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RESEARCH ARTICLE

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A COMPREHENSIVE ANALYSIS OF RESEARCH TRENDS IN ENTREPRENEURSHIP THROUGH NETWORK DATA MAPS

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ABSTRACT

The paper explores the role of network data maps as a practical tool for visual data classification in complex research literature, focusing on the discipline of entrepreneurship. This paper takes a closer viewpoint at contemporary research trends by analysing keywords defined by the authors in their publications. The bibliographic data from the Web of Science is investigated for indexed publications in the Social Sciences Citation Index, Science Citation Index Expanded, and Arts & Humanities Citation Index between 2010 and 2023. The study utilises VOSviewer to generate graphical representations of occurrences and total link strengths based on the comprehensive database results within the analysed group ("entrepreneurship"). The field of entrepreneurship management shows considerable progress due to developments, trends, and concepts in the entrepreneurship ecosystem. Key findings reveal that innovation, social entrepreneurship, entrepreneurship education, and entrepreneurial intention are the most frequently cited keywords in entrepreneurship literature. The visualisations of important findings are demonstrated to the attention of the researchers in the field. As a further study, the potential relationship between entrepreneurship and mechanical engineering is analysed.

Keywords: *Entrepreneurship, Incubation Centre, Innovation Management, Network Data Maps, Technology Management*

GİRİŞİMCİLİK ARAŞTIRMA EĞİLİMLERİNİN AĞ VERİ HARİTALARI ARACILIĞIYLA KAPSAMLI BİR ANALİZİ

ÖZ

Bu çalışma, araştırma literatüründe görsel veri sınıflandırması için pratik bir araç olarak önerilen ağ veri haritalarının rolünü, girişimcilik disiplinine odaklanarak incelemektedir. Çalışmada, yazarların yayınlarında tanımladıkları anahtar kelimeler analiz edilerek güncel araştırma eğilimlerinin tespit edilmesine odaklanılmaktadır. Web of Science'taki (WoS) bibliyografik veriler, 2010-2023 yılları arasında Sosyal Bilimler Atıf Dizini (SSCI), Genişletilmiş Bilim Atıf Dizini (SCI-E) ve Sanat ve Beşeri Bilimler Atıf Dizini'nde (A&HCI) indekslenen yayınlar ile elde edilmiştir. Çalışmada, analiz edilen grup ("girişimcilik") içindeki kapsamlı veritabanı sonuçlarına dayanarak anahtar kelimelerin var olma veya frekans değerleri ile toplam bağlantı güçlerinin grafiksel gösterimlerini oluşturmak için VOSviewer yazılımı kullanılmaktadır. Girişimcilik yönetimi alanı, girişimcilik ekosistemindeki gelişmeler, çeşitli eğilimler ve kavramlar sayesinde önemli bir ilerleme göstermektedir. Temel bulgular; inovasyon, sosyal girişimcilik, girişimcilik eğitimi ve girişimcilik niyetinin girişimcilik literatüründe en sık alıntılanan anahtar kelimeler olduğunu ortaya koymaktadır. Önemli bulguların görselleştirilmiş halleri, bu alandaki araştırmacıların dikkatine sunulmaktadır. Farklı bir bakış açısı sunmak amacıyla girişimcilik ile makine mühendisliği arasındaki potansiyel ilişki de mevcut veritabanı kullanılarak detaylı bir şekilde analiz edilmektedir.

Anahtar Kelimeler: *Girişimcilik, Kuluçka Merkezi, İnovasyon Yönetimi, Ağ Veri Haritaları, Teknoloji Yönetimi.*

1. INTRODUCTION

Entrepreneurship includes the entrepreneurial activities of individuals, groups, and organizations in discovering, creating, and realising opportunities for new products and services in the market. As the main driver of economic growth, it also plays a crucial role in enhancing social well-being due to its interdisciplinary and multifaceted nature. Entrepreneurship is not limited to the establishment of new businesses, it also provides significant opportunities for existing businesses to develop innovative solutions, create employment, and address societal challenges.

Entrepreneurship today is closely linked to concepts that shape the global landscape, such as digitalisation, gender equity, policy reform, circular economy and resilience in the face of crises like pandemics. Entrepreneurs drive innovation by integrating digital technologies, promote sustainability through eco-conscious business models, and contribute to social equity by empowering women in the workforce. Education and social capital are vital in fostering entrepreneurial skills and networks, while policy entrepreneurship serves as a tool for advancing systemic changes. Effective management of the entrepreneurial ecosystem is essential for ensuring economic sustainability and enhancing social welfare on both local and global scales. For instance, integrating refrigerator waste heat recovery for domestic fabric drying illustrates how entrepreneurial engineering can address energy challenges and create small-scale business opportunities (Onyeocha et al., 2020).

Mechanical engineering, a core discipline of engineering, plays a crucial role in addressing technological challenges and driving innovations across industries. The historical connection between mechanical engineering and entrepreneurship dates back to pioneers like Franz Reuleaux and Alois Riedler, who combined academic work with patenting, business ventures, and consultancy during Germany's industrialization era (König, 2017). Despite its fundamental significance, the relationship between mechanical engineering and entrepreneurship remains underexplored in the literature. Existing papers in the intersection of those two domains generally focus on how entrepreneurship can be integrated into mechanical engineering education. Nichols & Armstrong highlight the need for entrepreneurship within mechanical engineering curricula, emphasizing that innovation, creativity, and leadership are critical for product development and business success (Nichols & Armstrong, 2003). Muñoz-Guijosa et al. (2009) emphasize the importance of integrating entrepreneurial thinking and practical skills (such as initiative and responsibility) into mechanical engineering education to better prepare students for complex engineering challenges and entrepreneurial ventures. Silva & Faria (2012) argue for embedding entrepreneurship in engineering design courses rather than treating it as a separate discipline. This approach allows students to develop a comprehensive understanding of product development and commercialization.

Duval-Couetil et al. (2012) find that mechanical engineering students show greater interest in entrepreneurship education compared to other engineering fields, suggesting that such education enhances students' entrepreneurial confidence and career readiness. Brunhaver et al. (2012) examine how interdisciplinary courses, such as those combining mechanical engineering with electronics and software, can create learning ecosystems that foster entrepreneurship. These environments enhance students' ability to innovate and launch startups. Sandhu et al. (2025) propose a framework to incorporate entrepreneurial thinking alongside technical skills in engineering education, offering tools like the Lean Canvas Model to help students innovate and grow businesses.

Entrepreneurship through industry networks is also explored. Karlsen (2011) analyse how local networks and communities foster entrepreneurship in mechanical engineering. The findings indicate that specialization emerges not through external investments but through accumulated local knowledge, networks, and internal processes. The study introduces the concept of "reconfiguring communities of practice" to explain how local knowledge and spin-off firms drive growth. Comparative case analyses identify five distinct types of entrepreneurial initiatives, highlighting the role of parent firms as incubators in fostering expansion. The study argues that traditional cluster development policies that deliberately construct clusters are less effective in craft-based manufacturing industries like mechanical engineering. Instead, policies should support endogenous firm growth, spin-offs, and localized knowledge accumulation for strengthening mechanical engineering agglomerations. Today, mechanical engineering remains economically significant. For example, in Slovakia, it contributes 42% of total industrial output and employs 12% of the workforce, largely through small and medium-sized enterprises (SMEs) that play a key role in innovation and entrepreneurship (Lesáková et al., 2019).

The aim of this study is twofold: First, we provide a comprehensive analysis of trends in entrepreneurship, examining developments and emerging topics in this field. Second, we explore the relationship between entrepreneurship and mechanical engineering, investigating the intersection between these two disciplines. Given the rapidly evolving and dynamic nature of entrepreneurship, there is a growing need

for current and comprehensive studies. Understanding the key mechanisms and trends in entrepreneurship, as well as incubation management, is critical for empowering stakeholders to maximize their entrepreneurial potential. Insights into incubation management help optimize resources, reduce the failure rate of startups, and accelerate the commercialization of innovative ideas. Such studies inspire innovative visions and contribute to solving societal challenges, making substantial contributions to national development. Additionally, while mechanical engineering is a core engineering field with significant potential, its relationship with entrepreneurship remains underexplored in the literature. This gap underscores the need for further research on how mechanical engineering can evolve alongside entrepreneurial practices.

To address these issues the authors conduct a comprehensive analysis of research literature related to the concept of entrepreneurship using the Web of Science (WoS) database. With 22,877 documents published between 2010 and 2023, this database is one of the largest and most extensive collections of peer-reviewed literature available. By employing VOSviewer version 1.6.19, a specialized software tool for bibliometric analysis, indexed articles from the Social Sciences Citation Index (SSCI), Science Citation Index Expanded (SCI-Expanded), and Arts & Humanities Citation Index (A&HCI) can be analysed. This approach enables the identification of patterns, trends, and connections among different research papers discussing "entrepreneurship". This method ensures objectivity and realism while providing valuable insights into entrepreneurship management on a global scale. Additionally, further analysis is conducted to investigate the connection between entrepreneurship and mechanical engineering. The same dataset is used in the analysis and topics related to mechanical engineering are combined in the thesaurus set. The full list of keywords combined in the thesaurus set is provided in the appendix file. Keywords such as thermodynamics, fluid mechanics, materials science, mechanical systems, automotive engineering, energy systems, automation, aerospace, manufacturing technologies, and manufacturing industry are directly connected to the core sub-disciplines of mechanical engineering. When these keywords are combined, mechanical engineering's node is clearly visualized on the network map as the

"mechanical engineering". In this way, the relationship between mechanical engineering and entrepreneurship is presented clearly.

2. LITERATURE REVIEW

Entrepreneurship literature is reviewed and evaluated under four main categories: (1) entrepreneurship and incubation management, (2) innovation management, (3) social entrepreneurship and sustainability, and (4) development and employment. While the majority of the studies originate from primary fields such as social sciences, business management, and engineering management, entrepreneurship is a subject of research across various disciplines in the scientific community.

2.1. Entrepreneurship and Incubation Management

Entrepreneurship is the main driver of economic growth and a key component affecting the socioeconomic well-being of society. It focuses on discovering, creating, and realising opportunities for future goods and services in the market. The concept of an entrepreneurial ecosystem has emerged from various institutional efforts to characterise and develop entrepreneurial activity. This ecosystem offers a systemic view of entrepreneurship (Cavallo et al., 2019), encompassing factors like entrepreneurial networks, leadership, finance, talent, information, and support services (Spigel & Stam, 2018). It represents the social and economic environment that fosters local or regional entrepreneurship (Acs et al., 2017; Roundy et al., 2017). Entrepreneurial ecosystems take various forms, and their management benefits from the efficient use of digital technologies to strengthen entrepreneurial orientation (Bouncken & Kraus, 2022).

The persistence of a network connecting startups and other stakeholders is essential for a flourishing entrepreneurial ecosystem (Van Weele et al., 2018). This ecosystem provides support, including resources, mentoring, training, and networking, to empower entrepreneurs with innovative ideas to successfully establish businesses. It involves investors who offer venture capital to high-growth startups and promote crowdfunding initiatives (Brown et al., 2019). This ecosystem stimulates digital

transformation, digital technology utilisation, and digital entrepreneurship (Bican & Brem, 2020).

Incubation centres provide joint services to support and foster the growth of SMEs over a defined period (Udell, 1990). According to the European Commission, these centres facilitate the development of successful businesses by offering comprehensive support services such as location, business development, clustering, and networking. This effectively reduces overhead costs and enhances the survival and growth of new ventures (Busulwa et al., 2020). Incubation centres assist entrepreneurial firms in leveraging their abilities to accelerate commercialization (Smilor, 1987). They provide financial support through connections with angel investors and grants for early-stage entrepreneurs. Tailored programmes enhance entrepreneurial skills by linking entrepreneurs with experts in areas such as intellectual property rights, technology transfer, marketing, legal issues, finance, and human resources (Azadnia et al., 2022; Dichter 2010). Businesses graduating from these centres contribute to job creation, commercialisation, and local and national economies (Groen et al., 2015).

Incubation centres operate in three stages: pre-incubation, incubation, and post-incubation. In the pre-incubation phase, support includes innovation assessment, business plan development, and business modelling training. The incubation phase focuses on facilitating access to finance, mentoring, commercialisation training, and advanced business planning. Finally, the post-incubation phase involves activities such as innovation diagnostics, internationalisation support, clustering, and further business development. Figure 1 depicts an overview of the incubation providers (Smilor, 1987; Dichter 2010).

An entrepreneurial ecosystem consists of different actors, relationships, and resources (Liguori et al., 2019). Incubation centres are managed by private sector organisations, universities, government agencies, and non-profit providers. Universities contribute by supporting students, academics, and entrepreneurs with innovative ideas. Government agencies offer incentives like financial resources, tax benefits, training programmes and business development support. Private sector

organisations, including corporations, banks, funds, and private venture capital firms, support incubators. Non-profit organizations and networks offer free assistance with business development, financing, and marketing. Technology-oriented enterprises should strengthen their relations with universities by designing joint value-creation strategies (Quero et al., 2022).

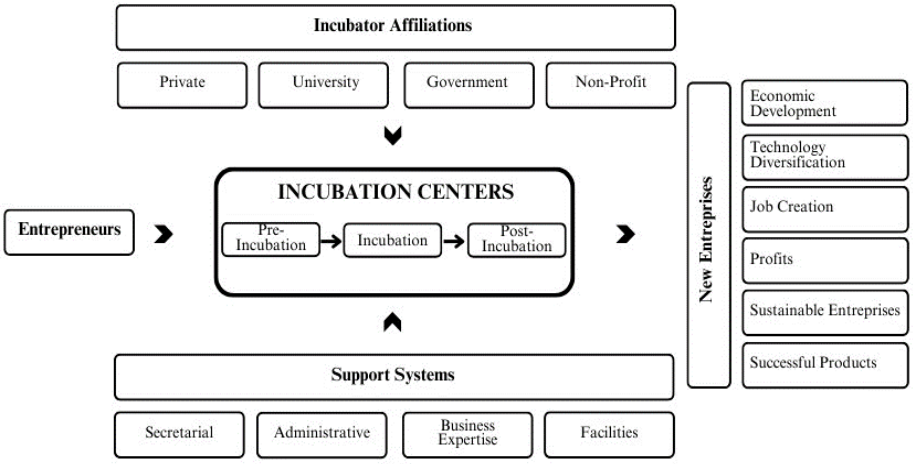


Figure 1. *Mechanism of incubation centre system.*

Entrepreneurship education is essential for promoting entrepreneurial activity (Bischoff et al., 2018). It improves the ability to identify business opportunities (DeTienne & Chandler, 2004) and makes entrepreneurial careers more attractive (Peterman & Kennedy, 2003). Two key theories, human capital and entrepreneurial self-efficacy, explain the link between education and entrepreneurial intentions (Bae et al., 2014). Human capital theory focuses on the knowledge and skills gained through education (Becker et al., 1990), while entrepreneurial self-efficacy theory highlights how education fosters confidence in entrepreneurial abilities, thus increasing entrepreneurial intention (Douglas, 2013). Entrepreneurship education provides students with the opportunity to engage in entrepreneurial activities, thereby improving their self-efficacy (Ahmed et al., 2020). Role models and case studies in further enhance self-efficacy, helping students overcome challenges (Nowiński et al., 2019).

The integration of artificial intelligence (AI) in entrepreneurship education and university incubation centers is emerging as a critical area for fostering entrepreneurial skills. Thottoli et al. (2025) conducted a systematic literature review and bibliometric analysis, highlighting the global trend of AI transforming entrepreneurship education, while identifying a significant research gap in the application of AI within university incubation centers. Their study emphasizes that AI tools, such as chatbots and intelligent business planning systems, can simplify complex entrepreneurial tasks and enhance the effectiveness of incubation programs, offering a promising direction for both academic research and practical implementation in higher education institutions.

The entrepreneurial intention has a strong relationship with the theory of planned behaviour and entrepreneurial self-efficacy (Lee & Wong, 2004). Bird (1988) emphasises that a certain level of entrepreneurial intention must be shown as the first stage in becoming an entrepreneur because entrepreneurship is an intentional and planned behavior (Krueger et al., 2000). Entrepreneurial motivation, a multifaceted phenomenon, influences entrepreneurial passion and success (Nabi et al., 2006). Researchers explore personal and environmental factors related to entrepreneurial passion as a key indicator of economic and social development.

2.2. Innovation Management

Innovation involves transforming new ideas, products, or processes into value by successfully bringing them to market (Thorgren & Wincent, 2015; Strobel & Kratzer, 2017). Key sources of innovation include universities, technology transfer units, and incubation centres. Entrepreneurial orientation supports the innovation process through an organisation's ability to take risks, openness to innovation, proactive behaviour, and the ability to seize competitive opportunities (Covin & Slevin, 1991). Social capital enables organisations to obtain valuable resources through relationships, networks, and trust-based connections within the organisation (Doh & Zolnik, 2011). Innovation management strengthens social capital by encouraging collaboration and knowledge sharing among employees. Market success of radical innovation is higher for entrepreneurs (Cubero et al., 2021).

To increase innovation capacity, organisations can improve employees' knowledge, skills, experience, and abilities (Unger et al., 2011). Effectively managing external networks is crucial, as organisations can promote innovation by acquiring knowledge and resources from external sources through collaboration (Elfring & Hulsink, 2003). Developing processes that collect, share, store, and use knowledge effectively supports the innovation process by strengthening the organisation's knowledge management infrastructure (Girard & Girard, 2015). Innovation management plays a pivotal role in increasing the innovative potential of organisations, supporting the innovation process, and achieving sustainable competitive advantage when all these factors come together.

The traditional technology transfer begins with an entrepreneur or a researcher explaining their invention to the Incubation Centre or Technology Transfer Office. This process involves reporting a scientific discovery with commercial potential (Thursby & Thursby, 2002). Besides processes such as disclosure of invention, technology evaluation, patenting and licensing, there are some other alternatives for technology transfer (Soares & Torkomian, 2021). Increases in skilled labour or human resource capital not only lead to greater technology transfer and adoption but also to in-house R&D investments and thus more innovation in the long run (Yasar & Rejesus, 2020). Companies adopt innovative technologies to achieve radical innovations by phasing out existing products or introducing new products to the market (Min et al., 2020). Estep et al. (2021) emphasise that market, financial feasibility, management skills, and technological, social and organisational perspectives are crucial for technology management and transfer.

2.3. Social Entrepreneurship and Sustainability

Sustainable entrepreneurship focuses on creating products and services with positive economic, social, and environmental impacts (Cohen & Winn, 2007; Hall et al., 2010; Schlange, 2009). It aligns with the Triple Bottom Line (TBL) framework which assesses performance across economic, social, and environmental dimensions (Sung & Park, 2018). Social entrepreneurs aim to integrate economic value creation with social and ecological benefits (Schaltegger & Wagner, 2011).

The United Nations endorsed the 17 Sustainable Development Goals (SDGs) in 2015 to advance sustainable development for people, prosperity, and the planet. These SDGs emphasise the significance of sustainability principles in addressing societal needs (Fonseca et al., 2020). Achieving these goals requires collaboration between governments, businesses, and markets (Rosário et al., 2022).

Social entrepreneurship focuses on solving societal issues rather than making a profit (Alvord et al., 2004; Mair & Marti, 2006). Social entrepreneurs provide innovative and sustainable solutions through non-profit organisations and challenge traditional business models (Nicholls, 2010). The aim is to create long-term societal impact by integrating economic value creation with social and ecological benefits (Thompson & Doherty, 2006). Recognising social entrepreneurship as a significant force in addressing societal issues offers promising prospects for future research and implementation (Sullivan Mort et al., 2003; Seelos & Mair, 2005).

Social entrepreneurship is increasingly examined in relation to sustainability, reflecting the growing importance of aligning social initiatives with long-term environmental and social outcomes. Kamaludin et al. (2024) proposed a conceptual framework linking social entrepreneurship to sustainability by identifying four key dimensions: social, economic, behavior, and governance.

Social entrepreneurship has gained recognition as a pivotal player, particularly during crises like the COVID-19 pandemic and times of increased political divisions. Its role in advancing the economy, addressing societal challenges, enhancing stability, and combating poverty is widely recognized (Trabskaia et al., 2023). Social entrepreneurship contributes to economic growth, fosters innovation, and offers solutions for societal change (Adro & Fernandes, 2022). It aligns with neo-capitalist perspectives, effectively tackling societal issues while reducing the traditional role of the state, particularly in the face of economic crises with limited resources for social welfare programmes (Dey, 2014). Social entrepreneurship is closely linked to commercial entrepreneurship, sustainable entrepreneurship, and social innovation (Cardella et al., 2021). Social networks play a critical role in the success of these initiatives (Dufays & Huybrechts, 2014).

2.4. Development and Employment

Entrepreneurship is widely recognised as a fundamental driver of economic growth and a significant contributor to societal well-being, fostering job creation, innovation, and economic competitiveness (McMullan et al., 1986; Liñán et al., 1986). Numerous studies have explored the impact of entrepreneurial activity on economic development (Thurik & Wennekers, 2004; Welter, F., Lasch, F., 2008), emphasising its pivotal role in generating economic output.

Incubators are essential tools for governments, supporting new businesses and economic development (Kiran & Bose, 2020). They help startups by encouraging technological diversification, business sector development, and the growth of sustainable enterprises (Koe, 2016). Women's involvement in entrepreneurship also strengthens the economy, with women entrepreneurs recognized as crucial for growth in emerging markets (Sarri & Trihopoulou, 2005; Stefan et al., 2021). Governments are creating supportive environments for women-owned businesses, acknowledging their role in national development (Azam Roomi et al., 2009).

Innovation and entrepreneurship are widely recognized as key drivers of national competitiveness and sustainable development. López-Rubio et al. (2025) used a fuzzy-set qualitative comparative analysis to identify combinations of conditions that lead to high national competitiveness, highlighting the critical roles of R&D, innovation, entrepreneurship support policies, and GDP per capita. Their findings indicates that well-developed entrepreneurship alone is insufficient without robust R&D and institutional infrastructures, providing important insights for policymakers in designing effective innovation and entrepreneurship strategies to enhance competitiveness. Deveci et al. (2020) investigate on the defense industry, investments and expenditures as an example. Technological changes and increasing competition in the process of continuous development are triggering countries to increase their military spending in the world.

Women's economic participation, particularly in establishing their businesses, not only empowers them economically but also makes significant contributions to national development (Sarri & Trihopoulou, 2005). Women entrepreneurs are

recognised as key drivers of growth and development in emerging nations (Stefan et al., 2021). Governments have created environments to support women-owned enterprises (Azam Roomi et al., 2009; Bogren et al. 2013), found that female entrepreneurs' motivation to expand is closely linked to the diversity of their networks.

The Low Touch Economy (LTE) concept, introduced by Gigauri (2021), is especially relevant in the context of the COVID-19 pandemic. Businesses need to adapt to new models by integrating LTE, the digital economy, and the circular economy to build resilience and maintain growth (Iacobucci & Perugini, 2021).

Silva Júnior et al. (2022), propose a competitiveness measurement system for startups, considering many critical success factors such as employee loyalty, founder characteristics, employee satisfaction, employee education level, founder team experience, and economic and technological environment. These factors, combined with the environment in which a venture or entrepreneur operates, shape their absorptive capacity (Solano et al., 2020). Additionally, Mackenzie (2004), defines policy entrepreneurship as the actions, behaviours, and characteristics of dynamic policy players advocating for policy change. Faling et al. (2019), express that much of the research focuses on environmental policies, with policy entrepreneurs predominantly being state actors like politicians and administrators.

The Global Entrepreneurship Monitor (GEM) is a research collaboration dedicated to investigating the association between entrepreneurship and economic development. The GEM aims to quantify the differences in entrepreneurial activity levels between countries. It aims to identify factors influencing national entrepreneurial activity levels (Bosma, 2013; Audretsch, 2007). The literature research in the field of entrepreneurship is used to identify relevant topics, and the findings are presented in Table 1.

Table 1. *The Scope of Entrepreneurship.*

Dimension	Scope	References
Entrepreneurship and Incubation Management	Management of technology, Management of entrepreneurship, Academic entrepreneurship and technology transfer, Entrepreneurial motivation, Entrepreneurial intention and behaviour, Entrepreneurship education, Commercialisation of innovation	Thottoli et al., 2025; Azadnia et al., 2022; Bouncken & Kraus, 2022; Kraus, 2022; Quero et al., 2022; Ahmed et al., 2020; Bican & Brem, 2020; Busulwa et al., 2020; Cavallo et al., 2019; Brown et al., 2019; Liguori et al., 2019; Nowiński et al., 2019; Bischoff et al., 2018; Spigel & Stam, 2018; Van Weele et al., 2018; Acs et al., 2017; Roundy et al., 2017; Groen et al., 2015; Bae et al., 2014; Douglas, 2013; Dichter et al., 2010; Nabi et al., 2006; DeTienne & Chandler, 2004; Lee & Wong, 2004; Peterman & Kennedy, 2003; Krueger et al., 2000; Udell, 1990; Smilor, 1987.
Innovation Management	Knowledge management, Technology management, Research & Development management, Technology transfer, Intellectual and industrial property rights	López-Rubio et al., 2025; Cubero et al., 2021; Estep et al., 2021; Soares & Torkomian, 2021; Yasar & Rejesus, 2020; Min et al., 2020; Strobel & Kratzer, 2017; Girard & Girard, 2015; Thorgren & Wincent, 2015; Doh & Zolnik, 2011; Unger et al., 2011; Elfring & Hulsink, 2003; Thursby & Thursby, 2002; Covin & Slevin, 1991.
Social Entrepreneurship and Sustainability	Sustainable entrepreneurship, Human resources management, Sustainability management, Effectiveness	Kamaludin et al., 2024; Trabskaia et al., 2023; Adro et al., 2022; Rosário et al., 2022; Cardella et al., 2021; Fonseca et al., 2020; Sung & Park, 2018; Dey, 2014; Dufays & Huybrechts, 2014; Schaltegger & Wagner, 2011; Nicholls, 2010; Hall et al., 2010; Schlange, 2009; Cohen & Winn, 2007; Mair & Martí, 2006; Thompson & Doherty, 2006; Seelos & Mair, 2005; Alvord et al., 2004.
Development and Employment	Management of organisations, Business development, Economic growth, Entrepreneurship policies	Silva Júnior et al., 2022; Gigauri, 2021; Iacobucci et al., 2021; Stefan et al., 2021; Deveci et al., 2020, Solano et al., 2020; Kiran & Bose, 2020; Faling et al., 2019; Koe, 2016; Bogren et al., 2013; Bosma, 2013; Liñán et al., 2011; Azam Roomi et al., 2009; Welter & Lasch, 2008; Audretsch, 2007; Sarri & Trihopoulou, 2005; Thurik & Wennekers, 2004.

3. METHODOLOGY

Science mapping, or bibliometric mapping, is an important area of bibliometric research that visualises intellectual connections within the constantly evolving landscape of scientific knowledge. VOSviewer, a bibliometric software tool developed by Nees Jan van Eck and Ludo Waltman at the Centre for Science and Technology Studies, Leiden University (2010), offers a user-friendly interface for constructing and analysing bibliometric maps (Cobo et al., 2011). Despite its capabilities, visually identifying the most significant themes in VOSviewer can be challenging.

Researchers utilised bibliometric and visualisation tools to explore trends in entrepreneurship and technology management across several studies. Rodriguez-Marin et al. (2022), analysed 2,154 documents on digital entrepreneurship trends (2001-2022) using VOSviewer and SCOPUS data. Yu et al. (2022), investigated strategic entrepreneurship evolution through 365 WoS publications (2001-2021). They employed both VOSviewer and CiteSpace tools for data processing. Similarly, Rosário et al. (2022), explored sustainability-focused entrepreneurship in SCOPUS, narrowing 80 relevant documents using VOSviewer. Furthermore, Gudanowska (2007) mapped current research trends in technology management based on SCOPUS publications (2011-2016).

This study presents the key findings of the WoS analysis conducted between 2010 and 2023 using the keyword “entrepreneurship”. The search, performed on May 24, 2023, retrieved a total of 22,877 publications classified as Article and Review Article in the SSCI, SCI-Expanded, and A&HCI indexes. To our knowledge, this study is exceptional in its broad scope and extensive examination of entrepreneurship, covering a substantial timeframe within the WoS database.

4. RESULTS AND DISCUSSION

This section presents comprehensive results, visuals, and tables from VOSviewer co-occurrence analysis. It offers an interpretation of the findings from an entrepreneurship perspective. The process of analysing articles and determining

cluster captions relies on the quality of the interpretation of results. This process is guided by the frequency, weight, and relationships of keywords within clusters. A detailed literature review helps authors identify core subject headings from the software-generated results.

The keywords used by the authors influence how the software groups entrepreneurship topics. To ensure semantic coherence, "Thesaurus Keywords" consolidate similar terms under unified expressions. The complete list of keywords combined in the thesaurus set is provided in the Appendix File. While VOSviewer generates clusters from the relevant keywords, the "Thesaurus Keywords" document and cluster naming were developed by the authors based on a comprehensive literature review.

4.1. VOSviewer Occurrence Analysis

In VOSviewer analysis, three key concepts are crucial: Links, Total link strength, and Occurrence. They provide insights into the relationships, strengths, and frequency of terms. Links represent the number of connections between items (e.g., authors or documents), while Total link strength measures the intensity of these connections, considering both the number of links and their weights (cumulative connection strength). Occurrences refer to how often a term appears in the dataset. In fractional counting, it represents the number of documents where the term appears at least once, while in full counting, it counts the total number of times the term appears across all documents. The key steps of the VOSviewer co-occurrence analysis are shown in Figure 2.



Figure 2. *Key steps of the VOSviewer co-occurrence analysis.*

In this study, bibliometric mapping is conducted using a co-occurrence analysis of VOSviewer with data from the WoS database. The author keywords is chosen as the unit of analysis while the counting method is set as full counting. To ensure

consistency, 42 similar keywords are examined. A total of 42 similar keywords are corrected, and some are merged. As a result of these corrections, the analysis is conducted with 36 keywords.

Similarly, in the section analyzing the relationship between entrepreneurship and mechanical engineering, a total of 159 keywords were corrected for spelling and synonymy, and some were merged. 117 different keywords fundamentally related to mechanical engineering, presented in the supplementary section, were accepted as "Mechanical Engineering". This section analyzes the topic of entrepreneurship with a total of 37 keywords.

For example, "business models" is consolidated into "business model". These keywords are inputted into the software through the "Thesaurus Keywords" file. The complete list of keywords combined in the thesaurus set used in the entrepreneurship occurrence analysis is provided in the appendix file. The threshold value for the minimum keyword occurrence is set to 50 to ensure consistency and relevant relationships among keywords within the clusters. Scenarios for Co-Occurrence Analysis are provided in the appendix file. Out of 37,165 keywords, 166 exceed this specified threshold. "Entrepreneurship" is excluded from the keyword selection as it serves as the search criterion for all articles. A network map is created using 165 words, excluding "entrepreneurship," which are provided in the scenarios section in the appendix file. Based on the analysis parameters of 42 thesaurus keywords and the requirement that a word occur at least 50 times (frequency), the map in Figure 3 is created with 165 words in this analysis.

The final output is presented in the form of a network map.

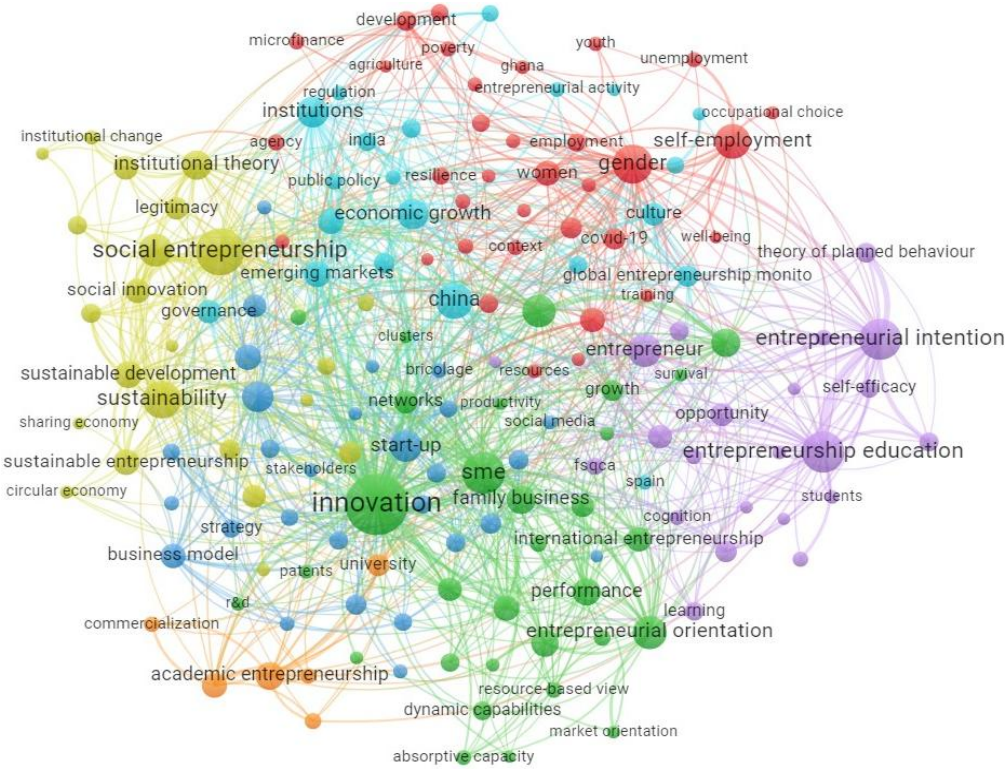


Figure 3. *Map of current research trends based on co-occurrence of the authors' keywords in entrepreneurship publications between 2010-2023.*

In VOSviewer analysis, items are represented by their labels, and by default, a circle is used in the network visualisation. The size of both the label and the circle reflects the item's weight. Items with higher weights have larger labels and circles. The colour of an item is determined by its cluster. Lines connecting items represent links. Larger nodes indicate higher occurrence while thicker lines signify stronger connections. Figure 3 shows the current research trends based on the co-occurrence of authors' keywords in entrepreneurship publications in the WoS database from 2010 to 2023.

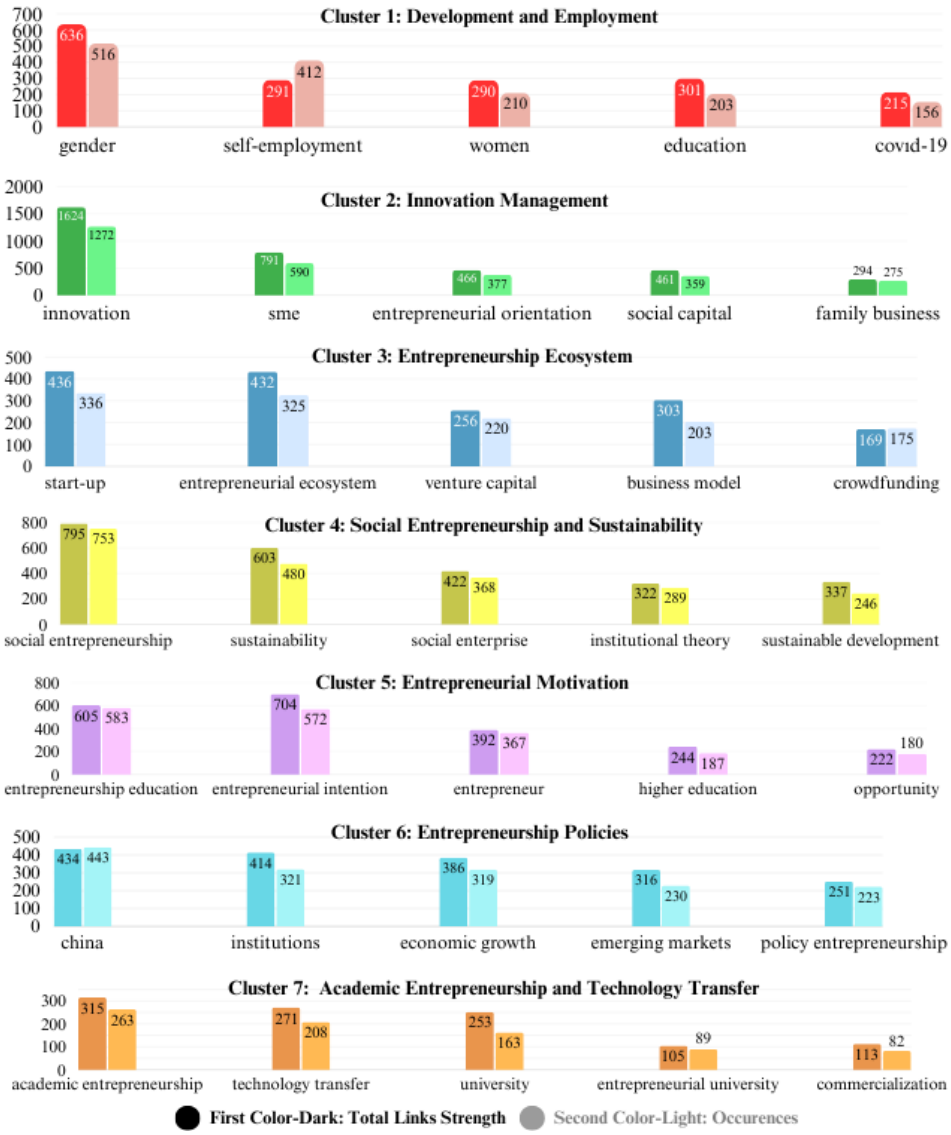


Figure 4. *Overview of all clusters based on occurrence values by the VOSviewer.*

Innovation, associated with cluster 2 (green), is a prominent keyword with 1,272 occurrences. Social entrepreneurship, which belongs to cluster 4 (yellow), shows significant relevance with 753 occurrences, underlining its importance within its

cluster. SME, part of cluster 2, appears 590 times, indicating its strong presence and connections within the cluster. Entrepreneurship education, found in cluster 5 (purple), is linked with 583 occurrences, highlighting its role in this specific context. Similarly, entrepreneurial intention, also within cluster 5, has 572 occurrences suggesting its significance in the cluster. Gender, a keyword in cluster 1 (red), exhibits 516 occurrences implying its relevance and connections within the cluster. Sustainability, associated with cluster 4 (yellow), demonstrates its importance with 480 occurrences. The top 5 keywords with the highest occurrences in each cluster are shown in Figure 4.

VOSviewer analyses relationships among papers to form clusters and visualises them as a network map with randomly assigned colours. Based on the literature review, the authors identified entrepreneurship-related captions for these clusters: (1) Development and Employment, (2) Innovation Management, (3) Entrepreneurship Ecosystem, (4) Social Entrepreneurship and Sustainability, (5) Entrepreneurial Motivation, (6) Entrepreneurship Policies, and (7) Academic Entrepreneurship and Technology Transfer.

The VOSviewer analysis is more comprehensive, covering all topics in the WoS database. Consequently, some differences in clustering between the literature review and the VOSviewer analysis results are expected. However, both approaches have identified closely related topics in common. Bibliometric studies aim to analyse and cluster large volumes of scientific literature, and experts agree that the four dimensions identified provide a generalized framework. In the VOSviewer analysis, a total of 165 author keywords were identified, excluding "entrepreneurship." Table 2 shows the total values for "Links," "Total Link Strength," and "Occurrences" for these clusters.

Table 2. *Occurrences and Total Link Strength by VOSviewer analysis in the field of entrepreneurship based on the WoS database.*

Clusters	**Keywords↓**	**Links**	**Total Link Strength**	**Occurrences**
Cluster-1: Development and Employment	34	1,916	4,452	3,781
Cluster-2: Innovation Management	31	2,233	7,768	5,973
Cluster-3: Entrepreneurship Ecosystem	28	1,906	4,607	3,424
Cluster-4: Social Entrepreneurship and Sustainability	23	1,554	4,918	4,240
Cluster-5: Entrepreneurial Motivation	22	1,358	4,156	3,398
Cluster-6: Entrepreneurship Policies	21	1,515	3,985	3,232
Cluster-7: Academic Entrepreneurship and Technology Transfer	6	382	1,162	887
Total	**165**	**10,864**	**31,048**	**24,935**

Cluster 2, labelled Innovation Management, includes 31 keywords and is the most interactive, with 2,233 Links, 7,768 Total Link Strength, and 5,973 Occurrences. Social Entrepreneurship and Sustainability (Cluster 4) is identified as the second most powerful cluster, establishing strong connections with other significant keywords with a total link strength of 4,918 and 4,240 occurrences. Despite the relatively low value of 1,554 for Links in this cluster, it has an important and interactive position in terms of total link strength. The following section discusses the top ten keywords of the clusters.

4.1.1. Cluster-1 Development and Employment

The first cluster includes terms related to the development and employment aspects of entrepreneurship. This cluster emphasises topics such as gender and women

entrepreneurship, self-employment, education, social networks, and COVID-19 impact and resilience. Entrepreneurship plays a crucial role in fostering employment, economic growth, and development. Within this cluster, gender is the most frequent keyword, with 516 occurrences, followed by self-employment at 412 occurrences. Gender and women's participation in entrepreneurship intersect with issues of gender equality and economic development. Women entrepreneurship promotes development by expanding the workforce, creating new businesses, and fostering gender equality. The outputs of the analysis highlight the potential of women entrepreneurship for both economic and social development. Therefore, entrepreneurship ecosystems need to develop strategies to support women entrepreneurs.

Self-employment, a form of entrepreneurship where individuals work for themselves, stimulates economic development by creating jobs, fostering innovation, and boosting local economies. Education plays a fundamental role in equipping individuals with entrepreneurial skills and training. Consequently, education policies and programmes are essential areas of focus for enhancing entrepreneurial potential. In this cluster, keywords such as **gender, self-employment, women, education and COVID-19** have the most notable occurrences and total link strengths. The full list of keywords belonging to the development and employment cluster is given in the appendix file.

Environmental factors such as COVID-19 have posed significant challenges to entrepreneurship, testing resilience and highlighting the need for research on crisis anticipation and prevention. These findings provide valuable insights for studies in the field of entrepreneurship and serve as a guide for policymakers aiming to improve entrepreneurial ecosystems. A better understanding of the complex relationship between entrepreneurship, employment and development is essential for fostering more sustainable and inclusive economic growth and social development.

4.1.2. Cluster-2 Innovation Management

The second cluster includes keywords related to innovation, one of the most tightly connected and popular nodes in the network. This cluster also explores other topics

such as SMEs, entrepreneurial orientation, social and human capital, family business, performance, corporate entrepreneurship and internationalisation. Innovation is the most remarkable keyword in this cluster with 1,272 occurrences, and it is followed by SMEs.

Innovation is a core driver of entrepreneurship, which provides the development of competitive products, services, or business models. It provides entrepreneurs with a competitive advantage to attract customers and investors, thus facilitating business growth. Innovative products and services not only enhance business performance but also lead to increased customer satisfaction and market positioning. Policies to improve innovation are crucial for economic growth and social progress.

SMEs are generally more innovative due to their flexibility and agile decision-making processes. SMEs, which actively search for new opportunities and embrace risks, encourage innovation through their entrepreneurial orientation. In this dynamic, social capital plays a pivotal role in generating innovative ideas by building strong relationships within their environment. Meanwhile, family businesses place a high value on innovation as a means of ensuring generational success, leveraging strong family ties and accumulated knowledge to maintain lasting competitiveness.

In this cluster, the keywords **innovation, SME, entrepreneurial orientation, social capital, and family business** have the most remarkable occurrences and total link strengths. The full list of keywords belonging to the innovation management cluster is given in the appendix file. Innovation, in particular, relies heavily on the human capital within businesses, where qualified, creative, and talented employees ensure effective management of innovation processes. In larger companies, corporate entrepreneurship enables them to adapt to change and respond quickly to market dynamics. Innovative ideas not only facilitate business expansion into international markets but also confer a competitive advantage in the global arena. Entrepreneurship-driven innovation plays a pivotal role in the success and sustainable growth of businesses. Embracing innovation allows businesses to seize new opportunities, adapt to change, and achieve sustainable growth.

4.1.3. Cluster-3 Entrepreneurship Ecosystem

The third cluster emphasises the interconnected components within the entrepreneurship ecosystem that contribute to the development of startup businesses. This cluster primarily focuses on topics such as venture capital, business models, crowdfunding, digital transformation, effectuation, uncertainty, and technological innovation. The entrepreneurship ecosystem encompasses a diverse array of stakeholders, which collaborate to nurture and support entrepreneurial ventures. Startups heavily rely on this ecosystem for support and resources to transform their business ideas into reality.

The two most frequent keywords in this cluster are startup and entrepreneurial ecosystem with total occurrences of 336 and 325, respectively. Facilitating access to diverse funding sources, from venture capital to crowdfunding, and providing education and training are essential for supporting the growth of startups and fostering an innovative culture.

Critical keywords related to this cluster include **startup, entrepreneurial ecosystem, venture capital, business model and crowdfunding**. The full list of keywords belonging to the entrepreneurship ecosystem cluster is given in the appendix file. Venture capital is an important funding source, driving growth and innovation for entrepreneurs and enabling the realization of new business ideas. Entrepreneurs must carefully design and adapt business models that deliver value to customers. A well-structured business model is essential for sustaining and scaling startups. Through crowdfunding, entrepreneurs can engage with a wide range of supporters and access new opportunities for financing their ventures.

Entrepreneurs leverage digital technologies to innovate and create digital-based business models, impacting the entire ecosystem. Strategic utilisation of digital technologies empowers entrepreneurs to gain competitive advantages and foster growth. The effectuation approach offers entrepreneurs the opportunity to cultivate effective decision-making capabilities during dynamic and uncertain conditions. Within the entrepreneurial ecosystem, knowledge-sharing and collaborative experiences are encouraged to help entrepreneurs. Key components such as

financing, collaboration, knowledge sharing and leadership development offer substantial, establishing a solid foundation for future success in the business realm.

4.1.4. Cluster-4 Social Entrepreneurship and Sustainability

The fourth cluster focuses on the intersection of entrepreneurship, social entrepreneurship, and sustainability. It covers topics such as social enterprise, social innovation, institutional theory, sustainable development, and sustainable entrepreneurship. The most frequent keyword, social entrepreneurship, has 753 occurrences, followed by sustainability with 480. Social entrepreneurship aims to create innovative solutions for social or environmental issues while developing sustainable business models for long-term societal well-being. This approach integrates entrepreneurial principles with a strong commitment to promoting social and environmental sustainability.

Unlike traditional entrepreneurship, which focuses on profit maximization, social entrepreneurship prioritises addressing societal or environmental concerns. Social innovation, closely related to social entrepreneurship, involves new ideas, products, or services to tackle social challenges and promote positive change. Key terms in this cluster include **social entrepreneurship, sustainability, social enterprise, institutional theory, and sustainable development**. The full list of keywords belonging to the social entrepreneurship and sustainability cluster is given in the appendix file.

Sustainability and sustainable entrepreneurship indicate that sustainability issues such as sustainable business models and environmental ethical responsibility are important within this cluster. The circular economy, which reduces waste and optimises resource use, is closely linked to sustainability and entrepreneurial innovation. Green entrepreneurship emphasises eco-friendly products and sustainable practices.

Institutional theory and institutional entrepreneurship examine how businesses operate within institutional frameworks and how they transform these frameworks. This cluster represents a critical area in the intersection of sustainability, social

impact, and institutional factors. Exploring these topics further is crucial for advancing sustainable business practices and enhancing efforts to generate social benefits. The insights gained from this cluster can inform both business and public policies.

4.1.5. Cluster-5 Entrepreneurial Motivation

The fifth cluster focuses on entrepreneurship education and the factors influencing entrepreneurial intention. It explores topics such as entrepreneurship education programmes, entrepreneurial intention, the role of higher education institutions, opportunities, creativity, the theory of planned behaviour, entrepreneurial self-efficacy, and motivation. The terms entrepreneurship education and entrepreneurial intention have the most remarkable occurrences and total link strengths. Entrepreneurship education equips individuals with the skills and knowledge to succeed in business, while entrepreneurial intention sparks the desire to become entrepreneurs. Entrepreneurship education is more prevalent with 583 occurrences, whereas entrepreneurship intention has greater links in the network with a value of 704. Entrepreneurship education, primarily offered by universities, private organisations, and institutes at the higher education level, is essential for encouraging entrepreneurial activity. It provides the specialised knowledge required for successful entrepreneurship. The widespread view is that entrepreneurship education contributes to improving entrepreneurial self-efficacy, which further increases entrepreneurial intention.

Entrepreneurial intention has a strong relationship with the theory of planned behaviour and entrepreneurial self-efficacy. Understanding how entrepreneurial intention is formed, has been a significant topic to pursue an entrepreneurial career. The theory of planned behaviour, a generic model of human behaviour, explores how the entrepreneurial environment influences perceptions of feasibility and the tendency to take action. Key concepts related to this discussion include **entrepreneurial education, entrepreneurial intention, higher education, opportunity and creativity**. The full list of keywords belonging to the entrepreneurial motivation cluster is given in the appendix file.

The entrepreneurship process includes changes in entrepreneurial attitudes, intentions, and behaviours over time. Demonstrating a certain level of entrepreneurial intention is the initial step towards becoming an entrepreneur, as entrepreneurship is an intentional and planned activity, This intention reliably predicts future entrepreneurial actions. Gaining insights into people's intentions toward entrepreneurship is crucial for supporting and fostering entrepreneurship, which ultimately contributes to economic growth.

4.1.6. Cluster-6 Entrepreneurship Policies

The sixth cluster represents keywords related to policy entrepreneurship and policy government. It emphasises topics such as China, institutions, economic growth, regional development, culture, global entrepreneurship monitoring and public policy. With 443 occurrences and a total of 434 links, China appears most frequently in this cluster. It has experienced substantial economic growth and has become one of the global hubs for entrepreneurship. It is followed by institutions to frame the importance of entrepreneurship enablers.

Institutions and governance are crucial in shaping policies that impact entrepreneurial activity and regional development. Institutions, such as government bodies, regulatory agencies, and legal systems, affect creating entrepreneurship-friendly environments. Conversely, ineffective or corrupt institutions reduce investor confidence and prevent entrepreneurs from growing while limiting access to capital. Emerging markets present unique opportunities and challenges for entrepreneurs.

Policy entrepreneurship, particularly associated with public policy, refers to the actions, behaviours, and characteristics of dynamic policy actors. These actors, often connected with governmental institutions, such as public administrators and politicians, play a key role in shaping environmental policies. By embracing inclusive strategies, these policy actors can cultivate a culture that fosters entrepreneurship, influencing policy formulation, combating corruption, and promoting policy entrepreneurship.

The top keywords in this cluster are **China, institutions, economic growth, emerging markets and policy entrepreneurship**. The full list of keywords belonging to the entrepreneurship policies cluster is given in the appendix file. By supporting entrepreneurship in less-developed regions, governments and organisations can reduce economic disparities, create job opportunities, and improve local economies. Entrepreneurship reflects a dynamic relationship that spans economic, cultural, institutional, and policy dimensions. Entrepreneurs, policymakers, and society collaborate to create an environment that nurtures innovation, drives economic growth, and addresses societal challenges. By better understanding and monitoring these relationships, regions and countries can better support the development of new ventures.

4.1.7. Cluster-7 Academic Entrepreneurship and Technology Transfer

The seventh cluster centres on academic entrepreneurship and technology transfer within universities. It explores the role of universities in entrepreneurial activities, the processes of technology transfer, the commercialisation of academic research, and the knowledge transfer between academia and industry. The most frequent keyword, academic entrepreneurship, has a total link of 315. It is then followed by technology transfer with a total of 208 occurrences.

Technoparks and incubation centres, established either within universities or independently, are important interfaces to encourage scientists to participate in the commercialisation of technologies. Innovative and R&D universities are increasingly investing in internal mechanisms and clear policies to enhance their technology transfer efforts, encouragement and support, aiming to reduce uncertainties, problems, and moral hazards associated with the process. The subject of **academic entrepreneurship**, an important and developing side of entrepreneurship, is the most important term. The term **technology transfer** represents the transfer of critical information, experience, know-how, findings and R&D outputs to another beneficiary for profit or collaboration purposes. University-industry cooperation can be considered an example in this context. The full list of

keywords belonging to the academic entrepreneurship and technology transfer cluster is given in the appendix file.

Sharing the knowledge of basic or applied sciences or institutional infrastructure of a university with business, industry and practitioners is of critical importance to produce an innovative R&D product or service. Entrepreneurial university describes a research institution that successfully engages in these activities by adopting an open innovation culture within the ecosystem. This includes managing intellectual and industrial property rights, facilitating knowledge transfer, and commercialising research outcomes.

4.2. VOSviewer Analysis of Entrepreneurship and Mechanical Engineering

Keywords related to Mechanical Engineering subfields have such low frequencies that they are not represented in the map. Therefore, a relationship map containing the keyword Mechanical engineering cannot be obtained in the main map in Section 4.1. A further analysis is conducted to investigate the link between entrepreneurship and mechanical engineering. Within the same period, "mechanical engineering" and "entrepreneurship" are selected as the primary keywords. As before, the analysis is performed with the minimum number of occurrences of 50. The complete list of thesaurus used in the analysis is provided in the appendix file. This means including all keywords identified in those papers. However, with a total of 37,165 keywords identified, creating a clear and visually interpretable relational map is presented.

The analysis revealed that the relationship between mechanical engineering and entrepreneurship has not been extensively explored in the existing literature. When the keywords mechanical engineering and entrepreneurship are used together in the article filtering in the Wos database, very few articles appear. This section supports that mechanical engineering being a core discipline with significant impact, its connection to entrepreneurship remains underexplored. This highlights a substantial gap in the research.

Mechanical engineering is a comprehensive engineering field that encompasses various fundamental disciplines. The concept of “mechanical engineering” does not

appear directly in Vosviewer analyses and visuals, but after the arrangements made by taking into account the sub-topics, it was determined that it has a significant relationship with entrepreneurship. The related keywords are combined under the concept of mechanical engineering and the map is redrawn. In subsections 4.1 and 4.2, two different network maps that support each other are obtained.

The keywords in the list are directly connected to **core sub-disciplines of mechanical engineering** such as thermodynamics, fluid mechanics, materials science, mechanical systems, automotive engineering, energy systems, automation, aerospace, manufacturing technologies, and manufacturing industry as well as listed in Appendix. These keywords reflect the industrial applications, educational dimensions, technological developments, and the significant role of mechanical engineering in sustainable energy transformation. When keywords related to the basic subheadings of mechanical engineering are brought together or merged, they are clearly visualized on the map as the "machine engineering" node. The relationships of this basic field with other prominent headings are also given on this map.

To better understand the interaction between these fields, clusters are formed based on the available keywords related to mechanical engineering as shown in Figure 5. This highlights the need for further research and attention in this crucial area, which could lead to valuable insights and innovations at the intersection of engineering and entrepreneurial practices.

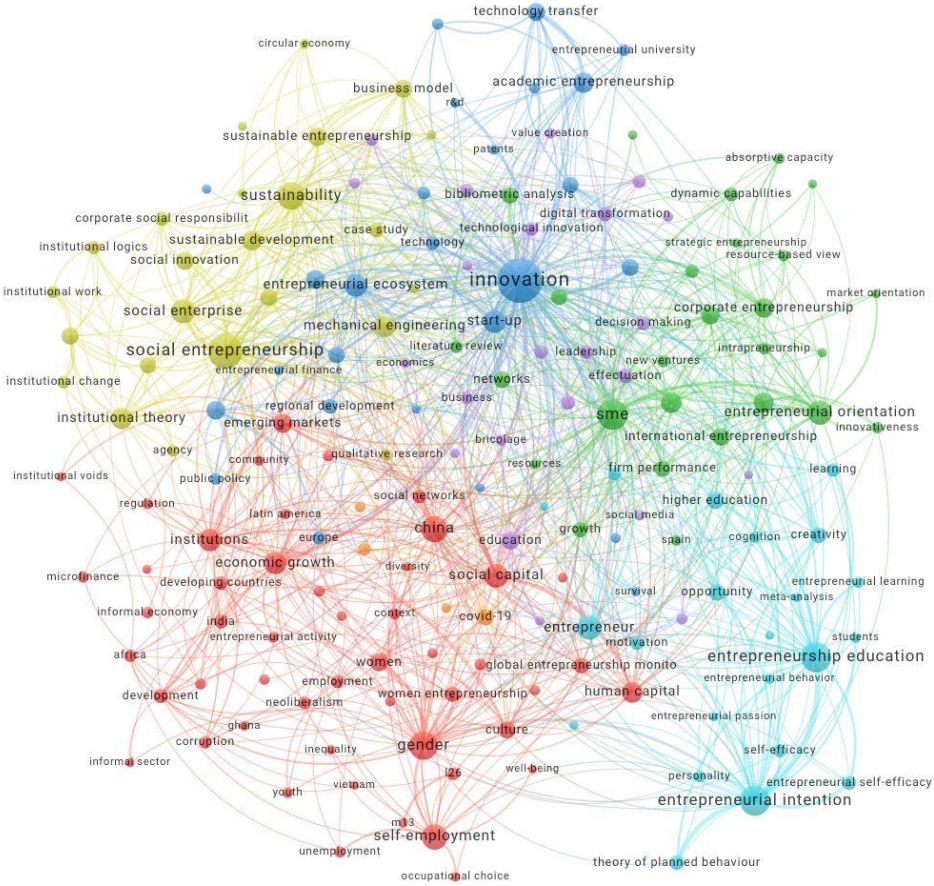


Figure 5. *VosViewer map of all fields and the relation with mechanical engineering discipline.*

Mechanical engineering is seen as an important node in the entrepreneurship ecosystem in Figure 6. This discipline acts as a catalyst in the development of innovative solutions and environmentally friendly technologies with its strong connections to technological innovation and sustainable development fields. Mechanical engineering's interaction with green entrepreneurship and innovative business models contributes to the spread of sustainable technologies. The relationships that the field of mechanical engineering has established with major economies such as China and India indicate that it plays a critical role in industrial

development, production and manufacturing processes in these countries and has a strategic importance. The connections of this field of science with the field of education reveal the role of engineering education curriculum in the development of entrepreneurial competencies and the importance of interdisciplinary approaches.

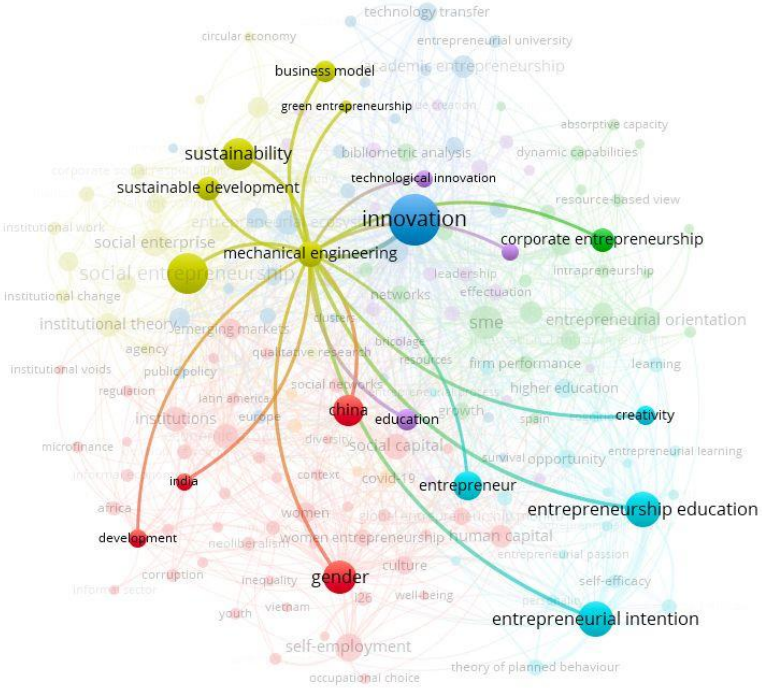


Figure 6. *VosViewer map of mechanical engineering and entrepreneurship.*

Mechanical engineering discipline has a strong relationship between innovation, social entrepreneurship, entrepreneurship education, sustainability, sustainable development and corporate entrepreneurship issues, this situation is demonstrated in Figure 6. This indicates that these machine-engineering concepts are directly related to the "core" topics in the literature. This observation highlights the need for further exploration into the relationship between mechanical engineering and entrepreneurship.

5. CONCLUSION

This study identifies trends in entrepreneurship research based on WoS papers indexed in SSCI, SCI-Expanded, and A&HCI. While scientific databases may present slight delays in capturing trends, they remain crucial for understanding the evaluation of research fields and ongoing scholarly discussions. This paper highlights entrepreneurship management as a rapidly evolving interdisciplinary field with significant research potential. This analysis helps researchers, especially those new to the field, to recognize well-explored areas and identify potential research niches with their scientific interests.

The study identifies several areas in entrepreneurship and incubation management that have the potential to become a leading research trend. Understanding current scientific discussions can inspire innovative visions in the field of entrepreneurship. Perception of issues in entrepreneurship and incubation management helps navigate the knowledge repositories within the discipline. Insights gained from this analysis benefit firms, entrepreneurs, and policymakers by enhancing their understanding and management of entrepreneurship.

The VOSViewer co-occurrence analysis of entrepreneurship research reveals seven clusters. Development and employment (Cluster-1) highlight the role of entrepreneurship in driving economic growth, job creation, and social progress, with a focus on women entrepreneurship and self-employment. Education is essential for equipping individuals with entrepreneurial skills, while resilience and preparedness are crucial for overcoming challenges like COVID-19. Innovation management (Cluster-2) addresses key aspects such as SMEs, social and human capital, and knowledge management, highlighting innovation's role in maintaining competitiveness and ensuring sustainable growth. Embracing innovation is vital for seizing opportunities, adapting to change, and achieving success in a competitive landscape.

Entrepreneurship ecosystem (Cluster-3) provides resources and support for transforming innovative ideas into successful businesses, with universities, governments, and the private sector playing key roles. Drivers like funding,

collaboration, and knowledge sharing are crucial for startup success, while digital transformation and open innovation further support growth. Social entrepreneurship and sustainability (Cluster-4) focus on addressing societal and environmental challenges through innovative solutions. Social entrepreneurs contribute to promoting sustainable social benefits. Sustainability serves as the cornerstone of socially and environmentally conscious entrepreneurship.

Entrepreneurial motivation (Cluster-5) centres around two fundamental principles: entrepreneurship education and entrepreneurial intention. Psychological theories and personality dimensions are considered to provide a systematic output, though the complexity of human behaviour makes establishing causality challenging. Entrepreneurship policies (Cluster-6) focuses on economic growth, policy entrepreneurship, and governance. Policy entrepreneurship addresses policy-related concerns and contributes to regional development. The Global Entrepreneurship Monitor provides valuable data for analysing the link between entrepreneurship and economic development. Academic entrepreneurship and technology transfer (Cluster-7) investigates the collaboration between universities and industry, focusing on R&D, patents, and knowledge transfer. Technology-oriented enterprises are expected to create an active university-industry ecosystem by implementing strategies to strengthen their relationship with academia. Technology transfer units and incubation centres play a key role in fostering university-industry cooperation and sharing innovative knowledge.

The analysis indicates that the connection between mechanical engineering and entrepreneurship is underrepresented in current academic literature, with few studies addressing both topics together. Despite mechanical engineering being a foundational and multidisciplinary field, its entrepreneurial aspects have not been sufficiently explored. Although the term “mechanical engineering” does not appear directly in Vosviewer analyses, reorganizing sub-topics’ keywords reveals a meaningful link to entrepreneurship. Network maps created from these keywords demonstrate strong connections between mechanical engineering subfields such as thermodynamics, mechanical systems, materials science, energy, engineering, automation and manufacturing.

This study reveals that incubators create a nurturing environment for startups by offering access to resources, training programmes, knowledge, networks, and capital. They enable entrepreneurs to develop holistically and gain a broad understanding of entrepreneurship. Furthermore, incubators help startups enhance their marketability and competencies while providing tools and support to foster growth and innovation.

There are some limitations and possibilities for future work. Only the WoS dataset is used in this study, which could be expanded by including other sources such as Scopus, Scholar, and PubMed. Future analyses could also explore entrepreneurship by combining different database search terms. Additionally, the use of "thesaurus keywords" (merged or synonymous terms) affects the results and mapping outcomes. The same methodology can be adapted to other engineering disciplines (such as industrial, electrical, civil, and environment engineering). In this case, only certain discipline-specific parameters and the keywords associated with each engineering field should be considered, allowing a similar analysis to be conducted for each research field. Therefore, the proposed approach is generalizable and provides a transferable model applicable to other engineering fields as well. Lastly, the study focuses on articles published between 2010 and 2023, which limits the scope to a period of heightened discussion around entrepreneurship.

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