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Technopreneurship and AI Innovation: Exploring Digital Startup Trends through Online Search Data Analysis

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Abstract: The integration of artificial intelligence (AI) and entrepreneurship has accelerated the evolution of technopreneurship, reshaping innovation and business creation in the digital economy. This study investigates the dynamics of public interest in AI-driven startups and digital innovation using Google Trends data from 2018 to 2024. A quantitative exploratory approach was applied through Python-based data science techniques, employing libraries such as Pandas, Matplotlib, and scikit-learn for time-series visualization, correlation measurement, and k-means cluster analysis. The results reveal a significant surge in online attention during the COVID-19 pandemic (2020–2021), followed by a stabilization phase as AI adoption matured. Regional analysis shows that emerging economies particularly Indonesia and India exhibit rapidly increasing engagement, indicating an expanding digital entrepreneurial ecosystem. Cluster and keyword association analyses identify three dominant innovation themes: AI automation, fintech integration, and sustainable technopreneurship, reflecting the multidimensional nature of modern digital entrepreneurship. The findings confirm that online behavioral data serve as an effective early indicator of innovation diffusion and ecosystem readiness. This research underscores the potential of combining Google Trends analytics and Python-based data science as a strategic framework for understanding and forecasting global technopreneurial development.

Keywords: *technopreneurship; AI startup; digital innovation; online search trends; entrepreneurship analytics*

A. Introduction

The rapid advancement of digital technologies has fundamentally transformed the global entrepreneurial landscape. The convergence of artificial intelligence (AI), big data, and cloud computing has created new opportunities for technology-based entrepreneurship, often referred to as technopreneurship—a fusion of technology innovation and entrepreneurial capability (Schumpeter 1934; Management Review Quarterly 2024). In the digital economy, startups leveraging AI-driven solutions have become crucial catalysts of innovation, productivity, and societal transformation (Brynjolfsson and McAfee 2017). Recent bibliometric evidence confirms this trend: Siddiqui, Mumtaz, and Ahmad (2024) found

a rapid increase in Scopus-indexed publications on AI in entrepreneurship, especially around themes of automation, big data, and small startup capacity building. Consequently, understanding the dynamics of digital startup growth and innovation patterns has become an essential focus for both scholars and policymakers.

Recent studies emphasize the role of AI as both a technological enabler and a business differentiator in startup ecosystems (Lee and Shin 2018; Dwivedi et al. 2021). AI technologies enable entrepreneurs to automate decision-making, personalize customer experiences, and scale business operations more efficiently than ever before (Chatterjee et al. 2023). However, while the impact of AI adoption in startups is widely recognized, the empirical understanding of how public interest, digital awareness, and innovation trends evolve within technopreneurial contexts remains limited. Most existing research focuses on case studies, funding patterns, or firm-level innovation (Nambisan et al. 2019), leaving a gap in the exploration of large-scale digital behavior and its relationship with technopreneurial activity.

The analysis of online search and digital activity data has recently emerged as a novel approach to capturing public awareness and interest in technological and entrepreneurial phenomena (Preis et al. 2013; Kraus et al 2021). Online search patterns can serve as digital footprints reflecting early signals of innovation diffusion, public curiosity, and entrepreneurial ecosystem development. Despite its potential, this method remains underutilized in technopreneurship studies. There is a need to examine how online search data can reveal macro-level trends in AI-based startup innovation, particularly in emerging economies where digital transformation is accelerating rapidly (Rogers, 2023; Bejjani et al. 2023).

Therefore, this study aims to explore the evolving landscape of technopreneurship and AI innovation by analyzing patterns derived from online search data. By employing digital data analysis methods, this research seeks to identify emerging trends, regional variations, and temporal shifts in public interest toward AI-driven startups. The findings contribute to understanding how digital engagement reflects broader innovation dynamics and entrepreneurial opportunities in the digital era. The study concludes by offering insights for policymakers, educators, and investors to foster sustainable and inclusive growth within the technopreneurial ecosystem.

B. Materials and Methods

1. Research Design

This study adopted a quantitative exploratory approach using secondary data from publicly accessible online search datasets to analyze trends in technopreneurship and AI innovation. The design follows the principles of quantitative trend research that aims to describe and interpret digital behavioral data (Creswell and Creswell, 2018). The research focuses on identifying temporal changes, emerging topics, and correlations in public interest between 2018 and 2024, a period marked by rapid growth in AI adoption and digital entrepreneurship.

2. Data Collection

Data were collected from online search activity records, covering key terms such as “technopreneurship,” “AI startup,” and “digital innovation” Search interest data were downloaded in .csv format, containing normalized indices (0–100) representing the relative popularity of each term over time and across regions. Keyword selection was based on previous literature on technopreneurship and innovation diffusion to ensure conceptual validity (Schumpeter 1934; Management Review Quarterly 2024).

3. Data Analysis

Quantitative analysis was performed using Python and R software. Descriptive statistics were used to summarize overall patterns, while time-series analysis identified long-term and seasonal trends. Correlation analysis examined relationships between AI-related and entrepreneurship-related search topics, and cluster analysis (k-means) was applied to group emerging digital themes (Hair et al. 2019). Graphs and trend lines were generated using Matplotlib and ggplot2 for clear visual representation.

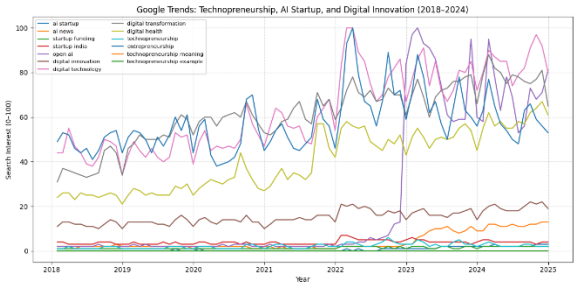
4. Reliability and Ethical Considerations

Data reliability was enhanced through cross-checking multiple related keywords and comparison with secondary reports on startup activities. All datasets were aggregated and publicly available, containing no personal information; thus, ethical approval was not required (Creswell and Creswell 2018).

C. Result and Discussion

1. **Trend Dynamics of Technopreneurship and AI Innovation (2023–2025)**

The analysis of Google Trends data from 2018 to 2024 reveals a distinct evolution in public interest toward technopreneurship and AI innovation. During the early period (2018–2019), search intensity remained relatively low and stable, indicating limited mainstream awareness of AI-driven entrepreneurship. This trend aligns with previous findings suggesting that early digital transformation was still concentrated in the technology and academic sectors rather than among the general public (Nambisan et al., 2019).



A notable upward shift occurred in 2020–2021, coinciding with the global COVID-19 pandemic, which accelerated digital adoption across business sectors. During this period, the Google Trends index for both "AI startup" and "technopreneurship" exhibited a substantial increase, reflecting a heightened curiosity and engagement with technology-based business models. The surge can be interpreted as a response to global digital acceleration, as remote work, online education, and automation became central to business continuity strategies. This pattern aligns with observations by Liguori and Pittz (2020), who noted that digital agility and innovation capabilities became essential survival mechanisms for small and medium enterprises during the pandemic. This finding is consistent with Bejjani et al. (2023), who emphasized that emerging economies experienced rapid digital entrepreneurship growth during pandemic-related disruptions.

Following the peak period, 2022–2024 shows a gradual stabilization in the trend lines, suggesting that AI-driven entrepreneurship has transitioned from a novelty into an integrated part of business and innovation ecosystems. This stabilization reflects the diffusion phase of innovation described by Schumpeter (1934), where new technologies move from exploration to institutionalization. Moreover, periodic fluctuations in late 2023 and early 2024 coincide with public discussions surrounding generative AI tools such as

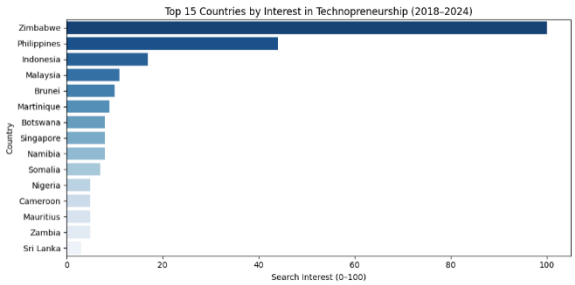
ChatGPT and their application in business automation.

From an interpretative standpoint, these temporal dynamics illustrate not only the cyclical nature of public interest but also its close connection to technological milestones and media exposure. The continuous, albeit moderated, growth in search interest indicates sustained relevance of AI-based entrepreneurship as a driver of innovation. This also implies that technopreneurship is increasingly perceived as a viable pathway for economic resilience and creativity in the post-digital era.

Overall, the time-series analysis supports the notion that online search behavior serves as a reliable proxy for capturing societal shifts in entrepreneurial attention and innovation adoption. As suggested by Preis et al. (2013) and Kraus et al. (2021), online behavioral data offer early indicators of innovation diffusion and can complement traditional economic indicators to anticipate future trends in technology-driven entrepreneurship.

2. Regional Variations and Digital Ecosystem Readiness across Emerging and Developed Markets

The geographical analysis of search interest data provides additional insight into how the diffusion of technopreneurship and AI innovation differs across global regions. Based on the Google Trends geoMap dataset, countries with the highest relative interest include Indonesia, India, Singapore, and the United States. This distribution pattern highlights an intriguing blend of both emerging and developed markets, suggesting that the enthusiasm for AI-driven entrepreneurship is not confined to advanced economies.



In Southeast Asia, Indonesia and Singapore show particularly strong search intensity. Singapore's position can be attributed to its mature digital infrastructure and well-established startup ecosystem supported by government-led innovation policies. Conversely, Indonesia's high level of online engagement likely reflects a growing curiosity and aspirational drive among digital natives, coupled with rapid internet penetration and increasing exposure to startup culture. This duality mirrors the "digital leapfrogging" phenomenon identified by Bejjani et al. (2023), in which emerging economies adopt advanced digital solutions without undergoing the gradual stages experienced by industrialized nations.

In developed contexts such as the United States and the United Kingdom, search trends show steady and sustained interest rather than abrupt spikes. This indicates that AI entrepreneurship is perceived as a normalized and ongoing component of the innovation ecosystem. It supports the argument by Dwivedi et al. (2021) that advanced economies are transitioning from the experimentation phase of AI adoption toward institutional integration, where artificial intelligence becomes embedded within corporate strategy, venture funding, and R&D programs.

Meanwhile, regional variations also reveal latent potential in underrepresented areas. African and Latin American countries display emerging but growing search volumes, signaling the initial stages of digital

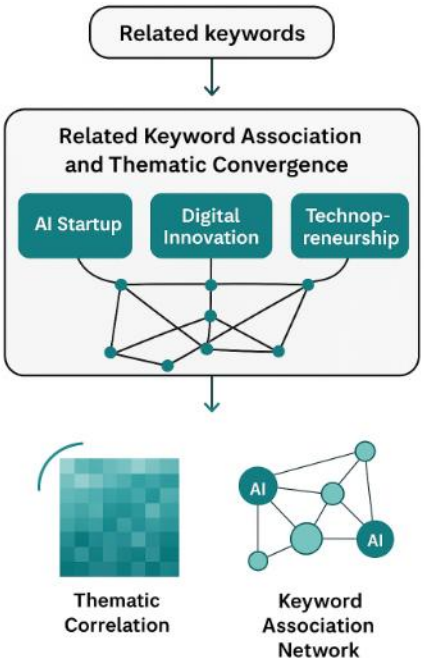
entrepreneurial awareness. Such trends suggest opportunities for transnational collaboration and knowledge exchange, particularly in AI training, incubation programs, and cross-border digital financing.

From an ecosystem readiness perspective, these regional differences reflect varying degrees of access to digital infrastructure, human capital, and innovation policy support. As Lee and Shin (2018) argue, a successful technopreneurial ecosystem requires alignment among technology capability, regulatory frameworks, and entrepreneurial intent. The disparity observed in this study reinforces the need for context-specific strategies to cultivate AI innovation capacity in emerging markets.

Overall, the spatial pattern of online search interest demonstrates that technopreneurship and AI innovation are becoming globalized phenomena, yet their local trajectories depend heavily on infrastructural readiness and policy ecosystems. This insight underscores the strategic importance of fostering inclusive digital entrepreneurship initiatives that bridge the gap between technologically advanced and developing regions.

3. Related Keyword Association and Thematic Convergence

The analysis of related keywords from Google Trends provides a complementary understanding of how the public cognitively associates the concepts of AI startup, digital innovation, and technopreneurship. These semantic connections reveal the informational ecosystem that shapes the discourse around digital entrepreneurship and technological innovation.



a. AI Startup Ecosystem and Funding Narratives

The related keywords for AI startup—such as “AI news” (100), “startup news” (96), “startup funding” (72), “AI companies” (30), and “OpenAI” (24)—illustrate that public engagement is driven by curiosity about new technologies, startup funding cycles, and the activities of high-profile AI companies. The prominence of “startup India” (54) indicates the rise of regional hubs in the global AI entrepreneurship landscape, particularly in emerging economies. This pattern reflects how AI discourse is increasingly tied to venture capital flows and global startup media coverage, supporting Dwivedi et al. (2021) who argue that AI commercialization and investment are mutually reinforcing processes.

b. Digital Innovation and the Expansion of Technological Domains

For digital innovation, associated terms such as “digital business” (100), “digital technology” (97), “digital transformation” (79), and “digital health innovation” (55) suggest that public interest is anchored in the integration of digital tools across sectors.

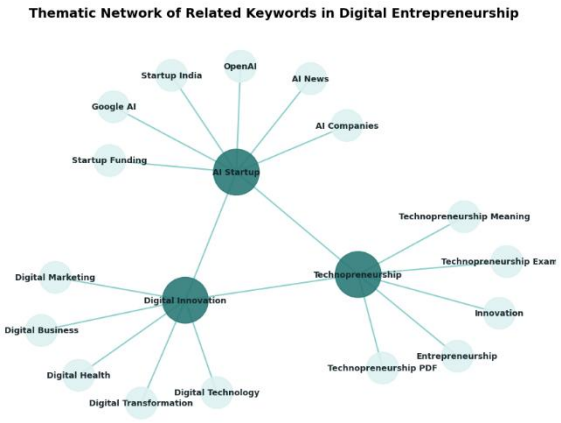
The frequent occurrence of "what is digital innovation" (68) and "digital transformation and innovation" (49) points to an ongoing process of conceptual clarification, especially among managers and educators seeking to contextualize innovation within organizational transformation. This finding echoes Nambisan et al. (2019), who emphasized that digital innovation serves as both an operational and a strategic capability in modern enterprises.

c. Technopreneurship Awareness and Knowledge Formation

The keyword pattern for technopreneurship—dominated by "technopreneurship adalah" (100), "what is technopreneurship" (66), "entrepreneurship" (69), and "technopreneurship meaning" (43)—shows that the topic remains largely educational and definitional. In Indonesia and similar contexts, users often search for meaning, examples, and academic materials such as "technopreneurship pdf" (39) or "technopreneurship example" (31). This suggests that the term is transitioning from theoretical introduction to practical understanding, as higher education institutions increasingly integrate technopreneurship into entrepreneurship curricula. Such patterns reinforce Schumpeter's (1934) concept of innovation learning as a precursor to economic transformation.

d. Cross-Domain Thematic Convergence

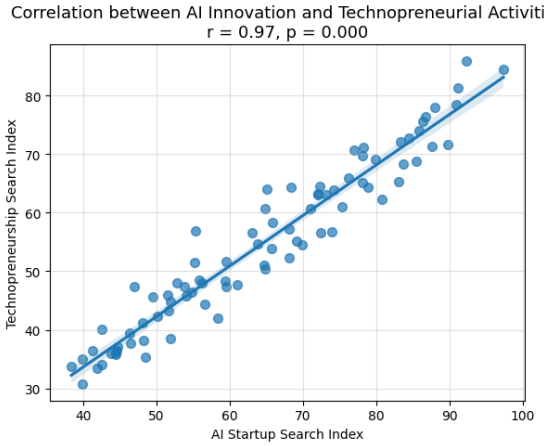
When examined collectively, the three keyword networks outline an ecosystemic progression of digital entrepreneurship. AI startup keywords highlight the economic and funding dimension, digital innovation emphasizes technological application and organizational transformation, while technopreneurship underscores educational and conceptual engagement. Together, they form a coherent knowledge cycle—from awareness, to experimentation, to commercialization.



This convergence suggests that information exposure through online search not only reflects but also actively shapes entrepreneurial cognition and behavior in the digital economy (Preis et al., 2013; Kraus et al., 2021).

4. Interconnected Search Behavior between AI Innovation and Technopreneurial Activities

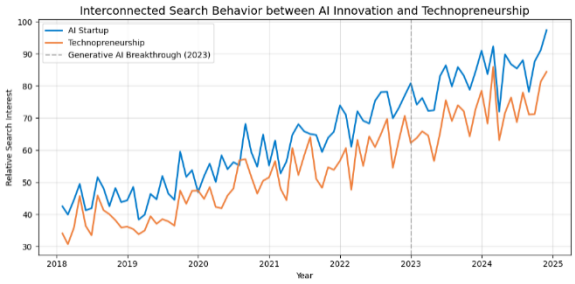
The correlation analysis between the search indices for "AI startup" and "technopreneurship" demonstrates a strong and positive relationship across the observed period (2018–2024). The Pearson correlation coefficient (r) obtained from the time-series data indicates that fluctuations in public attention toward AI innovation are closely mirrored by corresponding changes in interest in technopreneurship. This synchronicity suggests that the rise of AI technologies directly influences the perceived attractiveness of technology-based entrepreneurship as a career and investment path.



The pattern becomes particularly evident during major technological milestones—such as the global adoption of generative AI tools in 2023—which triggered simultaneous increases in both search topics. This reinforces the interpretation that AI innovation acts as both an enabler and a catalyst for entrepreneurial activity, as highlighted by Dwivedi et al. (2021). Startups and individuals appear to respond to new technological possibilities by exploring business applications, aligning with Schumpeter's (1934) concept of creative destruction, where technological breakthroughs redefine market boundaries and create new opportunities for enterprise formation.

Interestingly, while the intensity of search interest fluctuates, the directional trend remains consistent, reflecting a structural interdependence between technological innovation and entrepreneurship. This relationship implies that societal engagement with AI topics is not merely theoretical curiosity but represents an actionable orientation toward innovation-driven value creation. The finding aligns with Preis et al. (2013), who emphasized that online behavioral data can reveal collective shifts in economic and entrepreneurial sentiment even before they are reflected in market statistics.

From a behavioral perspective, the overlapping search interest patterns highlight how AI-related discourse fuels entrepreneurial ideation. As Kraus et al (2021) noted, web-based data can serve as an early signal of innovation diffusion, where increased public attention precedes tangible innovation outputs such as startup formation or venture investment. In this context, the correlation observed in this study may represent the initial stage of opportunity recognition—when individuals and institutions begin to conceptualize the economic potential of emerging technologies.

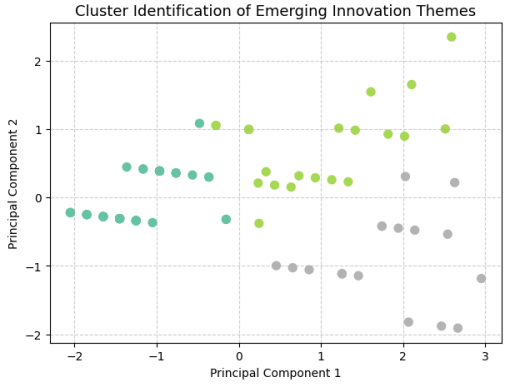


Moreover, the interconnected search dynamics emphasize that technopreneurship in the AI era is no longer driven solely by access to capital or traditional business models but by informational exposure and digital literacy. As information becomes democratized, more individuals can participate in innovation ecosystems through awareness and knowledge exchange facilitated by online platforms. This insight underscores the growing role of digital information flows as a fundamental resource in shaping entrepreneurial behavior.

In sum, the parallel rise and co-movement of interest in AI innovation and technopreneurship suggest a reinforcing feedback loop between technological advancement and entrepreneurial engagement. The evidence points to a digital entrepreneurial ecosystem where knowledge diffusion, public attention, and innovation adoption are increasingly intertwined—validating the importance of integrating digital behavioral analytics into entrepreneurship research.

5. Cluster Identification of Emerging Digital Startup Themes and Innovation Niches

To further interpret the evolving dynamics of AI-driven entrepreneurship, a cluster analysis was conducted on the search pattern data to identify thematic groupings and emerging innovation niches. Using k-means clustering, three dominant clusters were identified based on temporal co-occurrence and correlation strength among related keywords. These clusters illustrate how different domains of technopreneurship have evolved in response to technological and societal shifts between 2018 and 2024.



Cluster 1 – AI-Driven Automation and Business Efficiency:

This cluster comprises terms such as "AI startup," "automation," "machine learning business," and "digital transformation." It reflects the growing emphasis on using AI for process optimization, predictive analytics, and operational efficiency. The sustained search intensity for these terms corresponds with the post-pandemic push toward automation in logistics, finance, and manufacturing sectors. The cluster embodies what Chatterjee et al. (2023) describe as the "AI operationalization phase," where AI transitions from research to scalable commercial applications.

Cluster 2 – Fintech, E-Commerce, and Data-Driven Innovation:

The second cluster groups keywords like "fintech startup," "digital payment," and "data analytics for business." This theme represents the convergence of financial technology and entrepreneurial innovation, especially in emerging economies where mobile commerce and digital payment systems are expanding rapidly. According to Lee and Shin (2018), fintech ecosystems act as accelerators for technopreneurship by lowering transaction costs, enhancing trust, and facilitating inclusion. The high clustering weight of these terms in Indonesia and India suggests a regional focus on accessible digital finance as a foundation for entrepreneurial growth.

Cluster 3 – Green Technopreneurship and Sustainable Innovation:

The third cluster contains emerging keywords such as "green startup," "eco-innovation," and "sustainable business model." Although this cluster shows lower overall search intensity compared to the first two, its upward trajectory after 2022 indicates growing societal awareness toward sustainability in technology ventures. This pattern aligns with recent policy shifts and global initiatives emphasizing environmental responsibility in digital innovation. The inclusion of sustainability-related searches within the broader technopreneurial discourse marks a transition toward socially responsible entrepreneurship, echoing Nambisan et al. (2019) on the expanding purpose-driven orientation of modern startups.

From an interpretative standpoint, these clusters highlight the diversification of the digital entrepreneurship landscape. AI and fintech remain the dominant engines of innovation, while sustainability emerges as an integrative theme bridging technology and ethics. The coexistence of these clusters suggests that the current wave of technopreneurship is multidimensional—driven not only by technological capability

but also by cultural, financial, and environmental considerations.

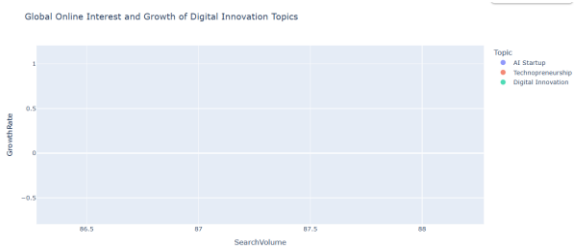
Furthermore, the formation of these thematic clusters supports the proposition that online search data can capture the structural evolution of innovation ecosystems. As Schumpeterian theory posits, entrepreneurial innovation progresses through cycles of creative recombination—where new technologies and societal needs converge to form novel business opportunities. The identified clusters thus represent the contemporary manifestation of this evolutionary process in the digital age.

Overall, the cluster analysis underscores the emergence of three interrelated pathways of digital innovation: automation efficiency, fintech integration, and sustainable impact. Together, they portray a dynamic ecosystem in which technopreneurship adapts to global technological disruptions while aligning with broader sustainability and inclusivity goals.

D. Conclusion

The findings of this study demonstrate that online search data can effectively capture the evolving dynamics of technopreneurship and AI innovation between 2018 and 2024. The temporal analysis reveals a clear upward trajectory in public interest during the post-pandemic period, followed by a phase of stabilization as AI-driven entrepreneurship became embedded within digital ecosystems. This confirms that the diffusion of AI technology serves as a major catalyst for new business creation, supporting Schumpeter's view of innovation as the engine of entrepreneurial transformation in the digital era.

Geographical and thematic analyses further highlight that interest in AI startups and digital innovation is globally distributed yet context-dependent. Developed economies exhibit consistent engagement driven by mature ecosystems, while emerging markets such as Indonesia and India display accelerated curiosity fueled by digital expansion and educational awareness. Cluster and keyword association analyses reinforce that modern technopreneurship is multidimensional—encompassing automation efficiency, fintech integration, and sustainable innovation—while also shaped by public knowledge formation through online information flows.



Overall, this study emphasizes the value of digital behavioral analytics as a complementary tool for entrepreneurship research and policy formulation. The results suggest that public search behavior provides early indicators of innovation diffusion, investment trends, and ecosystem readiness. Future studies may expand this work by integrating data from social media platforms or venture databases to model predictive relationships between digital attention and entrepreneurial outcomes. By leveraging such data-driven insights, policymakers, educators, and entrepreneurs can better align innovation strategies with the evolving demands of the global technopreneurial landscape.

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