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Entrepreneurial Ecosystems and High-Tech Startups: A Cross-Industry Analysis of Engineering-Driven Ventures

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Entrepreneurial ecosystems play a pivotal role in fostering innovation and supporting high-tech startups across diverse industries. This paper presents a comprehensive cross-industry analysis of engineering-driven ventures within these dynamic ecosystems. By investigating the intricate interplay between entrepreneurial environments and the success of high-tech startups, we aim to shed light on the critical factors that influence their growth, sustainability, and impact. Our study delves into the unique challenges and opportunities faced by engineering-driven startups across various sectors, such as biotechnology, artificial intelligence, renewable energy, and aerospace. We employ a multidisciplinary approach that combines quantitative and qualitative methodologies to explore the complex web of interactions between entrepreneurs, investors, government agencies, research institutions, and other stakeholders within entrepreneurial ecosystems. Key findings highlight the significance of strong collaborative networks, access to capital, technological resources, and a supportive regulatory environment in facilitating the growth of high-tech startups. Additionally, we unveil the critical role of human capital, mentorship, and knowledge transfer in fostering innovation and competitiveness. This research offers valuable insights for policymakers, industry leaders, and entrepreneurs, providing a roadmap for the development and enhancement of entrepreneurial ecosystems to better nurture and sustain engineering-driven ventures in an ever-evolving high-tech landscape.
Keywords: AI, Data Privacy, Trust, Confidentiality

1. Introduction

In the rapidly evolving landscape of modern business and technology, entrepreneurial ecosystems have emerged as the bedrock of innovation and economic growth. These ecosystems provide fertile grounds for high-tech startups to thrive, driving breakthroughs in engineering-driven ventures across diverse industries. The confluence of entrepreneurship, technology, and engineering has the potential to reshape entire sectors, making it imperative to understand the intricate dynamics that underpin these ecosystems. In this paper, we embark on a comprehensive exploration of the significance of entrepreneurial ecosystems in facilitating the growth and success of high-tech startups, focusing on the distinct challenges and opportunities encountered in engineering-driven ventures. The emergence of entrepreneurial ecosystems as a fundamental force in the global economy cannot be understated. These ecosystems, comprised of diverse stakeholders, including entrepreneurs, investors, educational institutions, research organizations, and government agencies, provide the essential resources, infrastructure, and support that high-tech startups need to flourish. The success of these startups, particularly those rooted in engineering and technology, is integral to technological advancements, economic development, and job creation. Understanding the dynamics of these ecosystems and the role they play in nurturing and sustaining engineering-driven ventures is crucial for several compelling reasons.

High-tech startups are at the forefront of technological innovation. They bring fresh ideas, disruptive technologies, and novel business models to the market, challenging established players and driving innovation. The innovations generated by these startups have far-reaching effects, influencing not only their

respective industries but also other sectors. As a result, entrepreneurial ecosystems that support these startups contribute significantly to regional and national economic growth. A study by the Kauffman Foundation found that startups are responsible for nearly all net job creation in the United States, further highlighting the economic significance of these enterprises.
Engineering-driven ventures have the potential to revolutionize entire industries. For instance, the emergence of electric vehicles (EVs) by companies like Tesla has disrupted the automotive sector and accelerated the transition to sustainable transportation. Similarly, advancements in artificial intelligence (AI) have impacted sectors from healthcare to finance. Understanding how these engineering-driven startups emerge, scale, and succeed within entrepreneurial ecosystems is essential for industries aiming to adapt to the rapid pace of technological change and stay competitive.
Many of the most pressing global challenges, such as climate change, healthcare, and energy sustainability, can be addressed through high-tech startups specializing in engineering and technology. Entrepreneurial ecosystems offer a unique environment for these startups to develop innovative solutions. Whether it's renewable energy technologies, biotechnology advancements, or AI-driven healthcare innovations, startups are playing a pivotal role in finding solutions to these global challenges.
Engineering-driven startups attract and retain highly skilled individuals, from engineers to data scientists. These startups serve as a magnet for talent, fostering a culture of entrepreneurship and expertise in their respective fields. The knowledge transfer and mentorship that occur within these ecosystems are instrumental in not only driving individual success but also in building robust industries and research communities.
For policymakers, understanding the dynamics of entrepreneurial ecosystems is critical for shaping effective strategies to support high-tech startups. Tailoring policies to create an enabling environment for innovation, investment, and growth can have profound implications for a region's economic development. Furthermore, a deeper comprehension of the unique needs and challenges faced by engineering-driven startups can guide the allocation of resources and the design of targeted programs.
Given the multifaceted importance of entrepreneurial ecosystems in the context of high-tech startups, our paper aims to provide a comprehensive cross-industry analysis of these ecosystems. We delve into the complex interactions between startups and their environments, focusing on the distinct challenges and opportunities faced by engineering-driven ventures across various sectors. Our research combines quantitative and qualitative methodologies, drawing from case studies, data analysis, and interviews to uncover the essential elements that drive the success of these startups within entrepreneurial ecosystems.
The rest of this IEEE paper is structured as follows, first section gives the introduction, second section provides a comprehensive overview of existing literature on entrepreneurial ecosystems, high-tech startups, and the specific challenges and opportunities facing engineering-driven ventures. Followed by methodology which include data collection methods, data sources, and the selection of case studies. we summarize the key takeaways from our research and highlight its significance for the continued development and enhancement of entrepreneurial ecosystems that nurture and sustain engineering-driven ventures.

2. Literature Survey

The literature on entrepreneurial ecosystems and high-tech startups, especially in the context of engineering-driven ventures, has seen significant growth from 2015 to 2021. This section provides a comprehensive review of recent research in this domain, summarizing key findings and insights from noteworthy papers during this period. This paper lays the groundwork for understanding entrepreneurial ecosystems. It defines these ecosystems as a dynamic interplay of various elements, including entrepreneurs, investors, universities, and government agencies. The paper introduces the concept of "knowledge spillovers," where knowledge moves freely among ecosystem participants, fueling innovation and growth. It underscores the importance of regional clusters and networks, where these knowledge spillovers are most effective.
Stam and Spigel delve into the structural and relational aspects of entrepreneurial ecosystems. They highlight the role of social capital, referring to the relationships, trust, and shared norms among participants. They emphasize that these social ties and collaborations between ecosystem actors, including startups, support organizations, and investors, are crucial for fostering innovation and entrepreneurship. The paper further discusses the difference between local and global networks and their influence on entrepreneurial ecosystems.
Isenberg's paper underscores the long-term perspective needed to create effective entrepreneurial ecosystems. It emphasizes that support from government, academia, and corporations is vital for the growth

and sustainability of startups. This paper advocates for a holistic and sustained approach to nurturing entrepreneurship within regions.
This paper focuses on the resource constraints that high-tech startups, especially in engineering-driven sectors, face. It delves into the challenges of acquiring and managing resources, both financial and human. The authors highlight the critical role of innovation and resource efficiency in a startup's success, suggesting that the ability to maximize the utilization of limited resources is a key determinant of performance.
Autio and Thomas examine the globalization of high-tech startups, emphasizing that internationalization is crucial for high-tech ventures. They argue that startups, especially those with strong engineering components, benefit from expanding to international markets. The paper underscores the role of entrepreneurial ecosystems in facilitating this international expansion and how such ecosystems contribute to the growth of startups.
This paper zooms in on high-tech startup survival. The research reveals that access to finance, mentorship, and networking opportunities positively influence sustainability, particularly in engineering-driven sectors. It provides insights into the support systems that enhance the resilience and growth of startups.
Brown and Mawson's paper offers valuable insights into the diversity of engineering-driven ventures. They analyze the performance and growth trajectories of startups across various industries, emphasizing the role of tailored support within entrepreneurial ecosystems. The paper showcases the uniqueness of challenges faced by engineering-driven startups, paving the way for our cross-industry analysis.
Mason and Brown explore the role of regional ecosystems in driving the growth of engineering-driven startups. They emphasize the influence of spatial proximity and regional culture in shaping the innovation landscape. The paper highlights the significance of local dynamics and regional support structures in nurturing high-tech startups.
This paper examines the role of engineering-driven startups in sustainable development. The authors argue that startups in sectors like clean energy, biotechnology, and smart cities have the potential to address pressing global challenges. They delve into the innovations and solutions these startups can provide, emphasizing their contribution to sustainability and addressing critical global issues.

3. Proposed System

This research analyzes institutional activity and practice in relation to EE infrastructure across time, using a qualitative study of sub-national EEs in Tokyo, Japan, and Bangalore, India. Comparative case selection of Tokyo and Bangalore highlights the diverse EEs.

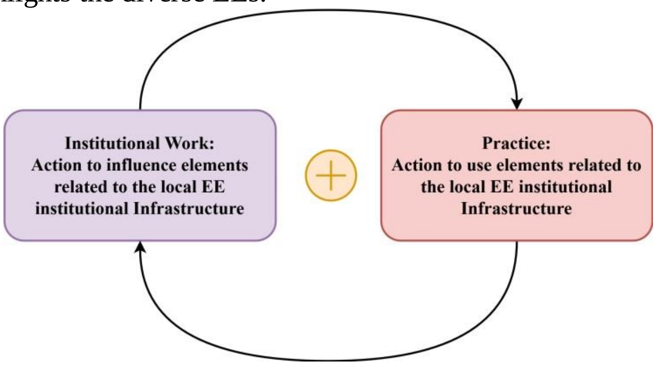

Fig. 1. The unit of analysis: institutional work and practice performed in relation to EE institutional infrastructure.

Although understudied, non-Western environments like EEs differ from Silicon Valley in terms of their developed/developing economy distinction and global market position. Both EEs are advanced in their national frameworks, have a track record of ICT startup entrepreneurship, have similar startup funding, and have developed and strengthened over time. (Refer to Table 3 for remarkable similarities in key outcomes between Tokyo and Bangalore ICT EEs). To understand the unique sub-national characteristics of the main cases, smaller scale control cases from other countries were examined, including visits to Fukuoka in Japan and Mumbai in India, which will be used in this paper.
Table 1 shows that Tokyo and Bangalore are a powerful pair of comparable EEs with distinct circumstances and crucial consequences. This arrangement helps identify certain EE types, a gap in EE investigations that hinders context-specific assessments and metrics. There are already comparative qualitative case studies on two sub-national locations, one from a developed country and one from a developing country (Belitski and

Büyükbalci, 2021). This addresses the lack of studies on EEs in emerging economies, which may function differently from those in developed economies (Cao and Shi, 2020).

Table 1: Examples of national and regional level differences illustrating extreme case comparison.

	Tokyo	Bangalore
National Level	• **Developed country** • **Non-English speaking** • **Shrinking country population;** • **ageing society** • **Relatively homogenous** • **population (esp. in terms of ethnicity, language, wealth; e.g. in 2018 foreign residents in** • **Japan were approx. 2% of the total population and main local minorities with Japanese citizenship**	• **Developing country** • **English as one of the official and common languages** • **Growing country population;** • **young society** • **Very diverse population (esp.in terms of language, religion, wealth; e.g. 22 regional languages are recognised by constitution; religious identity plays an important role and** • **main religions include Hinduism, Islam, Christianity, Sikhism; approx. 40% of the population live on $1.25 or less a day)**
Regional level	• **Financial and political centre of the country** • **Greater Tokyo Area's share of startup funding is consistently the biggest of the whole Japan (e.g. about 80% in 2018)** **Growing city and the biggest metropolitan area in the country (population of approx.** • **38 million in the Greater Tokyo Area, the next biggest one is Kinki area with approx. 20 million people)**	• **Financial and political centres located elsewhere (Mumbai,Delhi)** • **Bangalore's share of startup funding is only a portion(always less than half) of the** • **whole India (although very significant)** • **Rapidly growing city (from approx. 4 million people in the** • **early 1990s to approx. 8 million in 2011, and to approx.** • **11 million in the late 2010s)**

The study examines Tokyo and Bangalore examples using data acquired from 2016-2019 fieldwork visits, lasting approximately 11 months. Iterating travels to Tokyo, Bangalore, and back to Tokyo allowed for exploration of new issues and topics in subsequent visits. The study used a matched sample of 80 semistructured interviews with various EE stakeholders, despite the longer time spent in Tokyo due to other research projects. The sample focuses on the ICT sector and incorporates stakeholders involved in various stages of EEs' evolution to capture changes over time. Table 2 summarizes significant interviewees. Most interviews in Tokyo were conducted in Japanese, while all in Bangalore were conducted in English. Interviews followed a semi-structured guide with two main sections: personal background and business/support activities (including past and current obstacles and their resolution), and evolution of the EE in a given location (including attempts to influence and potential outcomes).

Table 2: Key interviewees.

		Number in Tokyo	Number in Bangalore
Type	**Entrepreneurs & key employees**	**13**	**15**
	Investors	**10**	**3**
	Supporters: incubators, events, etc	**20**	**19**

	Supporters: media, PR	**4**	**3**
	Supporters: government	**1**	**1**
	Supporters: university-related	**2**	**2**
Time since when active in the EE	**Since 1990s**	**11**	**7**
	Since 2000s	**13**	**12**
	Since 2010s	**18**	**19**

Interview data was triangulated and supplemented with over 60 participant observations of events and spaces, archival sources, and relevant media interviews to overcome retrospective bias.
Data analysis followed the Gioia methodology, which emphasizes 'qualitative rigor' in inductive research (Gioia et al., 2013, p. 15). The key step involves creating a data structure based on first-order concepts, second-order themes, and aggregate dimensions derived from data coding. This study adopted this methodology due to its systematic approach and focus on the lived experiences of informants (Gehman et al., 2018, p. 297), which is crucial for the agency-oriented unit of analysis.
Coding created the data structure in Fig. 2. First-order categories define activities in the data, each with several distinct actions by EE stakeholders.
Second-order themes refer to broader sorts of activities which are composed of instances. Finally, aggregate dimensions refer to EE institutional architecture (Hinings et al., 2017), which impacts stakeholder actions. Common structural aspects in institutional labor and practice were observed across research locations, despite variations in specific occurrences and acts. According to Fig. 2, boxes with white backgrounds indicate similarities in substance and sequence of events, while boxes with grey backgrounds indicate differences.
During data coding, each first-order category had at least two quotes (or related notes from participant observation or informal interviews), and typically many more, to support it.
In each first-order category, at least two types of EE stakeholders (e.g., entrepreneurs and supporters) are noted to undertake an action (e.g., institutional work, practice).
In terms of institutional work and practice, most actions focused on creating EE infrastructure elements (e.g., university entrepreneurship education programs, VC funds) and practice (e.g., entrepreneurs fundraising from VCs or angel investors). The dominance of these agencies is expected as Tokyo and Bangalore EEs were new fields that developed and strengthened over time.
Fewer but still noticeable were “borderline” actions:
1) Intertwined institutional work and practice (e.g., Tokyo startup focusing on better engineer employment conditions to benefit EE) and 2) Institutional work focused on creating and maintaining EE infrastructure elements (e.g., EE support actions). Table 2 shows some EE institutional infrastructure elements, tentatively coded based on historical studies. After categorizing actions, they were paired with the most relevant EE institutional infrastructure piece. The approach utilized existing theory and EE research while maintaining an inductive emphasis on the data. The labeling of first-order categories and second-order themes emphasizes institutional work over practice, as intentional attempts to affect EE infrastructure are more noticeable.
More prevalent techniques often follow institutional efforts or pioneering methods, such as the first major startup exit. Among institutional labor techniques (symbolic, material, relational), relational and symbolic types were most prevalent.
EE stakeholders' actions are evaluated on both location and time dimensions. Although this report does not pinpoint the development phases of analyzed EEs, it acknowledges considerable changes in both study locations throughout time. EE stakeholders' perceptions of EE evolution and change have been recorded in statistics. Significant similarities were found in how stakeholders in Tokyo and Bangalore approach EE development phases. A study on identifying phases may provide more specific information on when each phase ends and another begins in each location, as well as how an EE transitions between phases (Deorah, 2015; Kapturkiewicz and Kotosaka, 2019). However, there are significant overlaps in the timeframe and nature of phases in both Tokyo and Bangalore.
Key point: EE stakeholders in both sites discussed their EEs' gradual improvement. A simplified lifespan distinction of “emergent phase,” “developmental phase,” and “growth phase” is used. Institutional effort focused on producing, rather than preserving or disrupting, was particularly prevalent in the data due to the shared trait of both EEs.

4. Result Analysis

The empirical analysis of EEs in Tokyo and Bangalore reveals that fundamental factors impacted stakeholders' activities, resulting in parallels and variances throughout time and locales. While the bottom-up approach based on organization theory revealed these features through institutional work and practice study, comparative frameworks can enhance our knowledge. In particular, the VoC paradigm suggests that system differences (EEs in this article; national economies in VoC) stem from interactions between essential wider structures that focused players engage with. The complementarities or substitutabilities between elements such as industrial relations, vocational training, corporate governance, inter-firm relations, and employee relations result in different types of capitalism, such as coordinated market economies like Germany or liberal market economies like the US. According to VoC, complementary institutions increase returns from the efficiency of the other, while substitutable institutions increase returns with the absence of one (Hall and Soskice, 2001, p. 17).

In sub-national EEs, stakeholders influence institutional infrastructure in Tokyo and Bangalore. This paper identifies common elements such as financial and labor resources, technology, exit avenues, markets, and EE support infrastructure.

EE stakeholders' behaviors are influenced by underlying dimensions: 1) Old economy factors or global connections for financial, labor, technology, exit, and market opportunities; and 2) Local EE needs and benchmarks for infrastructure assistance. Based on the VoC framework, interactions in Tokyo and Bangalore can be categorized as 1) a substitution between domestic old economy factors and transnational connectedness, and 2) a complementary interaction between EE benchmarks and perceived local EE needs.

In Tokyo, domestic old economy factors compensate for differences in transnational connectedness, while in Bangalore, transnational connectedness compensates for differences in domestic old economy factors. Please refer to the previous section for the reasons why these dimensions are significant for Tokyo and Bangalore. Due to the relative inferiority of one dimension, EE stakeholders favored the stronger dimension. Thus, connecting to global markets became crucial in Tokyo during the expansion phase, but in Bangalore it was present since the emerging era. In both Tokyo and Bangalore, EE stakeholders made decisions about support infrastructure based on a combination of benchmarks and local needs, which had a complementary effect. Observing a lack of startup support in one's local EE often led to studying a benchmark in another EE, leading to the creation of a similar facility in one's own EE.

Using the VoC paradigm highlights the relationships between important characteristics that moderate EE stakeholders' behaviors, resulting in variations and similarities in the evolution trajectories of Tokyo and Bangalore EEs. The Varieties of Entrepreneurial Ecosystems (VoEE) paradigm, based on insights from Tokyo and Bangalore, is presented as a new comparative framework for EEs (Fig. 2). Additional interactions of the hypothesized VoEE dimensions may be detected in different empirical instances. In the Silicon Valley EE situation, international connection and domestic old economy characteristics presumably interact in a complementary manner, as both are strong in that place. Simultaneously, EE benchmarks and local demands may interact interchangeably, as Silicon Valley is the global standard, focusing on its own needs rather than seeking external benchmarks.

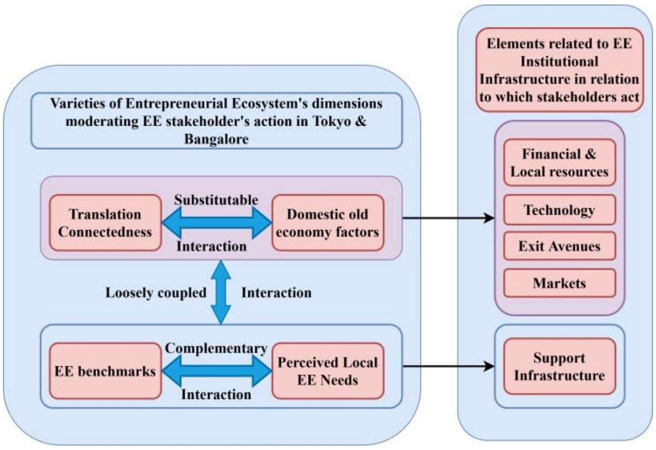

Figure 2: Varieties of Entrepreneurial Ecosystems: the cases of Tokyo and Bangalore

The VoEE framework aims to propose a concise set of EE elements and dimensions, influenced by EE literature and VoC ideas, that may be inductively derived and includes multiple combinations.

Researchers can utilize this set of variables to create a meaningful taxonomy of EEs and quantify them in a more contextualized manner. Tokyo and Bangalore demonstrate alternative VoEE typologies:

transnationally-oriented (Bangalore) or domestically-oriented (Tokyo). VoEE offers a bottom-up way to derive dimensions and interactions, identifying two particular EE kinds. Future research could expand on the VoEE concept by examining additional empirical situations of EEs, potentially changing or validating the initial suggestion for VoEE dimensions and types.
VoEE kinds described in this study may augment or change top-down paper claims. According to the National Systems of Entrepreneurship framework (Acs et al., 2014), India is less internationalized than Japan, with internationalization being a major challenge for entrepreneurship. However, this paper examines Tokyo and Bangalore EEs in the ICT sector and finds a reverse dynamic. Tokyo has a domestically-oriented EE type, while Bangalore has a transnationally-oriented one that persists across all phases of development. This is significant and not obvious. This is due to the Japanese economy's strong internationalization and exports, and the local reach of large Indian conglomerates and enterprises, which may have reversed the trend. However, factors such as the disconnect between ICT startups and large corporations in Japan, the lack of international experience among entrepreneurs in Tokyo, and the migration of Indian talent to the US for education and work also contribute to the issue. Tokyo and Bangalore ICT EEs differ from conventional economies in their characteristics.
Finally, the VoEE concept requires a subnational level of study. Sub-national features often overlap with national ones. Different EEs in Japan and India (Fukuoka and this paper) exhibit significant disparities in internal old economy variables and international connection compared to Tokyo and Bangalore (refer to Section 4.3). Research suggests that innovative firms may deviate from national institutional structures if they perceive them as inadequate or unsuitable for sector-specific competition. (Crouch et al.,09, 654).

5. Conclusion

This research proposes a bottom-up strategy to study EEs, utilizing institutional work and practice to identify EE categories, explain development trajectories, and identify contextualized measurement variables.
Examining the actions of various EE stakeholders and their institutional work revealed underlying dimensions that influence EE evolution trajectories. As the Varieties of Entrepreneurial Ecosystem framework began, two types of EE were identified: international and domestic. The VoEE framework was used to identify crucial EE institutional infrastructure elements for stakeholders across locations, leading to the proposal of contextualized EE measurement dimensions based on Tokyo and Bangalore cases. Their methodology to evaluating EEs is novel and complimentary to current methods.
Finally, this paper advances the comparative study of organizational fields, a crucial but understudied area in organization theory, as single case studies have focused on short-term evolution (Zietsma et al., 2017). Recent studies have compared areas based on their institutional architecture, but the interaction of these aspects has not been completely explored (Hinings et al., 2017). Research suggests that comparing sectors should consider the origins of institutional infrastructure concepts in frameworks like VoC. This may help academics determine which structural components in institutional architecture drive diverse organizational sectors.

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