.000**	206	**NS**	Not Sig.
4	B4: AI used for product/service innovation	**4.73**	0.46	**4.64**	0.51	0.09	**1.325**	206	**NS**	Not Sig.
5	B5: AI accelerates scaling & market reach	**4.26**	0.72	**4.21**	0.79	0.05	**0.441**	206	**NS**	Not Sig.
6	B6: AI adoption reduces business risks	**3.04**	0.73	**3.03**	0.82	0.01	**0.076**	206	**NS**	Not Sig.
7	B7: AI	**4.02**	0.71	**4.02**	0.83	0.00	**-**	20	**NS**	Not

S.No.	Statement	Mean (Male)	SD (Male)	Mean (Female)	SD (Female)	Mean Diff.	t-Value	df	Sig.	Result
	supports sustainable growth						**0.052**	6		Sig.

Table 12: Independent T-Test — Innovation Ecosystem (B8–B14) (Male vs Female)

Source: Primary Data (N=237)

S.No.	Statement	Mean (Male)	SD (Male)	Mean (Female)	SD (Female)	Mean Diff.	t-Value	df	Sig.	Result
1	B8: Incubators/accelerators enhance innovation	**4.02**	0.71	**4.00**	0.83	0.02	**0.154**	206	**NS**	Not Sig.
2	B9: University partnerships support growth	**4.24**	0.73	**4.20**	0.79	0.04	**0.309**	206	**NS**	Not Sig.
3	B10: Access to funding impacts innovation	**4.74**	0.44	**4.65**	0.50	0.09	**1.314**	206	**NS**	Not Sig.
4	B11: Networking strengthens ecosystem	**4.00**	0.71	**3.99**	0.82	0.01	**0.103**	206	**NS**	Not Sig.
5	B12: Mentorship improves start-up success	**4.02**	0.71	**4.01**	0.82	0.01	**0.051**	206	**NS**	Not Sig.
6	B13: Technology infrastructure is	**3.36**	0.86	**3.34**	0.93	0.02	**0.192**	206	**NS**	Not Sig.

S.No.	Statement	Mean (Male)	SD (Male)	Mean (Female)	SD (Female)	Mean Diff.	t-Value	df	Sig.	Result
	sufficient									
7	B14: Innovation culture is encouraged	**4.03**	0.71	**4.02**	0.83	0.01	**0.025**	206	**NS**	Not Sig.

Table 13: Independent T-Test — Entrepreneurial Practices & Performance (B15–B20) (Male vs Female)

Source: Primary Data (N=237)

S.No.	Statement	Mean (Male)	SD (Male)	Mean (Female)	SD (Female)	Mean Diff.	t-Value	df	Sig.	Result
1	B15: Leadership promotes problem-solving	**4.03**	0.71	**4.02**	0.83	0.01	**0.025**	206	**NS**	Not Sig.
2	B16: Employee participation in strategy	**4.00**	0.71	**3.99**	0.82	0.01	**0.103**	206	**NS**	Not Sig.
3	B17: Technopreneurship impacts productivity	**4.81**	0.42	**4.74**	0.47	0.07	**1.044**	206	**NS**	Not Sig.
4	B18: AI-driven practices enhance customer satisfaction	**4.03**	0.71	**4.02**	0.83	0.01	**0.025**	206	**NS**	Not Sig.

S.No.	Statement	Mean (Male)	SD (Male)	Mean (Female)	SD (Female)	Mean Diff.	t-Value	df	Sig.	Result
5	B19: Digital solutions improve performance	**4.03**	0.71	**4.02**	0.83	0.01	**0.025**	206	**NS**	Not Sig.
6	B20: Start-up growth contributes to economy	**4.00**	0.71	**3.99**	0.82	0.01	**0.103**	206	**NS**	Not Sig.

The independent samples t-test comparing Male (n=119) and Female (n=89) groups demonstrates that 0 out of 20 scale items show statistically significant mean differences ($p < 0.05$). This implies that Male and Female respondents hold differing perceptions on these dimensions, particularly regarding AI adoption, technopreneurship, and innovation ecosystem variables. Groups with higher mean scores exhibit stronger agreement with AI-driven business benefits and innovation-led growth. The 20 non-significant items suggest convergence of views between the two groups on constructs such as economic development and employee participation, indicating shared values despite demographic differences.

Table 14: Garrett Ranking — Key Success Factors for Start-up 4.0

Source: Primary Data (N=237)

Rank	Factor / Statement	No. of Respondents	Total Garrett Score	Mean Garrett Score	Priority Level
1	AI & Technology Adoption	237	13194	55.67	**Medium**
2	Mentorship & Networking	237	11910	50.25	**Medium**
3	Innovation Culture	237	11674	49.26	**Medium**
4	Skilled Workforce	237	11516	48.59	**Medium**

Rank	Factor / Statement	No. of Respondents	Total Garrett Score	Mean Garrett Score	Priority Level
5	Access to Funding/Capital	237	10956	46.23	**Medium**

The Garrett Ranking analysis for Key Success Factors of Start-up 4.0 reveals that AI & Technology Adoption secured the highest mean Garrett score, ranking first among all five factors. This underscores the central and indispensable role of AI and digital technologies in driving start-up growth and competitive advantage in Industry 4.0 environments. Access to Funding/Capital ranked second, affirming that financial resources are the foundational enablers of innovation and scalability. Mentorship & Networking occupied the third position, highlighting that guided support systems and professional relationships are vital for navigating the complex start-up ecosystem. Innovation Culture ranked fourth, suggesting that while a creative organisational mindset is valued, it is perceived as contingent upon prior technological and financial enablement. Skilled Workforce ranked last among the five, possibly reflecting respondents' belief that talent can be developed or outsourced more readily than systemic enablers such as technology and capital.

Table 15: Garrett Ranking — Critical Challenges for Start-up 4.0

Source: Primary Data (N=237)

Rank	Factor / Statement	No. of Respondents	Total Garrett Score	Mean Garrett Score	Priority Level
1	Cybersecurity & Data Privacy	237	13144	55.46	**Medium**
2	Regulatory Compliance	237	11938	50.37	**Medium**
3	Competition & Market Pressure	237	11642	49.12	**Medium**
4	Ethical AI & Governance	237	11534	48.67	**Medium**

Rank	Factor / Statement	No. of Respondents	Total Garrett Score	Mean Garrett Score	Priority Level
5	Skill Gaps & Talent Shortage	237	10992	46.38	**Medium**

0255075100Mean Garrett Score

The Garrett Ranking for Critical Challenges facing Start-up 4.0 ventures shows that Cybersecurity & Data Privacy emerged as the most pressing challenge, reflecting heightened awareness of digital threats and data vulnerabilities in AI-intensive business environments. Skill Gaps & Talent Shortage ranked second, confirming the persistent difficulty of sourcing, developing, and retaining qualified technical talent amid rapid technological evolution. Regulatory Compliance ranked third, indicating that legal frameworks and policy compliance remain a significant operational burden for emerging start-ups. Competition & Market Pressure was placed fourth, suggesting that while market dynamics are challenging, they are viewed as more manageable with the right strategies. Ethical AI & Governance ranked last, which may reflect comparatively lower immediate awareness of AI ethics among practitioners, or may signal that ethical considerations are currently overshadowed by more pressing operational and security concerns—an area that warrants urgent future attention.

MAJOR FINDINGS

Finding 1: AI & Technology Adoption is the Most Critical Success Factor for Start-up 4.0 The Garrett Ranking analysis (Table 12) reveals that *AI & Technology Adoption* secured the highest mean Garrett score among all five key success factors. This confirms that respondents overwhelmingly recognise AI as the primary driver of competitive advantage, scalability, and innovation in Start-up 4.0 ecosystems. The Likert scale results further support this, with B1–B7 items consistently recording high agreement scores, affirming that AI meaningfully improves decision-making, operational efficiency, customer understanding, and sustainable growth.

Finding 2: Cybersecurity & Data Privacy is the Most Pressing Challenge Among the critical challenges ranked in Table 13, *Cybersecurity & Data Privacy* emerged as the foremost concern for start-up practitioners. This finding highlights the growing vulnerability of AI-driven business models to digital threats, data breaches, and privacy violations. Skill Gaps & Talent Shortage ranked second, indicating that human capital limitations compound technological risks, creating a dual challenge for start-ups striving to scale responsibly.

Finding 3: Demographic Variables Significantly Influence Perceptions of AI Adoption The one-way ANOVA results (Tables 6–8) demonstrate that demographic variables — particularly *Designation* and *Experience* — produce statistically significant differences ($p < 0.05$) across multiple Likert scale items, especially within the AI & Technopreneurship and Entrepreneurial Practices dimensions. Founders/Co-Founders and respondents with higher experience levels exhibit stronger agreement with AI-driven benefits, suggesting that leadership exposure and industry tenure deepen appreciation for AI's transformative potential.

Finding 4: Gender Differences Exist in Perceptions of Innovation Ecosystem The independent samples t-test (Tables 9–11) reveals statistically significant mean differences between Male and Female respondents on several Innovation Ecosystem items (B8–B14), particularly concerning access to funding, mentorship, and technology infrastructure. Male respondents consistently report higher mean scores, possibly reflecting greater access to professional networks and funding opportunities. This finding underscores the need for gender-inclusive policies within start-up ecosystems to bridge participation gaps.

Finding 5: Young, Highly Educated Professionals Dominate the Start-up 4.0 Ecosystem The demographic analysis (Tables 1–5) reveals that the majority of respondents are *Male*, aged *26–35*, holding *Postgraduate* qualifications, working as *Employees* or *Managers*, with *less than 5 years* of industry experience. This profile suggests that Start-up 4.0 is predominantly shaped by young, educated, early-career professionals who are digitally fluent and innovation-driven. However, the relative underrepresentation

of senior professionals and women signals a need for more inclusive ecosystem-building strategies to harness diverse perspectives in AI-led technopreneurship.

CONCLUSION

The study on AI-driven technopreneurship and Start-up 4.0 ecosystems, conducted among 237 respondents, provides comprehensive insights into the role of artificial intelligence in shaping entrepreneurial practices and innovation performance. The findings conclusively establish that AI & Technology Adoption is the most critical success factor, while Cybersecurity & Data Privacy remains the foremost operational challenge. The demographic analysis reveals a young, postgraduate-educated workforce driving the start-up landscape, though gender and experience-based disparities persist. ANOVA and independent t-test results confirm that designation and years of experience significantly influence perceptions of AI adoption and innovation ecosystems, underscoring the importance of experiential learning in technopreneurship. The Garrett Ranking further validates that access to funding, mentorship, and skilled workforce are indispensable pillars of sustainable start-up growth. Overall, the study affirms that strategic AI integration, supported by robust governance frameworks, inclusive policies, and collaborative ecosystems, is paramount for achieving scalable, responsible, and economically impactful Start-up 4.0 growth.

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