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**TOWARD INNOVATION HUB EXCELLENCE: A
SCIENTIOMETRIC ANALYSIS OF SCIENCE TECHNO
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TOWARD INNOVATION HUB EXCELLENCE: A SCIENTOMETRIC ANALYSIS OF SCIENCE TECHNO PARKS WORLDWIDE (1982-2023)

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ABSTRACT

As part of the university's mission to drive innovation and economic development, the popularity of Science and Technology Parks (STPs) as a policy tool is rising. The synergy between innovative companies and universities is expected to facilitate knowledge exchange, fostering increased innovation. However, the evolution of STPs in diverse contexts and for different purposes has led to a fragmented research landscape, primarily consisting of case studies on individual parks across various disciplines. Drawing on 855 articles from the Scopus database since 1983, this study extracted and evaluated 552 research outcomes using the BibTeX method in the R studio software. Leading the list in terms of Aggregated Article Citations (AAC) are Spain (29.60), Georgia (23.8), China (11.40), and the USA (27.7). The research presents a comprehensive systematic literature review on STPs, shedding light on their evolving relationship with universities and encompassing new topics such as economic development, high-tech industries, innovation, science and technology, sustainable development, technological progress, and technology transfer.

ABSTRAK

Sebagai bagian dari misi perguruan tinggi untuk mendorong inovasi dan pengembangan ekonomi, popularitas Science and Technology Parks (STPs) sebagai alat kebijakan semakin meningkat. Keterpaduan antara perusahaan inovatif dan perguruan tinggi diharapkan dapat mendukung pertukaran pengetahuan, mendorong peningkatan inovasi. Namun, perkembangan STPs dalam konteks yang beragam dan untuk tujuan yang berbeda telah menghasilkan lanskap penelitian yang terfragmentasi, terutama melalui studi kasus pada STPs individual di berbagai disiplin ilmu. Berdasarkan 855 artikel dari database Scopus sejak tahun 1983, penelitian ini mengekstrak dan mengevaluasi 552 hasil penelitian dengan menggunakan metode BibTeX dalam perangkat lunak R studio. Hasil yang diperoleh dari rata-rata kutipan artikel yang terbit menunjukkan bahwa Spanyol (29,60), Georgia (23,8), Tiongkok (11,40), dan Amerika Serikat (27,7). Penelitian ini menyajikan tinjauan literatur sistematis yang komprehensif mengenai STPs, memberikan wawasan tentang hubungan mereka yang terus berkembang dengan perguruan tinggi, dan mencakup topik-topik baru seperti pengembangan ekonomi, industri teknologi tinggi, inovasi, ilmu dan teknologi, pembangunan berkelanjutan, kemajuan teknologi, dan transfer teknologi.

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INTRODUCTION

Science and technology parks are crucial in fostering technology transfer, facilitating knowledge exchange, and driving innovation. These parks act as collaborative hubs, bringing together scientific organizations and industry players (Peterková et al., 2022). Typically situated on university campuses, they offer companies not only physical spaces but also a framework of policies, programs, and services designed to enhance cooperation and support innovation activities (Abdirahman et al., 2020; Karpińska, 2020; Caloffi et al., 2023; Figueira et al., 2023).

The overarching goal of science and technology parks is to boost competitiveness and stimulate wealth creation, as highlighted by the International Association of Science Parks and Areas of Innovation (IASP, 2020). Often championed or endorsed by universities and other higher education institutions (HEIs), these parks serve as dynamic environments where knowledge is generated, shared among diverse organizations, and transferred to society (Świadek & Gorączkowska, 2020).

In this context, science and technology parks have emerged as critical components in the regional development strategies of many areas. Additionally, they play a significant role in the third mission activities of universities, referring to their involvement in social development and economic growth (Löfsten & Lindelöf, 2002). This underscores their pivotal contribution to advancing regional development goals and the broader societal and economic landscape.

Nevertheless, science and technology parks (STPs) have undergone diverse transformations, adapting to distinct contexts and serving varied purposes. Additionally, scholarly investigations into STPs have primarily taken the form of case studies focused on individual parks, leading to a dispersion of insights across different academic disciplines. This fragmentation poses challenges in comprehending the functioning and nature of STPs.

There is a crucial need to consolidate findings from a broad spectrum of individual studies to surmount these challenges. This integration becomes particularly vital for researchers delving into STPs as a phenomenon and seeking to understand their operational dynamics. Simultaneously, it holds significance for policymakers who view STPs as potential tools for innovation policy. Practitioners responsible for implementing these ideas also benefit from gaining a comprehensive overview of the current knowledge regarding STPs and their evolutionary trajectories.

In response to this gap in understanding, this paper aims to fill it by conducting a systematic literature review that synthesizes existing research on STPs and their interplay with universities. Through this comprehensive examination, we aim to contribute to a more unified and informed perspective on the role and evolution of science and technology parks.

The inception of science and technology parks (STPs) is traced back to notable examples such as the Stanford Research Park in the United States during the 1950s, Sophia Antipolis in France in the 1960s, and Tsukuba Science City in Japan in the 1970s (UN ESCAP, 2019). These pioneering initiatives set the stage for the widespread adoption of science parks globally. From a modest count of 25 STPs in the 1980s (UN ESCAP, 2019), the landscape has evolved



significantly, with an estimated 534 STPs worldwide in 2017 (UNESCO, 2018), predominantly concentrated in large economies.

The surge in the prevalence of science parks is mirrored in the research landscape. While early seminal works date back to the 1980s, such as Kee (1983) and Stuart & Abetti (1987), comprehensive scholarly exploration of the topic gained momentum much later. A noticeable shift occurred around 2002 when publications on STPs experienced a marked increase, reflecting a growing academic interest and recognition of the importance of these innovation hubs in shaping global technological landscapes.

In tandem with the proliferation of science and technology parks (STPs), these innovation hubs have become a focal point of research across various disciplines, including innovation management, industrial policy, and science and technology studies (Hobbs et al., 2017). The existing body of research endeavors to unravel the multifaceted roles of these spaces through diverse perspectives and disciplinary lenses. Scholars have delved into the analysis of STPs from angles such as public policy (Tonelli et al., 2015), management practices (Eveleens et al., 2017), the dynamics of university-industry collaboration (Zavale & Langa, 2018), risk management considerations (da Silva-Etges & Nogueira-Cortimiglia, 2019), and the intertwined aspects of firm and regional development (Lecluyse et al., 2019).

This extensive research landscape on STPs encompasses various topics, including their strategic frameworks, encountered barriers and limitations, geographical implications, experiential dimensions, and knowledge and technology transfer. Additionally, investigations have extended to explore the ripple effects of STPs on companies and their broader impact on regional and national economies. The comprehensive nature of this research provides a nuanced understanding of the intricate dynamics and implications associated with science and technology parks.

The diverse perspectives surrounding science and technology parks (STPs) have contributed to a rich tapestry of knowledge. However, this diversity has also resulted in a fragmentation of insights across different academic discussions. This paper seeks to bridge these gaps by undertaking a systematic literature review integrating varied panels across disciplines. The primary focus is on examining the relationship between STPs and universities.

Specifically, we aim to trace the evolution of research on this relationship, considering shifts in the understanding of the third mission of universities and the innovation process. Going beyond previous literature reviews, such as those by Hobbs et al. (2017), we extend our analysis to delve into the contents of publications. The objectives are twofold: firstly, to consolidate existing research on the intricate interplay between STPs and universities, including Higher Education Institutions (HEIs), and secondly, to synthesise knowledge, identifying key trends within publications about this relationship. To achieve these objectives, we examine the entire spectrum of publications concerning STPs and universities, complemented by a detailed content analysis of the published material. This rigorous approach aims to provide a holistic and nuanced understanding of the multifaceted dynamics inherent in the relationship between science and technology parks and academic institutions.

Through an in-depth analysis of the evolving landscape of research on Science and Technology



Parks (STPs) and by elucidating the current state-of-the-art, our study makes a meaningful contribution to the broader research domain encompassing firm innovation activities and the role of universities therein. By shedding light on the intricate dynamics between STPs, firms, and universities, our work advances academic knowledge and offers valuable insights for policy-makers and practitioners. This includes stakeholders such as STP managers, university liaison offices, and firms within STPs. The study aims to inform strategic decision-making by providing a comprehensive understanding of the evolving relationships within these innovation ecosystems, thereby facilitating innovation and knowledge transfer effectively.

The existing body of literature on Science and Technology Parks (STPs) reveals a notable fragmentation across several dimensions. Publications are dispersed across a diverse array of journals spanning various disciplines, with only a handful of journals featuring more than ten papers on the subject. The development of this literature has predominantly relied on case studies of individual STPs, with limited efforts toward large-N or comparative research that could systematically organize knowledge across diverse contexts.

Notably, the research has primarily aimed at providing decision-making support, emphasizing a management and technology-transfer perspective. However, crucial spatial and geographical viewpoints are notably underrepresented given the significance of co-location in the STP concept. At the same time, the geographical scope of the literature has expanded over time, with a substantial focus on East Asia, particularly China and Taiwan, which is indicative of the popularity of STPs as a policy tool in that region.

Furthermore, the evolving literature has witnessed a broadening understanding of STPs. Initially rooted in a concept influenced by cluster policy, with a primary focus on high-technology firms and industries, the contemporary perspective on STPs is increasingly shaped by the principles of open innovation. This shift reflects a more comprehensive and dynamic understanding of the role and nature of STPs in fostering innovation and collaboration.

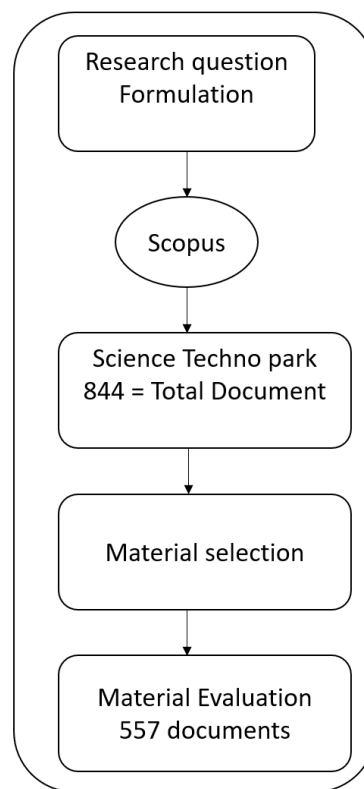
The present study has identified key areas of focus for future research on Science and Technology Parks (STPs). These areas encompass authors, geographic distribution, research outputs, prominent keywords, global citation trends, and emerging topics within the field. The study's findings offer a comprehensive perspective on the existing knowledge base related to STPs and underscore their significance in addressing scientific and technological challenges. This research not only sheds light on current gaps in knowledge but also serves as a guide for future investigations. By exploring the scholarly publications on STPs, this study aims to facilitate the identification of potential research avenues, promote further exploration, and recommend future research prospects in the dynamic landscape of Science and Technology Parks.

METHOD

This study adopts a systematic literature review approach, as defined by Kitcharoen (2004), aimed at systematically identifying, evaluating, and interpreting all pertinent research related to a specific phenomenon of interest. Following the reproducible process delineated by Denyer and Tranfield (2009), this method integrates both quantitative and qualitative aspects,

encompassing a descriptive and content study. The present investigation meticulously assessed all gathered data from the designated data repositories, namely Scopus and Web of Science (WOS), utilising RStudio version 127.0.0.1:5645 software with the bibliometric R-package for scientometric analyses. After importing the data into RStudio, a refined bibliographic data format was implemented to eliminate duplicates originating from both archives. The schematic representation of the data retrieval and analysis process is elucidated in Figure 1. A meticulous approach was employed to circumvent redundancy in peer-reviewed articles extracted from the two archives, restricting replicated papers to a single record for analysis. Notably, the study ensured the removal of author names, author's keywords (DE), and keywords plus (ID) for a more transparent comprehension of the knowledge stratification within the specific research domain of science and technology parks.

Fig. 1 Methodological scheme



RESULTS AND DISCUSSIONS

The guiding inquiries employed in this study are articulated as follows: 844 results from Scopus Core Collection (TITLE-ABS-KEY ("science park technopark" OR "technopark" OR "technology park") AND ALL ("innovation" OR "technology transfer" OR "incubator" OR "research and development" OR "startups" OR "entrepreneurship" OR "industrial development" OR "knowledge-based economy")).

The present research encompasses a comprehensive analysis of 552 documented research studies from 1983 to 2023, as detailed in Table 1. The examination during this timeframe



yielded 1,311 contributing authors, with 135 instances of single-author contributions. Notably, international co-authorships were observed in 17.03% of the articles, translating to an average of 2.7 authors per research output. Additionally, an average of 12.22 citations per article was documented throughout this study.

Table 1. Essential details regarding the collected published documents on science and technology parks sourced from Scopus databases

Description	Results
MAIN INFORMATION ABOUT DATA	
Timespan	1983:2023
Sources (Journals, Books, etc)	362
Documents	552
Annual Growth Rate %	8.09
Document Average Age	7.78
Average citations per doc	12.22
References	0
DOCUMENT CONTENTS	
Keywords Plus (ID)	1420
Author's Keywords (DE)	1661
AUTHORS	
Authors	1311
Authors of single-authored docs	123
AUTHORS COLLABORATION	
Single-authored docs	135
Co-Authors per Doc	2.7
International co-authorships %	17.03
DOCUMENT TYPES	
article	513
article article	4
article editorial	1
conference paper	3
editorial	2
erratum	2
note	2
review	24
short survey	1

As illustrated in Fig. 2, the findings reveal a discernible trend in research publications related to science and technology parks. Notably, there was a relatively modest output of research publications in the overall period spanning from 1983 to 2023. However, a noteworthy shift occurred after 2003, signifying an increasing interest and substantial momentum in research studies on science and technology parks. This trend experienced a steady upward trajectory, culminating in a surge until 2018. By 2023, the cumulative count surpassed 513 articles, underscoring the growing significance and attention directed toward this subject matter (Fig. 2).

Fig. 2 Annual scientific research outputs (from 1983 to 2023) on science park park technopark

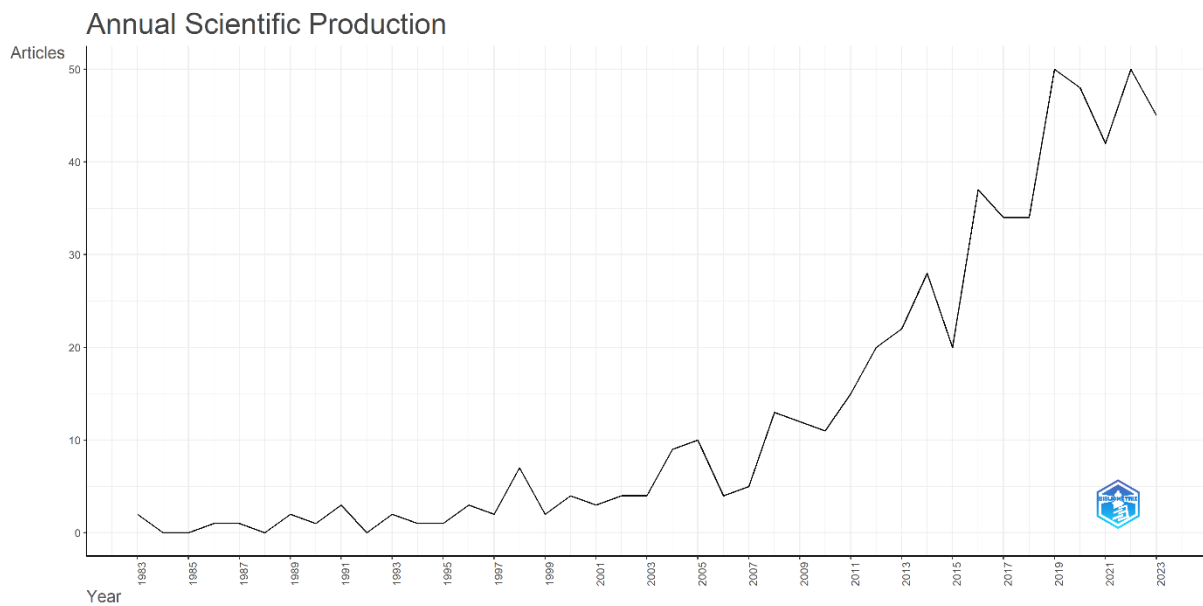


Table 2 presents the outcomes of the average article citations (AAC) for countries with the most frequently cited research outputs in science and technology park research. Leading the list in terms of AAC are Spain (29.60), Georgia (23.8), China (11.40), and the USA (27.7).

Table 2 The leading 20 nations with the highest average article citations (AAC) in science and technology parks from 1983 to 2023.

s/n	Country	Total citations	Average Article Citations
1	SPAIN	1273	29.60
2	GEORGIA	476	238.00
3	CHINA	469	11.40
4	USA	360	27.70
5	UNITED KINGDOM	354	20.80
6	ITALY	311	28.30
7	TURKEY	252	25.20
8	BRAZIL	243	7.40
9	IRAN	237	7.00
10	CANADA	236	59.00
11	POLAND	109	7.80
12	KOREA	105	10.50
13	SINGAPORE	103	51.50
14	MALAYSIA	97	16.20
15	AUSTRALIA	85	10.60
16	GERMANY	69	9.90
17	PORTUGAL	65	21.70
18	CHILE	58	14.50

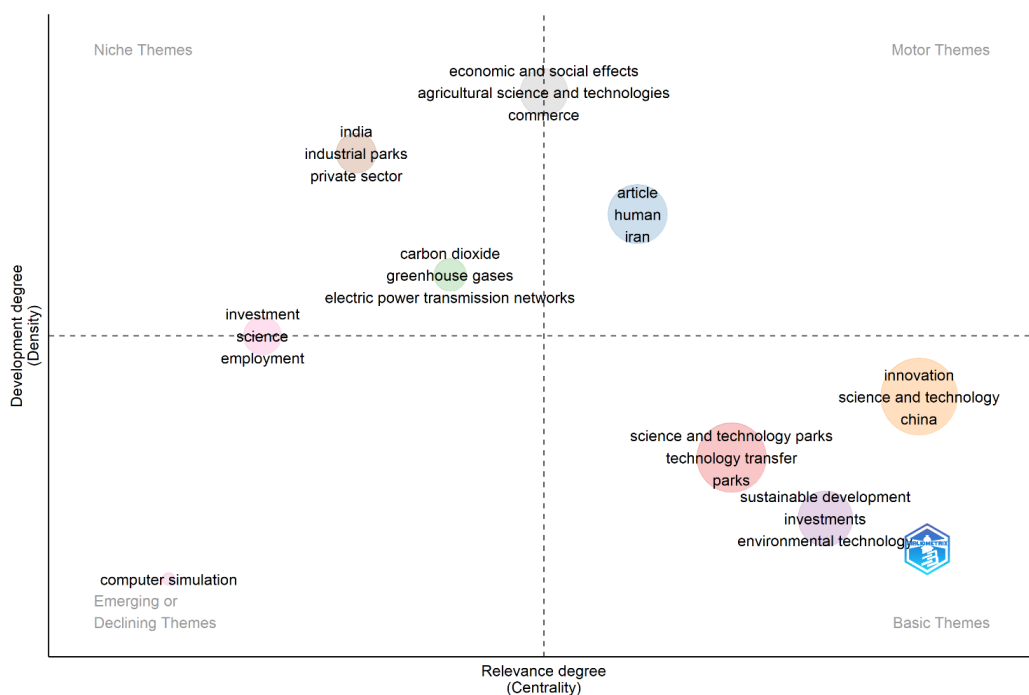
s/n	Country	Total citations	Average Article Citations
19	SWEDEN	53	26.50
20	JAPAN	48	24.00

Keyword analysis

Thematic map

The thematic map is a self-explanatory graphic representation, employing quadrant analysis to evaluate the study's subject matter. Thematic maps, as discussed by Cobo et al. (2011), offer a method to estimate and visually represent a specific research branch. The X-axis of the thematic map denotes the centrality, while the Y-axis indicates density. Centrality gauges the importance of the central theme, and density measures the development of the chosen theme. Thematic maps are divided into four quadrants, each conveying distinct insights. In the context of this map, numerous studies are observed in science and technology parks. Following the classification by Cobo, Lopez Herrera, Herrera-Viedma, and Herrera (2011), the upper right and left quadrants signify highly specialised themes, while the lower right and left quadrants denote underlying and emerging themes, respectively. This intuitive plotting allows for the analysis of themes based on their quadrant placement: (1) the upper right quadrant signifies a motor theme; (2) the lower right quadrant indicates a primary theme; (3) the lower left quadrant represents themes that surface or fade away; and (4) upper left quadrant signifies specific particular/niche theme.

Fig. 3. Thematic Map-based Keyword Plus



The outcomes derived from the R-bibliometric thematic map, utilising both keywords plus and author keywords, are visually represented in Figure 3. The identified themes central to the investigation of science and technology parks encompass innovation science technology, sustainable development investment, environmental technology, and technology transfer. Future research in science and technology parks will focus on motor themes such as computer simulation, investment science, and employment. A distinctive and niche piece uncovered in the study of science and technology park actors pertains to carbon dioxide, greenhouse gases, and electric power transmission networks.

Word Cloud

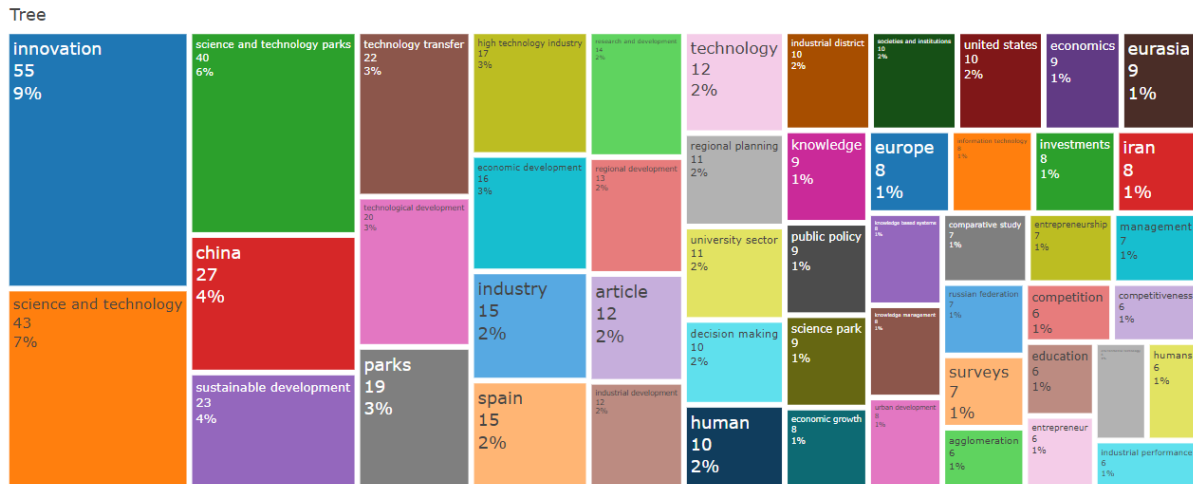
Figure 5 and Figure 6 shows figure 6 show the word cloud and treemap selected based on the plus keyword. Innovation, science and technology parks, and sustainable development are most often used in the literature for science technopark. Mapping shows that the highest frequency is science and technology and gardens, which are the main study in this article. Innovation is a keyword used mainly in the study of science techno park technopark.

Fig 4 Word cloud of a science park technopark



Treemap

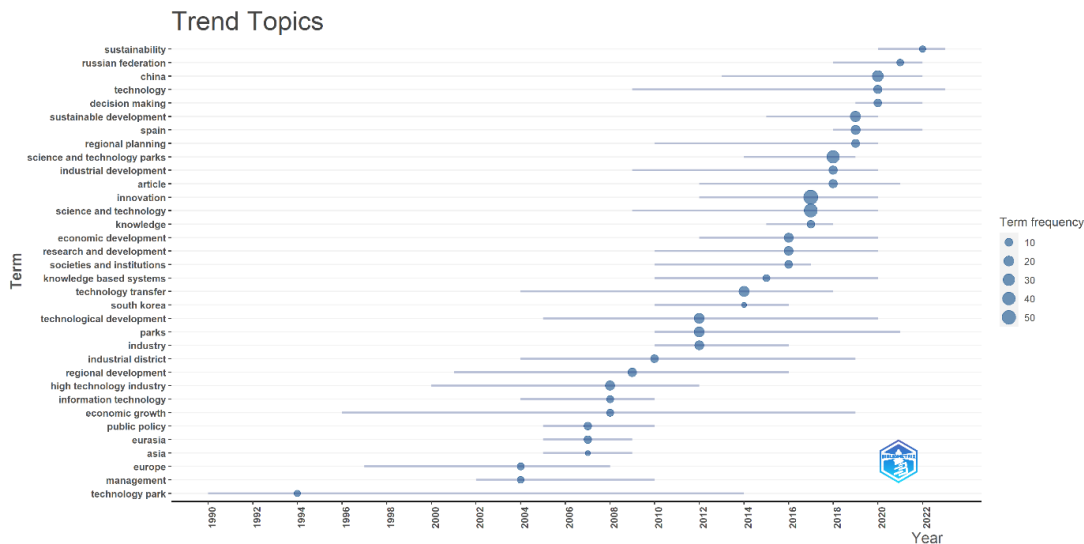
Fig. 5 Treemap of Science Technopark Science Techno Park



Trend Topics

From 1983 to 2023, an extensive examination of science and technology parks has unfolded. Vital: The thematic trend has consistently explored critical aspects such as sustainability, technology, and knowledge transfer, as depicted in Figure 6. These four interrelated topics—science and technology park dynamics, sustainability, technology advancements, and knowledge transfer—are anticipated to persist as focal points in future research, demonstrating their enduring global relevance within the science and technology park domain.

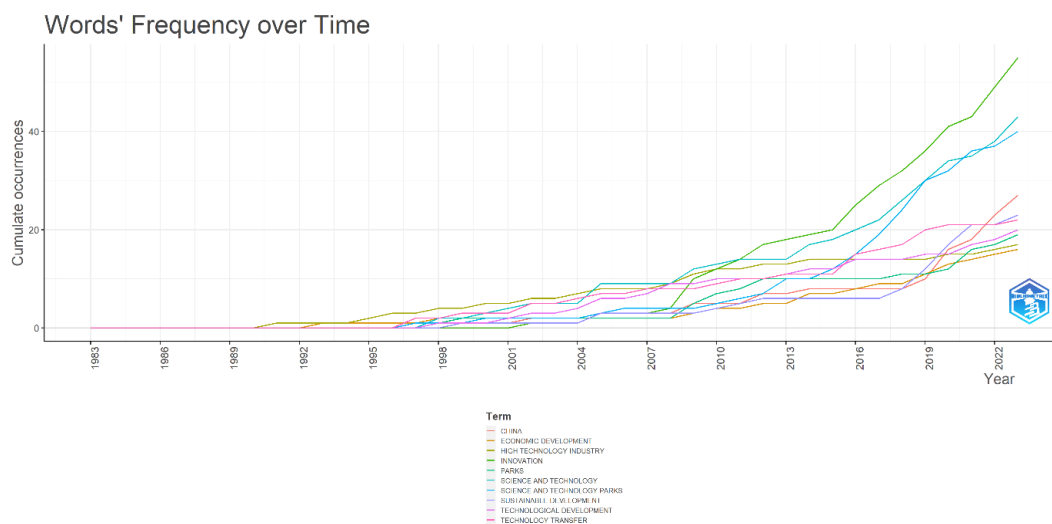
Fig. 6 Trend Topics of Science Techno Park



Illustrated in Figure 7 is the evolution of terminology since 1983, a period marked by significant strides in information technology. Science and technology parks emerge as a focal point in academic investigations within university development, particularly in enhancing institutional

performance. The word treemap visually underscores potential keyword combinations indicative of pivotal themes, including economic development, high-technology industry, innovation, science and technology, science and technology parks, sustainable development, technology advancements, and technology transfer. This portrayal encapsulates the dynamic landscape of research keywords associated with the multifaceted dimensions of science and technology parks.

Fig. 7 Words frequency over time of science Technopark



CONCLUSION

Aligned with the mission of universities to foster innovation and economic development, Science and Technology Parks (STPs) have emerged as a prominent policy tool across various countries and regions. Rooted in the principles of co-location for enhanced collaboration and knowledge exchange, STPs draw inspiration from established concepts in innovation policy, such as clusters, industrial districts, and regional innovation systems. The underlying premise is that the proximity of innovative firms and universities fosters valuable knowledge spillovers and facilitates the practical application of university research within the industry. Notably, the conceptualisation of STPs, like many aspects of cluster policy, has been influenced, in part, by the pioneering model of Silicon Valley, notably the Stanford Research Park, founded in 1951.

Our analysis discerns three distinctive phases in the Science and Technology Parks (STPs) literature. Commencing with an initial phase centring on the early instances of STPs, the literature gained momentum notably from 1983 onwards. The first phase witnessed a geographical expansion from 1983 to 2023, wherein studies on parks transcended boundaries and delved into diverse contexts. This expansion notably encompassed developing and emerging economies, with a pronounced focus on Europe and Asia. Reflective of the widespread adoption of STPs as a policy tool, particularly in East Asian nations and prominently in Spain, Georgia, and China, over half of the publications exploring the relationship between STPs and universities empirically concentrate on Europe and Asia. Notably, Spain accounts for nearly 30% of the average citations in articles on this topic, underlining its significant presence in the discourse.



For the future trajectory of this scholarly domain, we advocate for contributions incorporating empirical data from diverse parks through comparative studies. An intriguing yet unexplored avenue lies in investigating whether the evolutionary path of science and technology parks (STPs) mirrors the literature's progression. Given the prevailing emphasis on case studies in the literature, it is plausible to hypothesise that the development in scholarly discourse aligns with the geographical expansion and varied policy applications of STPs. However, the validation of this hypothesis necessitates further empirical investigation. Moreover, we encourage scholarly works that transcend prescriptive advice for decision-makers, aiming to unravel the intricacies of how and why STPs operate, elucidating their connections to overarching concepts of innovation, economic development, and the third mission of universities. Despite the alluring portrayal of STPs as innovative policy tools, a discerning analysis of the literature underscores its inclination to follow trends in the broader innovation discourse rather than engendering transformative insights into the mechanisms of the innovation process and the nuanced roles that universities can assume.

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