Article

INDUSTRY & Higher Education

Industry and Higher Education
2025, Vol. 0(0) 1–21


Article reuse guidelines:
sagepub.com/journals-permissions
DOI: 10.1177/09504222251370090
journals.sagepub.com/home/ihe
Sage

From transfer to co-creation: Charting the prospects for university-industry cooperation

Telmo N Santos[1,2], José G Dias[1] and Sandro Mendonça[1,3,4,*]

Abstract

This study documents the evolution of university-industry cooperation (UIC) intermediaries and identifies implications for management and policy. By applying topic modelling to around 150 research papers on the dynamics of UIC intermediaries, it finds a transition from a linear perspective of university-industry technology transfer to more systemic relationships based on co-creation. This work also sheds light on themes previously hidden in the literature that have implications for practice and policy The findings highlight the leadership role of intermediaries, emphasising proactive stakeholder engagement as central to effective university-industry cooperation. It also underlines the importance of intermediaries in actively connecting university and industry and anticipating trends.

Keywords

university-industry cooperation, intermediaries, co-creation

Introduction

Many governments and international organisations have recognised the value of universities[1] and university-industry cooperation (UIC) in promoting economic development (Rossoni et al., 2023; WIPO 2017; Ćudić et al., 2022). This realisation is that effective cooperation between universities and industry is an important growth factor for exploiting the knowledge economy (Rossoni et al., 2023; Ćudić et al., 2022) and digital and green transitions (Austin et al., 2021; Hens et al., 2017; Ziedonis et al., 2020). Scientific evidence adds that UIC is a source of new ideas and a way to reduce company risk (De Fuentes and Dutrénit 2012; Villani 2013). At the same time, it also funds universities (Algieri et al., 2013). In this environment, links between universities and industry have grown (Bastos et al., 2021; Li et al., 2024) and the innovation systems in which they are has become denser and "wired up". This strengthens university-industry connections and knowledge can flow more freely among them (Martin and Johnston 1999). However, these connections face several challenges (Nasirov and Joshi 2023), and intermediaries serve to overcome them (Good et al., 2019).

Current studies of UIC intermediates from a range of theoretical approaches. The "channel theory" look at UIC as informal or formal. UIC can also be either explicit or implicit. An alternative perspective known as "entrepreneurial university" recognises the significance of institutional and academic governance for UIC. According to a third perspective, demand-led models for UIC can be created through national, regional, and local UIC intermediary structures, in which industry partners work together in university-industry networks to facilitate the industrial articulation of the particular knowledge they are seeking (Albats et al., 2022). Following Santos et al. (2023: p. 457), we define UIC "as the interchange between higher education research systems and all parts of the productive economy to build common interests and pursue mutual benefits".

Intermediaries are another factor that influences the success of UIC and facilitates its emergence. Universities are currently promoting collaborations with industry through various intermediaries (Villani et al., 2017). Intermediaries act as boundary organisations in the university-industry hybrid area by building relationships, facilitating communication and cooperation, and preventing

[1]Business Research Unit (BRU-IUL), Instituto Universitário de Lisboa (ISCTE-IUL), Lisboa, Portugal
[2]CCG/ZGDV Institute, Campus Azurém, Guimarães, Portugal
[3]UECE-REM, ISEG/University of Lisbon, Lisbon, Portugal
[4]SPRU, University of Sussex, Brighton, UK

*Current affiliation: Faculty of Business, City University of Macau, Macau

Corresponding author:
Telmo N Santos, CCG/ZGDV Institute, Campus Azurém, Guimarães, Portugal.
Email: telmo.santos@ccg.pt

disagreements and misunderstandings between universities and industry (Villani et al., 2017), with an importance that is becoming increasingly clear (Kim et al., 2019). Following Santos et al. (2023), we define UIC intermediaries as "individuals or organisations that facilitate the exchange of (scientific and technological) knowledge between universities and industry by creating two-way value-added relationships. These intermediaries are understood to be positioned halfway between the knowledge producers and users, even if they are a part of the university or the industry (Santos et al., 2023: p. 457).

This paper aims to provide new information on the UIC in the context of innovation systems and on UIC intermediaries in these innovation systems, particularly in fostering productive relationships between two key actors: universities and industry (Edquist 2006). The research question to be addressed here is: "How has the positioning of UIC intermediaries shifted as UIC links became denser?". Positioning, in this case, refers to how organizations are presented to and understood by stakeholders (see e.g., Henry 2021). This paper extends the literature by systematically identifying hidden dynamics of UIC intermediaries through topic modelling and, revealing a transition from linear transfer models to co-creative systemic models, with direct implications for strategic management and policy. As a result of this work, we compiled the existing understanding of UIC intermediaries and identified eight topics. This work finds evidence of a shift from a linear to a non-linear/systemic approach to the UIC, and key findings highlight the importance of strategic management of UIC intermediaries, where leadership and stakeholder engagement are crucial.

The literature examining UIC from a non-linear perspective has evolved recently (Mathisen and Jørgensen 2021; Rossi et al., 2017). De Silva et al. (2023) argue that UIC requires advanced and up-to-date knowledge from universities and market/industry companies to jointly address specific challenges and solve problems (De Silva et al., 2023). Various authors argue that unidirectional, linear transfers of academic knowledge to companies, often observed in the creation of spin-offs and intellectual property (IP) licensing, and non-linear, bilateral transfers involving co-creation (Caraça et al., 2009; De Silva et al., 2023; Rossi et al., 2017). This non-linear perspective requires a deeper understanding to identify the specific context in which UIC intermediaries are located (Mathisen and Jørgensen 2021; Neal et al., 2023; Rossi et al., 2017). We also need a more comprehensive understanding of the strategies by which UIC intermediaries operate (Neal et al., 2023).

The non-linear view of UIC is consistent with the innovation systems framework, which views the innovation process as complex with a multitude of components, including organisations and institutions and the relationships between them (Edquist 2006). The non-linear view of UIC is coherent with the coexistence of the scientific and technology-based innovation (STI) modes and learning-by-doing-using-interacting (DUI) innovation modes (Parrilli and Heras 2016). It is also aligned with a delicate combination of hard and soft innovations (non-technological strategies) (Costa and Mendonça 2019; Mendonça 2014). A non-linear perspective emphasises the importance of DUI and soft innovations as complements to "hard" technologies. To gain new clarity on the nature of UIC dynamics, this study uses a methodology that, to our knowledge, has not yet been fully implemented (see Ferguson-Cradler 2023). We discuss the evolution of the UIC debate, taking advantage of the opportunities presented by the availability of digital content and recent advances in powerful computational methods. Probabilistic topic modelling algorithms that can automatically infer text structure have emerged as a promising and viable approach for analysing large collections of documents. Following an "exciting new trend" (Abramitzky 2015: p. 1248), text mining and topic modelling are used to transform qualitative know-how into quantitative information, enabling the exploration of large corpora. We first use bibliometrics to identify the boundaries of documents that address UIC from an academic perspective. However, unlike bibliometrics, we further transform corpora content into metric data that is amenable to further interpretation.

There are still several gaps and limitations in the current UIC literature, which are addressed in this paper. Despite the rise of UIC as a research theme, a clearer and more integrated approach to examine UIC as a co-creative process is needed to advance the field, and there is a lack of a unified theoretical frame and empirical analyses of infrastructure co-creation success factors. What organizational, cultural and technological factors are most important (or interact) in promoting effective UIC co-creation? In general, there is a lack of understanding of the specific context in which UIC intermediaries find themselves and the trends that influence them. The next section describes the methodology, followed by a discussion of the findings. Finally, we discuss the implications of this study.

Research methodology

The current study employs a text-mining approach using topic modelling (Latent Dirichlet Allocation) focused on extracting meaningful information from unstructured text. The data collection followed the PRISMA protocol.

Data collection

A two-phase approach was adopted to identify articles that addressed UIC intermediaries. In the first phase, relevant keywords were identified from the literature and used in a Boolean search to find articles that were specific enough to be helpful but prevented the inclusion of irrelevant publications. We used the keywords "university-industry" and "intermediar*" to search for articles and reviews written in

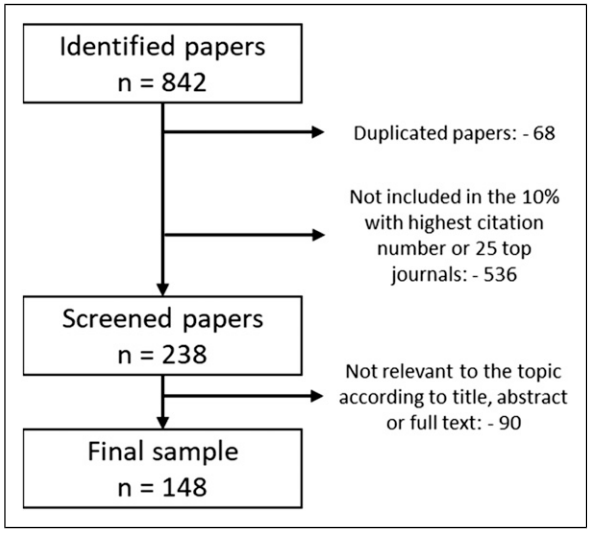

Figure 1. Selection of relevant papers—process depiction.

English on specific categories of topics such as social sciences, humanities, economics, and business studies, using the SciVerse Scopus database. This search yielded a total of 31 articles, each of which was subjected to an in-depth analysis.

Any word or expression related to UIC intermediaries or equivalent was recorded. In the second phase of the search, these keywords were combined as descriptors in several Boolean searches by title, abstract, and keywords, in a total of 29 search strings. This phase of the search was carried out in August 2023 also using the SciVerse Scopus database. After controlling for duplicates, a total of 774 papers (excluding duplicates) were extracted (Figure 1). To ensure the quality and relevance of the results, we adopted methods that have already been proven in previous studies (Chen et al., 2016; Good et al., 2019; Ratinho et al., 2020). In short, to ensure thematic focus, the final set of articles should be either (1) published in the top 25 journals on technology transfer (Bengoa et al., 2021) or (2) restricted to those in the top 10% of the total corpus of retrieved papers based on SciVerse Scopus citation count. After excluding 536 papers, we examined the titles and abstracts of 238 articles. In case of ambiguities, the full text was analysed, and 90 papers were further excluded because the framework or analysis was not related to this research topic. For example, papers that analysed innovation intermediaries but not specifically UIC intermediaries were also excluded. Our final sample consisted of 148 published papers.

Figure 2 shows the distribution of the 148 papers by year of publication from 1982 to 2022 (2023 is not included due to incomplete data). Over time, the number of publications tended to increase. This trend continued into this century, peaking in 2021 with 10 publications. The usual bibliometric approach is sufficient to count papers and describe their characteristics.

Topic modelling

Topic modelling, a special form of text mining, identifies recurring themes from texts (Schmiedel et al., 2018). Topic models have been used in the field of science & technology policy design and monitoring (e.g., Bonaccorsi et al., 2021; Vázquez et al., 2022), but also in the curiosity-driven humanities and business sciences (e.g., Corbet et al., 2019; Ferguson-Cradler 2023; Gillings and Hardie 2023). This paper applies this computer-assisted/digital-humanities paradigm to offer a new perspective on trends latent in textual sources. We draw inspiration from computational innovation studies applications (see Hecking and Leydesdorff 2019; Santos and Mendonça 2022) and

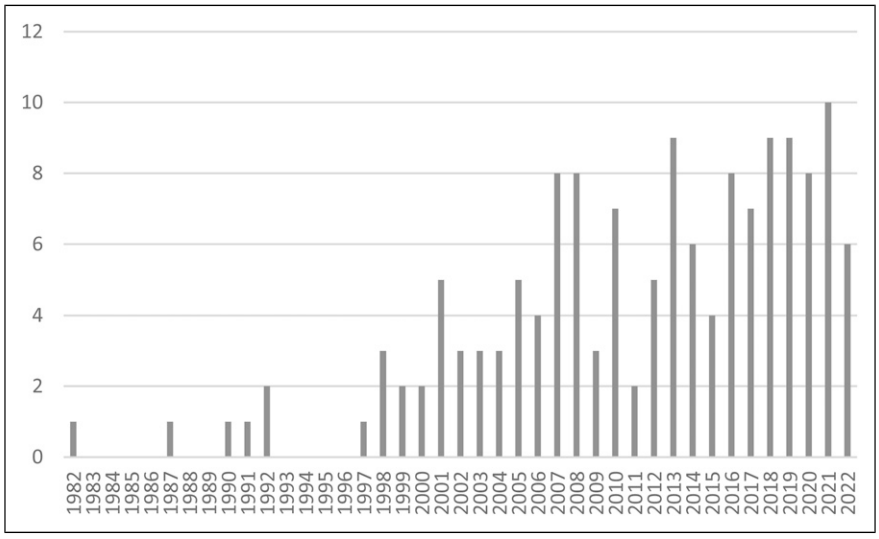

Figure 2. Distribution of the articles per year.

computational economic historiography (see Ballandonne and Cersosimo 2023; Wehrheim 2019) to discover the phases and changes in the UIC field. Topic modelling employs algorithms to analyse text and create an overall representation of the topics discussed in the text (Blei and Lafferty 2009; Hannigan et al., 2019). This approach allows for a more granular and in-depth analysis of the literature. Therefore, this study differs from other analyses of UIC intermediaries. The reason for this is that, in addition to systematising the bibliography about the topic, it analyses the content of previous studies, learns from the combination of the contents, and draws conclusions based on new ideas and insights about the UIC and its intermediaries. This approach effectively creates new knowledge about the topic rather than just a synthesis or summary of previous research. We use the Latent Dirichlet Allocation (LDA), an algorithm that identifies hidden (latent) topics from clusters/patterns of word occurrences in documents, which discovers unknown thematic structures without human bias (Hannigan et al., 2019). The goal is to identify and analyse the "patterns" or regularities that define a scientific domain and would otherwise be undetectable or unnoticed (Bonazzi et al., 2024). In their seminal work, Blei et al. (2003: pp. 996) proposed that documents can be "represented as random mixtures over latent topics, where each topic is characterised by a distribution over words". The LDA model assumes a Bayesian specification and estimation approach. Topic interpretation is based on a list of terms associated with each topic. The selection of the number of topics is predetermined and based on a trade-off between goodness-of-fit (model explanation) and avoiding overfitting (model complexity). We use four well-known indicators from the literature (Arun et al., 2010; Cao et al., 2009; Deveaud et al., 2014; Griffiths and Steyvers 2004). The estimation is performed in R/RStudio using the *'topmodels'* package. The parameter β (beta) is an important component of the LDA model. It represents the distribution of words across the topics in the model. In other words, β represents the probabilities of words within a given topic. The value of β_{ij} represents the probability of word j within topic i. A higher β_{ij} value means a stronger association between word j and topic i, making β an important determinant for understanding the semantic architecture of each topic. In simple terms, topic modelling identifies groups of words that frequently occur together, helping uncover hidden themes in a large body of texts without human bias.

After obtaining the topics, we use a series of steps that allow us to gain more information from analysing the results: (1) identify the 12 most common words within each topic; (2) assign each paper to a topic; (3) identify the most relevant paper in each topic; and (4) conduct a complete analysis of each topic, based on the total list of papers assigned to it. This information is combined to present a comprehensive analysis of each topic. Then, we (5) analyse the relevance and concentration of topics over time using a visual representation and the Herfindahl-Hirschman Index, and (6) represent correlations between topics (spatial representation). In addition, the most representative journal's keywords for each topic were identified from the journal blurb (Santos and Mendonça 2022). The blurbs were codified independently by two of the authors and validated by the third to reach a consensus on the keywords. This approach is an innovative and complementary way to identify themes within topics.

Details of each of these points is provided below:

(1) For each topic, we used the 12 most relevant terms identified by the LDA model. These terms are selected based on their β values. The β value for each of these terms is presented graphically. It is used to identify and differentiate topics, as well as to highlight the hierarchical structure of term relevance within each topic. By analysing the distribution of β values across topics, we can infer the thematic focus of each topic. This approach allows for the identification of themes and trends that may not be readily apparent from a literature review.
(2) We then assigned each paper to the topic with the highest value of γ (gamma) of the paper, obtaining a list of the most relevant papers for each topic. γ provides the topic distribution for each paper, i.e., an estimate of the proportion of each topic present in each paper
(3) The paper with the highest γ value within each topic is considered the paper most representative of that topic. In these papers, we identified the main themes and labelled each topic based on the 12 most relevant words for each topic.
(4) A comprehensive analysis of all the papers on each topic was then conducted. This analysis allowed us to identify and systematise the main ideas and themes for future research on each topic. This analysis also includes descriptive statistics for each topic.

Temporal dynamics

The topic model analysis was complemented by a longitudinal analysis of the distribution of the topics over time using a Dirichlet regression model (Douma and Weedon 2019). For each topic, the total γ is calculated for the papers in each year. This calculation yields the total value of γ per topic and per year, which represents the relevance of each topic over time, taking into account the presence of each topic in the literature and allowing us to understand the comparative weight of each topic. Currently, the Herfindahl-Hirschman Index (HHI) is a widely used index to measure the agglomeration of diversified industries. This work proposes an innovative use of HHI to measure topic concentration over time. The HHI calculated for each year is a 4-year moving average.

Finally, we consider the content analysed in (4) to establish correlations between topics and understand the most highly linked. All topics were somehow interconnected, so we created the multidimensional scaling map, with the topics acting as nodes.

The topics

The topic modelling approach allowed us to identify eight different topics in the analysed body of papers. The order of the topics was chosen according to the median date of contributions for each topic (minimum to maximum median). If two topics had the same median value, we used the mean. Table A1 in the Appendix provides detailed information on the most representative paper for each topic. The paper with the highest γ value within each topic is considered the paper most representative of that topic. Table A2 in the Appendix provides bibliometric information on the topics, including the average and median of the publication year of each topic. Table A3 in the Appendix report for each topic all papers that have a γ larger or equal to 0.5. Figure 3 provides a visual representation of each topic's most common words / expressions based on beta values.

Topic 1 – University research and technology transfer

In Topic 1, the most frequently used terms are "technology", "research", "univers" and "transfer", indicating the presence of a general theme related to university research and technology and their transfer. The most representative paper on this topic is "The transfer and commercialisation of university-developed medical imaging technology: Opportunities and problems" (Del Campo et al., 1999). This paper explains the strategies and obstacles to commercialising medical technology developed at universities. It highlights the importance of selecting technology transfer tactics that are appropriate to the level of development of the technology and future applications, linking publication incentives to intellectual property protection, and encouraging partnerships with healthcare experts and companies. This article shows that Topic 1 addresses general issues related to commercialising university research outputs and technology transfer. Topic 1 contains 26 papers, the median publication year is 2006, and the most represented journals are *The Journal of Technology Transfer* and *International Journal of Technology Management*. Topic 1 is a broad theme that examines the processes, structures, and results of technology transfer between universities and industry. The focus is on technology transfer, research commercialisation, and university organisational dynamics. Articles on this topic provide details on the relationships that exist between universities and industry, the role of intermediaries in these relationships (e.g., Carr 1992), and specifics of these relationships, particularly in the areas of technology development and commercialisation (e.g., Dooley and Kirk 2007; Markman et al., 2005). These articles also note that effective cooperation depends not only on science and technology but also on organisational structures. They explore the disadvantages and advantages of this type of relationship and highlight the transformative potential of UIC. The MIT model is cited as an effective example of how university research can be turned into commercial products (e.g. Carr 1992; O'Shea et al., 2007). Technology transfer plays a central role in linking laboratory discoveries with real-world applications.

Topic 2 – Spin-offs and incubators

Topic 2 is led by the terms "univers", "ventur", "compani", "spin-off" and "incub". These present a topic with a strong focus on university spin-offs and incubators. The most representative paper is "The importance of surrogate entrepreneurship for incubated Swedish technology ventures" (Lundqvist 2014). The paper focuses on the importance of surrogate entrepreneurship in promoting technology companies in Sweden; it found that 35% of these ventures benefited from incubators' recruitment of surrogate entrepreneurs, leading to significantly better growth and revenue results than non-agency companies. The study shows how surrogate entrepreneurship can improve venture performance. These results support further research on incubator techniques related to the formation of entrepreneurial teams. According to this study, Topic 2 is likely to address new businesses and the role of incubators and surrogate entrepreneurs. Topic 2 consists of 18 papers with a median publication year of 2008, and the most represented journal is *The Journal of Technology Transfer* and *Research Policy*. According to Topic 2, technology transfer is supported by a complex network of incubators, venture capitalists, and entrepreneurial networks acting as UICs intermediaries. University inventions give rise to spin-offs. Venture capitalists are interested in these spin-offs and support them through their development by providing them with financial support as well as strategic and managerial advice. This financial support is not a simple transaction but is influenced by a complex interaction of policies, theoretical frameworks, and empirical evidence (e.g., Leitch and Harrison 2005; Lockett and Wright 2005; Lundqvist 2014). Translating research discoveries into practical and commercially viable solutions is a complex process. Moreover, with the rise of academic entrepreneurs, this dynamic ecosystem has acquired another dimension. These talents are essential to commercialising the technology and ensure that academic geniuses find the right place in the larger corporate environment. They are often supported by networks and surrogate

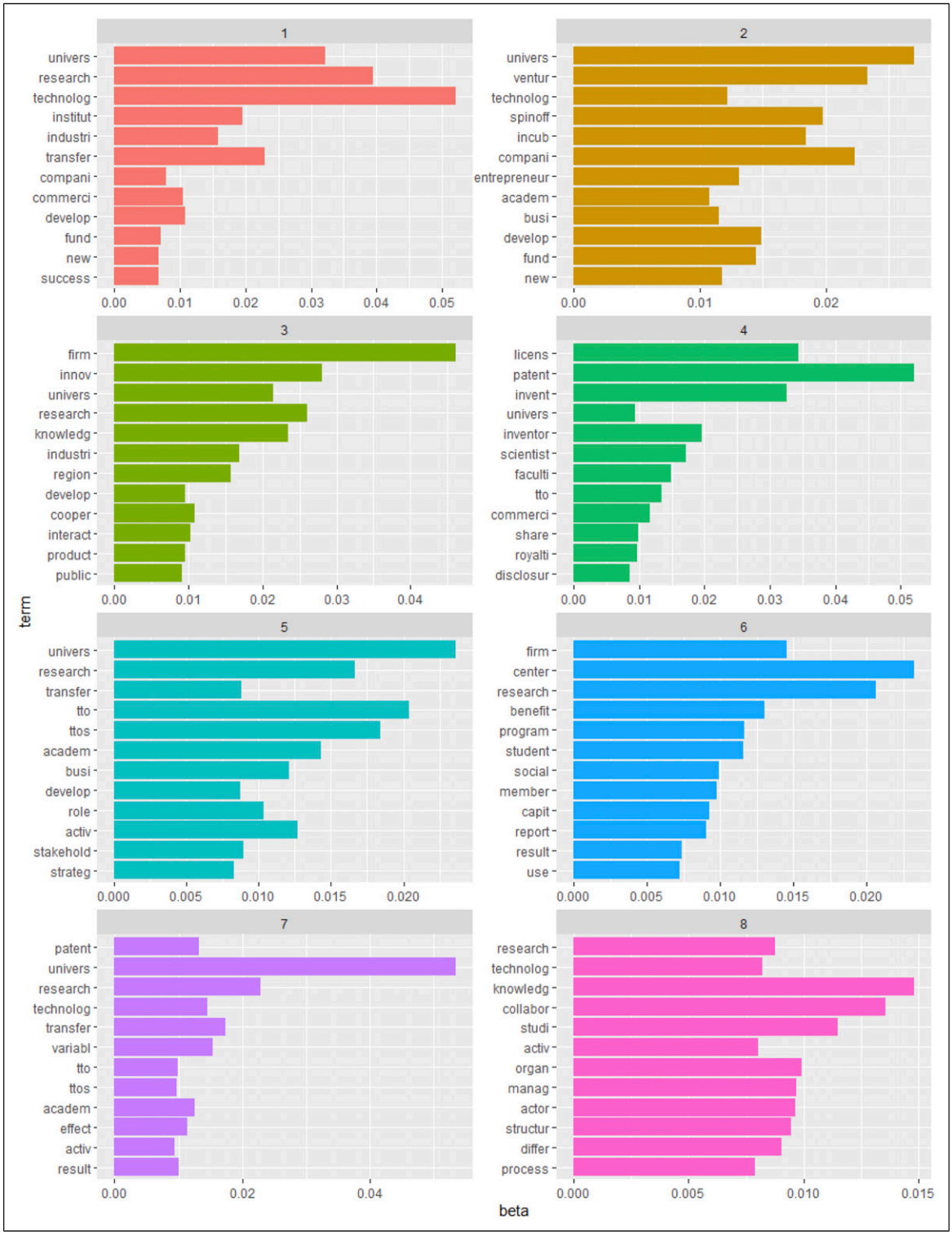

Figure 3. Relation between words and topics (Beta estimates).

intermediaries with management competencies (e.g., Civera et al., 2020; Rodríguez-Gulías et al., 2018). When universities, venture capitalists, and entrepreneurs work together, they help advance technology and improve society (e.g. Franklin et al., 2001; Mosey et al., 2007).

Topic 3 – Industry-centered UIC

The most frequent word in Topic 3 is "firms", followed by "innov" and "research". Unlike the other topics, this seems to be a topic focused on the industry perspective on UIC and

UIC intermediaries, as universities are mentioned far less frequently than companies. The most representative paper is "Sources of innovation and industry-university interaction: Evidence from Spanish firms" (Segarra-Blasco and Arauzo-Carod 2008). This paper analyses how industry and company-specific characteristics such as size, R&D intensity, innovative activities, and access to public funds influence UIC. The result shows that the choice of R&D cooperation, especially with universities, is significantly influenced by the company's quality and the industry's specifics. Topic 3 comprises 17 papers with an average publication year of 2008, and the most represented journals *Research Policy* and *The Journal of Technology Transfer*. One of the main themes in Topic 3 is industry engagement, which focuses on the role and contribution that companies play in developing these collaborations with universities, and how companies strategically interact with it and whether they benefit from it (e.g., Bodas Freitas et al., 2013). Topic 3 also addresses research and knowledge sharing, exploring how industrial demands and academic research can cooperate to create useful applications and disseminate important knowledge (e.g, Fukugawa 2017). There is also a focus on fostering innovation, a process where industry progress and competitiveness are facilitated through collaborations that catalyse new concepts, innovations, and technologies (e.g., Gusberti and Bretas 2018). Moreover, this topic tackles the larger business environment and how it interacts with universities for mutual development and impacts the development of UICs (e.g., Yusuf 2008). Topic 3 contains references to intermediaries that are important for both the promotion and regulation of UIC.

Topic 4 – Patenting and licensing in UIC

Topic 4 is dominated by "patent", "licens" and "invent" and leads to topics focusing on patents and their licenses. The most representative paper is "The role of patents for bridging the science to market gap, Journal of Economic Behavior and Organization" (Hellmann 2007). This theoretical paper examines the "science to market gap" and the legitimacy of patenting scientific breakthroughs. To bridge this gap, patents are essential as they influence search intensity. They encourage patenting as a secondary activity to scientific research, thus not only bridging the gap but also allowing scientists to focus more on their research. Therefore, Topic 4 seems to focus on patents and their functions in the UIC. Topic 4 comprises 16 papers with a median publication year of 2011. The most represented journals are *Research Policy* and *The Journal of Technology Transfer*. Methods, procedures, and critical roles in the commercialisation of academic research are the focus of Topic 4 (e.g., Backs et al., 2019). The focus is on understanding management and commercialisation strategies for university-generated innovations, including licensing, patenting, and other methods, as well as the role of UIC intermediaries in facilitating this process (e.g., Backs et al., 2019; Dahlborg et al., 2017). This topic also considers different channels and procedures, such us licensing, for transforming academic research into commercial goods and services (e.g., Kim et al., 2019). Furthermore, this topic focuses on patent protection and commercialisation process, and examines the role of intermediaries in bridging the knowledge gap between academic research and industrial application and their roles, efficacy, and difficulties. (e.g., Hellmann 2007; Kim et al., 2019).

Topic 5 – Technology transfer offices dynamics

In Topic 5, "TTO"/"TTOs" and again "univers" and "research" clearly dominate. Therefore, Topic 5 seems strongly influenced by university Technology Transfer Offices (TTO). The most representative paper is "University technology transfer offices: The search for identity to build legitimacy" (O'Kane et al., 2015). This paper examines how university TTO build credibility by defining their identity with faculty and university administrators. TTO have two sides: a university side that addresses science and an industry side that addresses business. Therefore, TTO need to create a clear and inclusive brand to strengthen their credibility and that they need to re-evaluate their strategies for interacting with university stakeholders. According to this paper, TTO management and strategy seem to be the subject of Topic 5. Topic 5 includes 12 papers with an average publication year of 2015. The most featured journal is *The Journal of Technology Transfer* and *Technovation*. The focus of Topic 5 is how TTO can help bridge the knowledge gap between industry and universities. This topic explores the importance of strategic planning, stakeholder engagement, operational management, and boundary-spanning operations in these offices (e.g. Geoghegan et al., 2015; Huyghe et al., 2014). The effectiveness, goals and vision of these TTO and the way they support knowledge transfer and innovation are the main concerns. Themes covered include how university TTOs can successfully connect cutting-edge research with real-world applications; at the same time, universities improve their business structures to ensure that research results are translated into commercial applications (e.g., Kalantaridis and Küttim 2020). As "boundary spanners," university TTOs are located at the interface between research and business needs (e.g., Garrett-Jones et al., 2010; Huyghe et al., 2014).

Topic 6 – Collective research centres as UIC intermediaries

The most common words in Topic 6 "center", "research", "firm" and "benefit", which seem to focus on research centres involving companies and their benefits. The most representative paper is "A policy mix experiment to promote start-up success: exploratory evaluation of the NSF Small Business Innovation Research (SBIR)/Industry University Cooperative Research Center (IUCRC) membership supplement" (Gray et al., 2022). This paper evaluates a US-

based Collective Research Center (CRC). The findings show important R&D benefits as well as commercial advantages in CRC, including cost savings, access to cutting-edge technology, and improved market potential. The data show that companies with strong ties to universities generate more benefits. This highlights the value of collaborative research and the potential of combining policies to promote innovation and commercialisation in high-tech companies. Researching CRC as a UIC intermediate is proposed in Topic 6. Topic 6 includes 7 papers with the median of the publication year of 2016. The most representative journals are *The Journal of Technology Transfer*, *Technological Forecasting and Social Change*, and *IEEE Transactions on Engineering Management*. Topic 6 examines and evaluates the dynamics, outcomes, and structures of university-industry collaboration, with a particular focus on management issues related to CRC. Papers in this topic specifically address the CRC's administration, structure, and roles. The dual responsibility of principal researchers is to advance knowledge and manage a broad group of collaborators (e.g., Boardman and Ponomariov 2014), highlighting the importance of management abilities in research settings. The quality of management directly impacts the effectiveness and success of these centres. Furthermore, the effectiveness of these centres is strongly influenced by leadership dynamics such as "leader-member exchange" and "trust" (Davis and Bryant 2010). It also explores the impact of policy, focusing on the role of policy measures in promoting UIC. In addition, there is a strong desire to understand the benefits of these collaborations. It proposes a comprehensive assessment of the value created by these collaborations, incorporating both theoretical developments and real-world applications. Companies and students will be important stakeholders. The former can benefit from new research findings, and the latter from industry and new educational opportunities (e.g., Leonchuk and Gray 2019). In addition to practical insights, the focus is also on the theoretical frameworks underlying these collaborations.

Topic 7 – Managing Technology Transfer Offices

The most common term in this topic is "university," far more common than "research", "TTO/TTOs," and "transfer." Therefore, the topic seems to focus on universities and university TTOs. The most representative paper on this topic is "Knowledge flows between universities and industry: the impact of distance, technological compatibility, and the ability to diffuse knowledge" by Mukherji and Silberman (2021). These authors study the flow of information from 91 research universities in the US to companies. It concludes that knowledge spillovers are significantly more pronounced when companies and institutions are located close to each other. At the same point, geographic proximity becomes less important. The relevance of aligning research interests is highlighted by the significant increase in citations resulting from technological interoperability between industry and university patents. This paper also shows that TTO positively impacts universities' knowledge dissemination capabilities by enabling spillover channels for university knowledge to markets (licenses, royalties, start-ups) and spillover effects on knowledge flows outside the market (citations to university patents). This paper takes TTO as its main theme and proposes factors that affect technology transfer. Topic 7 contains 33 papers with a median publication year of 2016. The most representative journals are *The Journal of Technology Transfer*, *Research Policy*, and *Technovation*. Topic 7 examines TTO functions, mechanisms, difficulties, and management best practices to facilitate technology transfer from universities to industry. This topic aims to provide insight into how academic technology is managed and channelled to industry through TTOs by understanding the strategies, challenges and results of such activities (e.g., Faccin et al., 2022). Five main themes can be identified in these papers: (1) Strategic considerations for TTOs (e.g., Horner et al., 2019); (2) Patenting and commercialisation (e.g., Giuri et al., 2018); (3) Operational and academic spin-offs (e.g., Ramaciotti and Rizzo 2015); (4) Patent management and performance metrics (e.g., Anderson et al., 2007); (5) Efficiency and licensing in TTOs (e.g., Faccin et al., 2022). Papers on this topic address TTO optimisation and emphasise the important role of humans in increasing TTO effectiveness (e.g., Micozzi et al., 2021). This highlights the different roles that TTOs play and their importance in helping research institutions maximise their research efforts. It also discusses researchers' views on patents for novel ideas and how patent managers work strategically to monetise these inventions (e.g., Giuri et al., 2018). Moreover, it provides valuable insights into how patent management practices have changed over time. This analysis highlights that researchers tend to participate more in business-oriented activities (e.g., Huyghe et al., 2016). At the same time, it addresses potential obstacles related to TTO initiatives. In particular, TTO is an important platform for monetising patent exploitation and highlights the involvement of researchers in this process. Topic 7 also assesses TTO operations, including identifying metrics that support TTO management (e.g., Faccin et al., 2022).

Topic 8 – Intermediaries and UIC

Topic 8 contains very important terms that lead to a very broad range of themes covered in this topic. The most common terms are "knowledg", "collabor", "studi", "organ", "manag", "actor", and "structur". This combination of words seems to indicate a general approach to collaboration, its management, and the structures and actors involved in it. The most representative paper is "Traditional, virtual, and digital intermediaries in university-industry collaboration: exploring institutional logics and bounded rationality" (Albats et al., 2022). These authors compare traditional models with modern virtual and digital platforms and

Table 1. Synthesis of the topics.

Topic	Title	Focus	Topic blurb
1	University research and technology transfer	Processes, structures, and results of technology transfer between universities and industry	• Technology transfer • Entrepreneurship and innovation • Technology management
2	Spin-offs and incubators	Development and support of university spin-offs and incubators	• Policy and management • Technology transfer • Entrepreneurship & innovation
3	Industry-centred UIC	Cooperation driven by industry needs and interests	• Technological foresight • Technology transfer • Entrepreneurship & innovation
4	Patenting and licensing in UIC	Intellectual property management, including patenting and licensing	• Strategic behaviour • Technology transfer • Entrepreneurship & innovation
5	Technology transfer offices dynamics	Role and dynamics of TTOs in facilitating technology transfer	• Technology management • Technology transfer • Entrepreneurship & innovation
6	Collective research centres as UIC intermediaries	Structures of cooperation between universities and industry, focusing on management issues concerning CRCs	• Technology management • Technology transfer • Entrepreneurship & innovation
7	Managing technology transfer offices	Functions, mechanisms, difficulties, and management best practices of TTOs	• Technology management • Technology transfer • Entrepreneurship & innovation
8	Intermediaries and UIC	Role of intermediaries in UIC, stakeholder management, and engagement strategies	• Technology management • Technological foresight • Technology transfer

examine the evolution of university-industry cooperation through knowledge transfer intermediaries (KTIs). They present an analytical approach to assess and define 20 global KTIs. The study revealed the broader structure and services of KTIs, reflecting a trend towards more adaptable network-based partnerships that provide extended value chains and overcome traditional connectivity barriers. According to this paper, the ability of KTIs to negotiate institutional logic and cognitive regimes becomes a crucial factor for their effectiveness in university-industry collaborations. This suggests that Topic 8 could consider UIC as a complex process. Topic 8 includes 19 papers with a median publication year of 2018. The most representative journals are *Technological Forecasting and Social Change*, *The Journal of Technology Transfer*, and *Technovation*. Topic 8 addresses the function and importance of intermediaries that support university-industry cooperation and information transfer procedures between them. A complex network of interconnected organisations, including public agencies, start-ups, SMEs, industry, and universities, form this innovation ecosystem. An essential function of intermediaries is to maintain harmony between these different actors (e.g., Albats et al., 2022; Ankrah et al., 2013). Papers in Topic 8 (e.g., Villani et al., 2017) highlight the significance of effective knowledge transfer mechanisms and collaboration between universities and industry (e.g., Villani et al., 2017). Innovation and knowledge creation result from collaboration between university researchers and industry. It also covers different types of intermediaries, including different public and private intermediaries, as well as their functions and ways to bridge this gap (e.g., Ankrah et al., 2013). Key themes include university-industry links, how these partnerships are managed, why those sectors want to collaborate, what benefits they want to achieve and what difficulties they face (e.g., Albats et al., 2022). Another recurring theme is the whole ecosystem, all its actors and parts and how they work together to foster innovation.

Topic overview

Topics 1 to 8 provide an overview of UIC intermediaries literature (Table 1). Certain topics represent a broader perspective of UIC (e.g., Topics 1 and 8), while other topics address specific types of intermediaries (e.g., 5, 6 and 7).

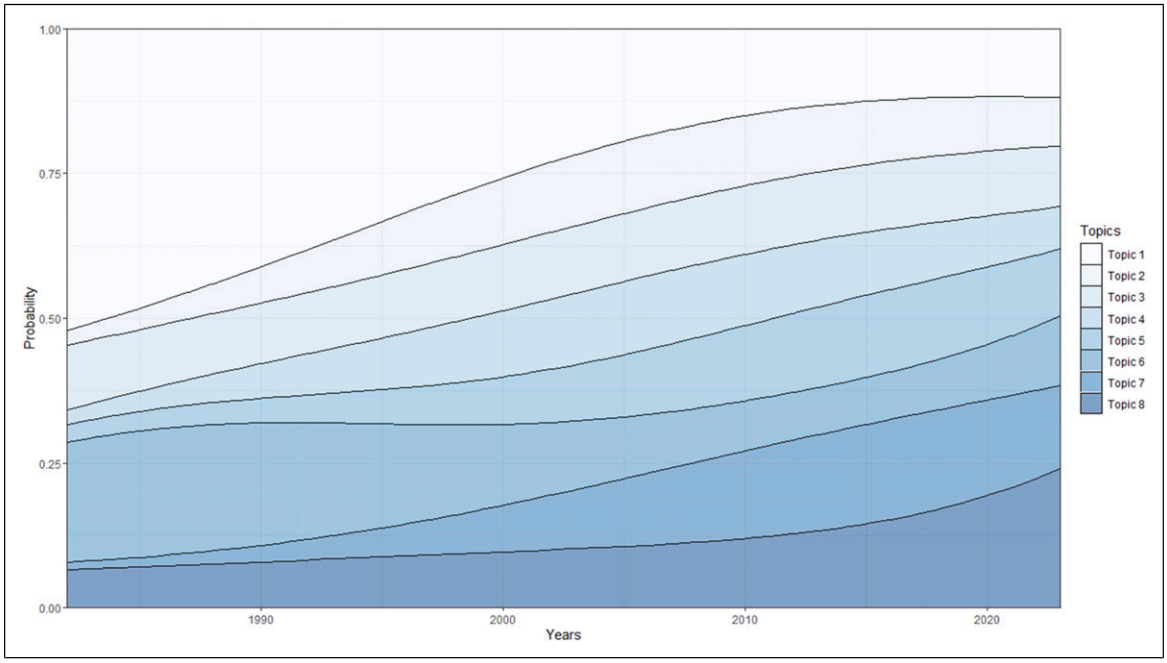

Figure 4. Distribution of topics over time (1982-2023).

Other topics continue to address specific issues of importance to UICs and intermediaries (e.g., 4). Topics 5, 7, 1, and 8 appear to cover the same topic but have different perspectives that are worth considering.

In Topics 5 (Technology Transfer Offices dynamics) and 7 (Managing Technology Transfer Offices), TTO is an important theme. However, Topic 5 focuses on the internal and operational aspects of the TTO and its role, including its function as boundary spanners and its mission and identity. Topic 7 focuses on management-related aspects of TTO: performance and business models. It also examines policy implications and the influence of TTO characteristics on UIC and academic spin-offs.

Topics 1 (University Research and Technology Transfer) and 8 (UIC and intermediaries as a system) cover UIC more broadly, in contrast to the remaining topics, which have a more specific scope. There are two main differences between the topics. First, it is due to the high presence of UIC intermediaries in topic 8; second, both topics have different approaches to UIC. Topic 1 focuses on technology transfer as a cooperation process between universities and industry, transferring knowledge and technology from one to the other. Topic 8 emphasises a systems approach that involves various stakeholders, including intermediaries. This is not linear and cooperation encompasses more options than knowledge and technology transfer from universities to industry.

Table 1 provides an interpretation of the focus of each topic in summary and structured form. This overview is based on our best understanding of the topic. The list of keywords was obtained from the blurb of the most representative journals of each topic. Assuming that the blurbs of most representative journals are consistent with the content of these journal issues (Santos and Mendonça 2022), the keywords indicate the general purpose of each topic. If we analyse of the keywords in the "Topic blurb" of Table 1, Topic 1 is distinctive. Its uniqueness fades, and the next topics become more similar and overlap, culminating in the last one. These keywords mark a transition from "technology transfer," which appears prominently in the first topic, to "technology management," which is emphasised in the last topic. This indicates a shift from a transfer-based approach to a management-oriented approach for the UIC. In addition, the last topic, "technological foresight", emphasises the need for foresight regarding environmental trends. This observation is consistent with the increasing importance of intermediaries' management and strategic planning for success, observed in Topics 7 and 8.

Topic dynamics

This section explores the evolution of topic weights from 1982 to 2023. Figure 4 represents the distribution of topics over time, by showing the probability of each topic in each year. It highlightsthe shifting trends within the field. It also examines the concentration of topics over time, using the Herfindahl index as a measure of the size of each topic relative to the whole.

As shown in Figure 4, the initial dominant topic was university research and technology transfer (Topic 1), followed by collective research centres as UIC intermediaries (Topic 6). The most prominent topics at the end of the period are UIC and intermediaries as a system (Topic 8), management of technology

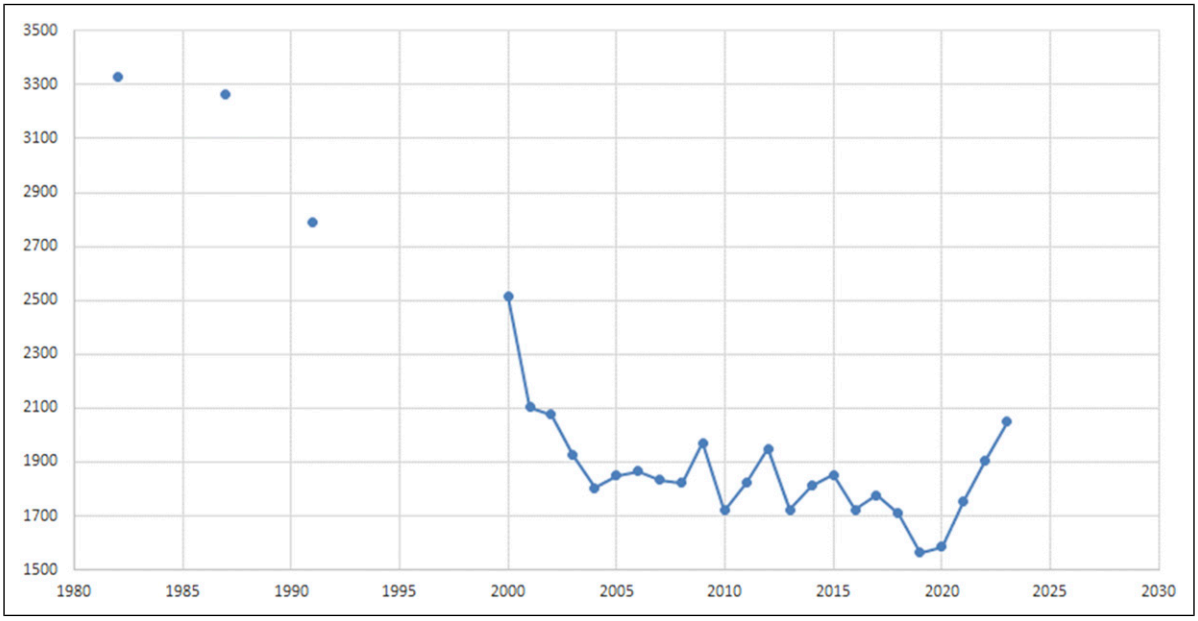

Figure 5. Concentration of papers per Topic, over time. Years when no paper was published were removed from the graphic.

transfer offices (Topic 7) and Industry-centred UIC (Topic 3). Two periods can be identified: pre- and post-2000 to 2004. These two periods are dominated by Topics 1 and 6, and Topics 5 (Technology Transfer Offices dynamics) and 8, respectively. This transition from Topics 1 and 6 to Topics 5 and 8 reflects a change in the conceptualisation and operationalisation of UIC. This may indicate a broadening of the focus to include not only on technology transfer but also on more collaborative and reciprocal interaction models where the benefits and contributions are more evenly distributed. In addition, research on CRCs (Topic 6), which was central to UIC intermediaries, has declined and made way for other forms of intermediaries. However, Topic 6 has recently seen an increasing trend and should be followed up in the coming years as the importance of CRCs may be increasing again in the literature.

Research on the topics of Technology Transfer Offices (Topic 5), Managing Technology Transfer Offices (Topic 7) and UIC and intermediaries as a system (Topic 8) has increased significantly. This means that the study of technology transfer as a general phenomenon has shifted towards more specific themes and intermediaries, particularly TTOs. These topics may also be expanded by technological advances requiring new UIC forms. For instance, rapid changes in digital technology, biotechnology or advanced manufacturing may increase the focus on these topics, particularly 5 and 7. This is because these topics are often the channels for the transition of new technologies from university laboratories to commercial applications. The increase in Topic 7 shows the recognition that TTOs need to be professionalised and developed further to cope with the increasing complexity and scale of technology transfer activities. This development also recognises the role of intermediaries in a wider phenomenon of university-industry cooperation that occurs within the system.

The relevance of spin-offs and incubators (Topic 2) and of licenses and patents (Topic 4) has increased in the 2000s in line with their relevance in practice and policy but has slightly decreased in recent years. This trend may reflect an adaptation to market demands for commercialisation and the increasing importance of intellectual property in university-industry cooperation. This may be influenced by policy changes that encourage universities to participate more directly in the economy through innovation and entrepreneurship. The growth of Topic 2 also reflects a growing interest in entrepreneurship driven by start-up culture and innovation policy. Surprisingly, industry-oriented UIC research (Topic 3) has not increased over the years. This indicates that the UIC study has focused on intermediaries from a university perspective rather than an industry perspective.

Although some topics have seemingly become smaller than others, this does not necessarily mean they have lost their absolute relevance. It is important to note that this is not the case. This may simply indicate that other areas are growing faster or that research on these topics is reaching saturation. Additionally, the emergence of new sub-topics and nuances within these broad topics may also explain shifts in the graph.

Herfindahl-Hirschman Index was applied to analyse paper concentration over time. Figure 5 represents the HHI value in each year. A higher HHI value means that papers are concentrated on fewer topics. Figure 5 show three main moments: a decrease in topic concentration until 2004, a stabilisation, and an increase from 2020 onwards. Figure 4 illustrates this observation. Topic 1 was dominant until 2004 but steadily decreased with the increase in other topics.

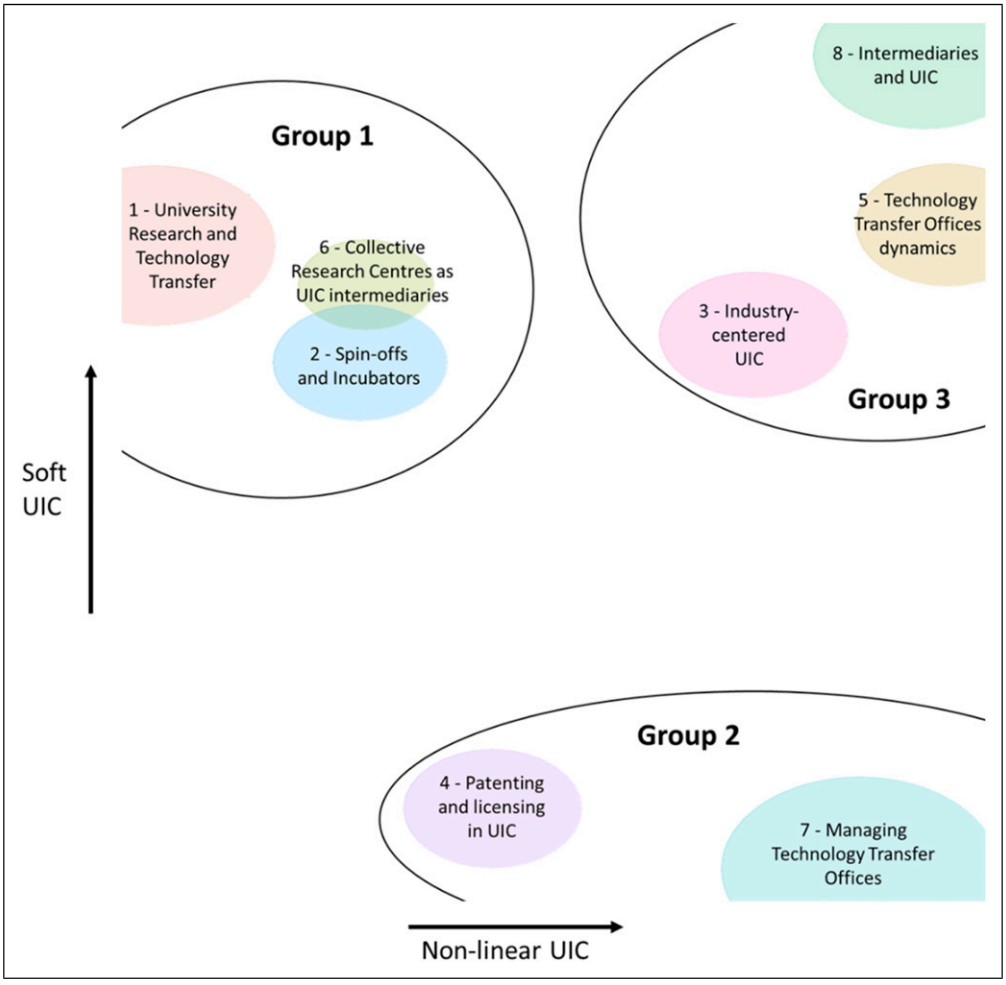

Figure 6. 2D spatial representation of the proximity and size of each topic.

After that, the relevance of Topic 1 will be dominated by other alternate topics until 2020. However, from 2020 onwards, Topic 8 will increase. As explained above, Topic 1 and Topic 8 cover UIC in a broader sense. Topic 1 is focused on the process of knowledge and technology transfer from universities to industry. Topic 8 emphasises systems approach, including different actors and co-creation approaches. Therefore, by analysing Figures 4 and 5, we conclude that the literature moves from a view of UIC as a linear technology transfer process to a more holistic and complex system view of UIC that is not linear and involves a variety of actors. Knowledge creation and innovation require the contributions of different stakeholders, and the relationship between universities and industry is evolving from transfer to co-creation. This is in line with recent literature (De Silva et al., 2023; Mathisen and Jørgensen 2021; Rossi et al., 2017; Ruess et al., 2023). Based on shared papers (gamma indicator), we can see that different topics are more or less close to each other. Figue 6 reflects the closeness of each topic. Each circle represents a topic; larger circles are associated with dominant topics in multiple papers. Thus, the circle size of a given topic is proportional to the number of papers included in that topic[2].

This visual representation of topic relationships helps us understand their proximity and interconnections to make further observations and conclusions about the topic. It provides a quick and visual way to assess the correlations between topics.

As shown in Figure 6, there are three groups of related topics. Topics 1 (University Research and Technology Transfer), 2 (Spin-offs and Incubators) and 6 (Collective Research Centres as UIC intermediaries) – Group 1 – are the most closely related, while Topic 2 and Topic 6 overlap. This could indicate the proliferation of spin-offs based on technologies developed in the CRCs. In general, these topics are strongly focused on universities and refer to the view of universities as new sources of innovation for the economy (Dalmarco et al., 2018; De Fuentes and Dutrénit 2012; Heaton et al., 2019; Villani 2013), which involves a linear technology transfer approach (Topic 1).

Topics 4 (Patenting and licensing in UIC) and 7 (Managing Technology Transfer Offices) – Group 2 – relate to the view of

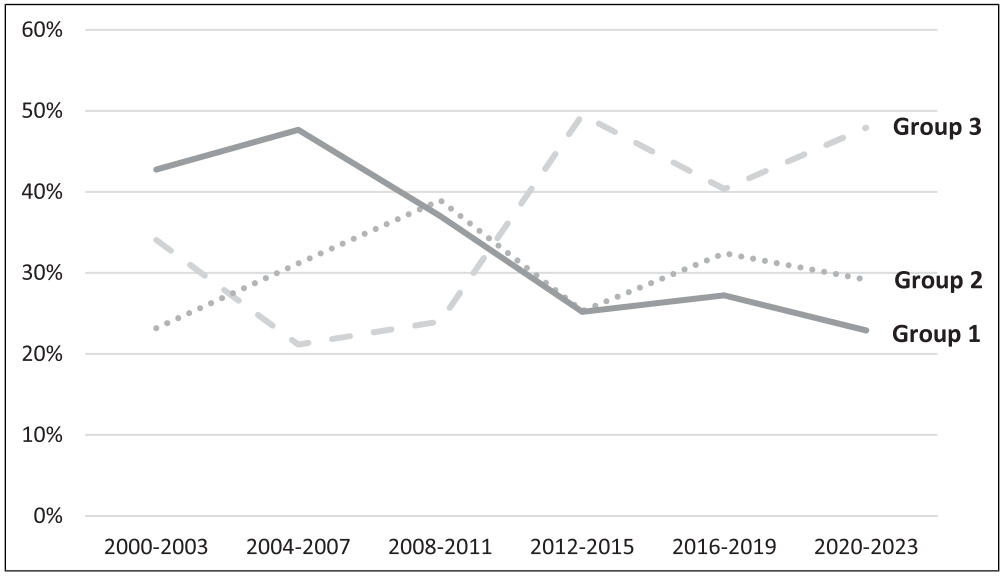

Figure 7. The weight (%) of each group of topics over time. The values are calculated over a period of 4 years. Note: Group 1: Topics 1, 2 and 6; Group 2: Topics 4 and 7; Group 3: Topics 3, 5 and 8.

UIC intermediaries as knowledge-driven intermediary services. Topics 5 (Technology Transfer Offices dynamics), 8 (UIC and intermediaries) and 3 (Industry-centred UIC) are also more closely related – Group 3. This observation suggests that Technology Transfer Offices are central to UIC from both university and industry points of view. This point highlights the importance of TTOs in UIC and shows the perspective of UIC intermediaries as knowledge brokers with direct and fundamental industry involvement (Frølund and Ziethen 2016; Santos et al., 2023). This leads to a UIC approach that includes direct and dynamic industry involvement.

In summary, the analysis in Figure 6 suggests the existence of two main distinct groups (1 and 3) regarding the theoretical framework of the eight identified topics related to UIC intermediaries: UIC intermediaries as bridgebuilders in a system that involves the participation of universities and industry (Group 3) and UIC intermediaries participate in a process mainly focused on universities. Therefore, Figure 6 indicates that UIC intermediaries progressively positioning themselves towards a soft and non-linear UIC.

Figure 7 shows the relative weight (%) of each of the three groups in the total for the period 2000-2023, measured by the number of papers in each group compared to the total. To smooth the values, each measurement is 4 years long. Figure 7 shows the tendency of Group 1's weight to decrease, while Group 3's weight tends to increase. Group 2 is stable from the beginning to the end of the period.

The analysis of previous results allows several conclusions. The main turning points in the evolution of topics are shown in Figures 4 and 5, with major shifts around 2005 and 2020. Importantly, the decrease in the weight of "Group 1″ and the increase in "Group 3″ indicate a trend away from approaching UIC as a linear technology transfer process towards a holist process. Here, collective learning management is essential. This new approach strongly involves both universities and industry and reflects an innovation system framework that considers innovation processes as complex. This shift from linear to non-linear also coincides with a shift in Topic 1 from the scientific and technologically-based innovation (STI) mode to the learning-by-doing, using, and interacting (DUI) mode, Topic 8 (Parrilli and Heras 2016). This shift is also consistent with a shift from an overarching focus on "hard" innovation (technologically deepening interventions) to a delicate combination of hard and soft innovation (non-technological strategies) (Costa and Mendonça 2019; Mendonça 2014). This framing of UIC as a non-linear process of knowledge co-creation is confirmed by recent literature (e.g., De Silva et al., 2023; Mathisen and Jørgensen 2021; Rossi et al., 2017; Ruess et al., 2023), the rise of multiplayer, multichannel, open and interactive learning modes (Caraça et al., 2009; Santos et al., 2021). In addition to the implications of knowledge production from a scientific and technological perspective, this co-creation also draws attention to the need to connect and coordinate different groups for co-innovation actively (Ozdemir et al., 2023) and the importance of strategic and organisational knowledge in the innovation process. This is "fertile ground" for UIC intermediaries (Santos et al., 2023). The importance of organisational management and stakeholder engagement in UIC is related to another finding of this study: the increasing importance of management, strategy, and organisational structure for the success of UIC intermediaries. These findings and discussions answer the research question of this paper very clearly. It thus emerges that analytical work on UIC seems to detect a movement

from linear to post-linear set-ups, where dynamic and interactive processes based on soft management functions are crucial. UIC is, therefore, becoming a more balanced, holistic and systemic phenomenon where real co-creation is at the core. The realisation that a soft and post-linear positioning of intermediaries is becoming an upfront concern by public authorities who nevertheless wish to maximise the commercial value of R&D (see, e.g., Harrison et al., 2023).

Conclusion

Our results explore UIC and the important role of intermediaries in facilitating it. These intermediaries act as bridges in the innovation ecosystem, facilitate collaboration, manage relationships, and foster the flow of ideas and innovations. Understanding the dynamics, efficiency, and influence of these intermediaries is central to enhancing the effectiveness of UIC (Alexandre et al., 2022; Temel et al., 2021). This paper also contributes to this effort.

The most surprising result is related to the existence of a debate about the organisational structure and management characteristics of intermediaries and the impact on their performance. Although this aspect is often overlooked in practice, it turns out to be one of the most important in the literature and definitely offers room for future research. Another unexpected aspect is the under-utilisation of the theme of interdisciplinarity in UIC intermediaries and their role as an interface of different disciplines. We identified two main ideas that influence practices and policies related to UIC intermediaries, which are related to management: (1) effective leadership within the intermediaries plays a pivotal role in the success of the intermediary. To achieve this, management must prioritise two key aspects: strategic planning and leadership development. Managers must also rationalise intermediary operations, optimise resource allocation, and adopt best practices. In addition, it is important to develop clear metrics and evaluation criteria. These metrics enable evidence-based decision-making and encourage continuous improvement and adaptability; (2) intermediaries should also focus on strong stakeholder engagement. This involves proactive networking with various stakeholders, including academic researchers, industry partners, and policymakers.

Another contribution of this study is identifying the shift from a linear and unidirectional UIC technology transfer approach to a more systemic and complex approach. This transformation suggests a new approach that considers UIC as a co-creation process representing more than just the transfer of technology and knowledge from universities to industry. This is in line with the conclusions of recent authors who argue that a variety of co-creation concepts related to UIC have emerged in recent years (De Silva et al., 2023; Ruess et al., 2023). This means that UIC intermediaries are increasingly positioning themselves as managers of relationships between stakeholders, universities, and industry. They are facilitators who actively bring organisations together while anticipating trends (Santos et al., 2023). The results of this study also call for the recognition of the increasing importance of the coordination capability of intermediates within innovation systems (Caraça et al., 2009). These conclusions justify the previous observations concerning the increasing importance of stakeholder engagement and strategic planning for intermediaries. They provide new insights with relevant implications for innovation policies and practices to promote UIC.

The limitations of this study are that it focuses on English-language publications and relies on probabilistic topic models, which, while informative, may ignore nuanced interpretations of traditional qualitative reviews. Another limitation concerns the methodology used to remove articles of questionable quality and relevance from the total of articles analysed. To reduce the impact of this drawback, we based our approach on similar methods already published in high-impact articles. Besides, the subjective nature of the content analysis of each topic also represents a limitation. To reduce the impact of this limitation, we ensured that this analysis was conducted after analysing all articles. Regarding future research avenues, we propose the need to conduct longitudinal studies on UIC intermediaries, considering changes in policy and changes in UIC characteristics. Future research could help to uncover how intermediates' strategies and operations have changed over time. Future work should also expand the linguistic and cultural coverage and explore hybrid methods. Another relevant theme for future research is understanding the unique challenges and practices of intermediaries in diverse sectors such as healthcare, manufacturing, and agri-food. Besides, the impact of digitalization on UIC intermediaries also deserves close attention. Research could examine how digitalization supports or changes intermediary functions and what impacts it has on their stakeholders. Finally, from a purely academic perspective, future research could aim to create an integrated model of UIC that recognizes the multi-stakeholder nature within innovation systems to further develop the role of key factors in the management of UIC intermediaries.

Acknowledgement

We sincerely appreciate the valuable comments and suggestions from the reviewers, which helped us to improve the quality of the article.

ORCID iD

Telmo N Santos https://orcid.org/0000-0002-5738-4995

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: Financial support from Fundação para a Ciência e Tecnologia (UIDB/00315/2020) is greatly appreciated.

Declaration of conflicting interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Data Availability Statement

All data generated or analyzed during this study are included in this published article.

Notes

1. Higher education institutions are different from each other and include universities, university research centres, and polytechnics. "University" is the term used in this article to refer to higher education institutions.
2. Proximity indicates shared similarities and high correlation between topics in the entire corpus, i.e., the correlations between the gamma values of two topics. These associations are projected into a "2D-space" using multidimensional scaling.

References

Abramitzky R (2015) Economics and the modern economic historian. *The Journal of Economic History* 75: 1240–1251.

Albats E, Alexander AT and Cunningham JA (2022) Traditional, virtual, and digital intermediaries in university-industry collaboration: exploring institutional logics and bounded rationality. *Technological Forecasting and Social Change* 177: 121470. DOI: 10.1016/j.techfore.2022.121470.

Alexandre F, Costa H, Faria AP, et al. (2022) Enhancing university–industry collaboration: the role of intermediary organizations. *The Journal of Technology Transfer* 47: 1584–1611.

Algieri B, Aquino A and Succurro M (2013) Technology transfer offices and academic spin-off creation: the case of Italy. *The Journal of Technology Transfer* 38: 382–400.

Anderson TR, Daim TU and Lavoie FF (2007) Measuring the efficiency of university technology transfer. *Technovation* 27: 306–318.

Ankrah SN, Burgess TF, Grimshaw P, et al. (2013) Asking both university and industry actors about their engagement in knowledge transfer: what single-group studies of motives omit. *Technovation* 33: 50–65.

Arqué-Castells P, Cartaxo RM, García-Quevedo J, et al. (2016) Royalty sharing, effort and invention in universities: evidence from Portugal and Spain. *Research Policy* 45/9: 1858–1872.

Arun R, Suresh V, Madhavan CEV, et al. (2010) On finding the natural number of topics with latent dirichlet allocation: some observations. *Lecture Notes in Computer Science* 6118: LNAI.

Austin D, May J, Andrade J, et al. (2021) Delivering digital health: the barriers and facilitators to university-industry collaboration. *Health Policy and Technology* 10: 104–110.

Backs S, Günther M and Stummer C (2019) Stimulating academic patenting in a university ecosystem: an agent-based simulation approach. *The Journal of Technology Transfer* 44/2: 434–461.

Ballandonne M and Cersosimo I (2023) Towards a "text as data" approach in the history of economics: an application to adam Smith's classics. *Journal of the History of Economic Thought* 45: 27–49.

Barra C and Zotti R (2018) The contribution of university, private and public sector resources to Italian regional innovation system (in) efficiency. *The Journal of Technology Transfer* 43/2: 432–457.

Bastos EC, Sengik AR and Tello-Gamarra J (2021) Fifty years of university-industry collaboration: a global bibliometrics overview. In: *Science and Public Policy*. Oxford University Press. DOI: 10.1093/scipol/scaa077.

Bengoa A, Maseda A, Iturralde T, et al. (2021) A bibliometric review of the technology transfer literature. *The Journal of Technology Transfer* 46: 1514–1550.

Blei DM and Lafferty JD (2009) *'Topic Models'. Text Mining - Classification, Clustering, and Applications*. Chapman and Hall/CRC. DOI: 10.1201/9781420059458-12.

Blei DM, Ng AY and Jordan MI (2003) Latent dirichlet allocation. *Journal of Machine Learning Research* 3/null: 993–1022.

Boardman C and Ponomariov B (2014) Management knowledge and the organization of team science in university research centers. *The Journal of Technology Transfer* 39: 75–92.

Bodas Freitas IM, Geuna A and Rossi F (2013) Finding the right partners: institutional and personal modes of governance of university-industry interactions. *Research Policy* 42: 50–62.

Bonaccorsi A, Chiarello F and Fantoni G (2021) Impact for whom? Mapping the users of public research with lexicon-based text mining. *Scientometrics* 126/2: 1745–1774.

Bonazzi R, Viscusi G and Solidoro A (2024) Crowd mining as a strategic resource for innovation seekers. *Technovation* 132: 102969. DOI: 10.1016/j.technovation.2024.102969.

Cabral R (1998) Refining the Cabral-Dahab Science Park Management Paradigm. *International Journal of Technology Management* 16(8): 813–818. Available at: https://doi.org/10.1504/IJTM.1998.002694

Caldera A and Debande O (2010) Performance of Spanish universities in technology transfer: an empirical analysis. *Research Policy* 39: 1160–1173.

Cao J, Xia T, Li J, et al. (2009) A density-based method for adaptive LDA model selection. *Neurocomputing* 72: 1775–1781.

Caraça J, Lundvall BÅ and Mendonça S (2009) The changing role of science in the innovation process: from queen to cinderella? *Technological Forecasting and Social Change* 76/6: 861.

Carr RK (1992) Menu of best practices in technology transfer (part 2). *The Journal of Technology Transfer* 17: 24–33.

Chan YE, Krishnamurthy R and Sadreddin A (2022) Digitally-enabled university incubation processes. *Technovation* 118: 102560. DOI: 10.1016/j.technovation.2022.102560.

Chapple W, Lockett A, Siegel D, et al. (2005) Assessing the relative performance of U.K. university technology transfer offices: parametric and non-parametric evidence. *Research Policy* 34: 369–384.

Chen A, Patton D and Kenney M (2016) University technology transfer in China: a literature review and taxonomy. *The Journal of Technology Transfer* 41: 891–929.

Civera A, Meoli M and Vismara S (2020) Engagement of academics in university technology transfer: opportunity and necessity academic entrepreneurship. *European Economic Review* 123: 103376.

Collins S and Wakoh H (2000) Universities and technology transfer in Japan: recent reforms in historical perspective. *The Journal of Technology Transfer* 25(2): 213–222.

Corbet S, Dowling M, Gao X, et al. (2019) An analysis of the intellectual structure of research on the financial economics of precious metals. *Resources Policy* 63: 101416.

Costa CM and Mendonça S (2019) Knowledge-intensive consumer services. Understanding KICS in the innovative global healthcare sector. *Research Policy* 48/4: 968–982. DOI: 10.1016/j.respol.2018.10.026.

Ćudić B, Alešnik P and Hazemali D (2022) Factors impacting university–industry collaboration in European countries. *Journal of Innovation and Entrepreneurship* 11: 33.

Dahlborg C, Lewensohn D, Danell R, et al. (2017) To invent and let others innovate: a framework of academic patent transfer modes. *The Journal of Technology Transfer* 42/3: 538–563.

Dalmarco G, Hulsink W and Blois GV (2018) Creating entrepreneurial universities in an emerging economy: evidence from Brazil. *Technological Forecasting and Social Change* 135: 99–111.

Davis DD and Bryant JL (2010) Leader-member exchange, trust, and performance in national science foundation industry/university cooperative research centers. *The Journal of Technology Transfer* 35(5): 511–526.

De Fuentes C and Dutrénit G (2012) Best channels of academia–industry interaction for long-term benefit. *Research Policy* 41/9: 1666–1682.

De Silva M, Al-Tabbaa O and Pinto J (2023) Academics engaging in knowledge transfer and co-creation: push causation and pull effectuation? *Research Policy* 52: 104668.

Del Campo AA, Sparks A, Hill RC, et al. (1999) The transfer and commercialization of university-developed medical imaging technology: opportunities and problems. *IEEE Transactions on Engineering Management* 46(3): 289–298.

Delorme D (2023) The role of proximity in the design of innovation intermediaries' business models. *Technological Forecasting and Social Change* 188: 122246. DOI: 10.1016/j.techfore.2022.122246.

Deveaud R, SanJuan E and Bellot P (2014) Accurate and effective latent concept modeling for ad hoc information retrieval. *Document Numérique* 17: 61–84.

Dooley L and Kirk D (2007) University-industry collaboration: grafting the entrepreneurial paradigm onto academic structures. *European Journal of Innovation Management* 10: 316–332.

Douma JC and Weedon JT (2019) Analysing continuous proportions in ecology and evolution: a practical introduction to beta and dirichlet regression. *Methods in Ecology and Evolution* 10: 1412–1430.

Edquist C (2006) Systems of innovation: perspectives and challenges. In: Fagerberg J, Mowery DC and Nelson RR (eds) *The Oxford Handbook of Innovation*. Oxford University Press, 181–208.

Faccin K, De Beer C, Martins BV, et al. (2022) What really matters for TTOs efficiency? An analysis of TTOs in developed and developing economies. *The Journal of Technology Transfer* 47/4: 1135–1161.

Ferguson-Cradler G (2023) Narrative and computational text analysis in business and economic history. *Scandinavian Economic History Review* 71: 103–127.

Fitzgerald C and Cunningham JA (2016) Inside the university technology transfer office: mission statement analysis. *The Journal of Technology Transfer* 41: 1235–1246.

Franklin SJ, Wright M and Lockett A (2001) Academic and surrogate entrepreneurs in university spin-out companies. *The Journal of Technology Transfer 2001* 26(1): 127–141.

Frølund L and Ziethen M (2016) The wisdom of the intermediary: the role, function, and ways-of-being of the intermediary in a strategic program for university-industry relations. *Triple Helix* 3/1: 1–21.

Fukugawa N (2017) University spillover before the national innovation system reform in Japan. *International Journal of Technology Management* 73: 206–234.

Garrett-Jones S, Turpin T and Diment K (2010) Managing competition between individual and organizational goals in cross-sector research and development centres. *The Journal of Technology Transfer* 35: 527–546.

Geoghegan W, O'Kane C, Kane NA, et al. (2015) Technology transfer offices as a nexus within the triple helix: the progression of the university's role. *International Journal of Technology Management* 68: 255–277.

Gerbin A and Drnovsek M (2016) Determinants and public policy implications of academic-industry knowledge transfer in life sciences: a review and a conceptual framework. *The Journal of Technology Transfer* 41: 979–1076.

Gillings M and Hardie A (2023) The interpretation of topic models for scholarly analysis: an evaluation and critique of current practice. *Digital Scholarship in the Humanities* 38: 530–543.

Giuri P, Grimaldi R, Kochenkova A, et al. (2018) The effects of university-level policies on women's participation in academic patenting in Italy. *The Journal of Technology Transfer* 45(45/1): 122–150.

Good M, Knockaert M, Soppe B, et al. (2019) The technology transfer ecosystem in academia. An organizational design perspective. *Technovation* 82-83: 35–50.

Gray D, McGowen L, Michaelis TL, et al. (2022) A policy mix experiment to promote start-up success: exploratory evaluation of the NSF small business innovation research (SBIR)/industry university cooperative research center (IUCRC) membership supplement. *The Journal of Technology Transfer* 47: 176–212.

Griffiths TL and Steyvers M (2004). 'Finding scientific topics', In *Proceedings of The National Academy of Sciences of the United States of America*. National Academy of Sciences. 1. DOI: 10.1073/pnas.0307752101.

Gusberti TDH and Bretas AC (2018) Diagnosis of the market for ideas and the role of industrial associations as intermediaries in the Brazilian context. *Industry and Higher Education* 32: 9–22.

Hannigan TR, Haans RFJ, Vakili K, et al. (2019) Topic modeling in management research: rendering new theory from textual data. *The Academy of Management Annals* 13(2): 586–632.

Harrison P, Loan J, Adler C, et al. (2023) *Review of the New Zealand product accelerator*. Octobre: Report, Ministry of Business, Innovation and Employment, NZ.

Heaton S, Siegel DS and Teece DJ (2019) Universities and innovation ecosystems: a dynamic capabilities perspective. *Industrial and Corporate Change* 28: 921–939.

Hecking T and Leydesdorff L (2019) Can topic models be used in research evaluations? Reproducibility, validity, and reliability when compared with semantic maps. *Research Evaluation* 28: 263–272.

Hellmann T (2007) The role of patents for bridging the science to market gap. *Journal of Economic Behavior & Organization* 63: 624–647.

Henry A (2021) *Understanding Strategic Management*. 4th edition. Oxford: Oxford University Press.

Hens L, Cabello-Eras JJ, Sagastume-Gutiérez A, et al. (2017) University–industry interaction on cleaner production. The case of the cleaner production center at the university of Cienfuegos in Cuba, a country in transition. *Journal of Cleaner Production* 142: 63–68.

Horner S, Jayawarna D, Giordano B, et al. (2019) Strategic choice in universities: managerial agency and effective technology transfer. *Research Policy* 48: 1297–1309.

Hülsbeck M, Lehmann EE and Starnecker A (2013) Performance of technology transfer offices in Germany. *The Journal of Technology Transfer* 38/3: 199–215.

Huyghe A, Knockaert M, Wright M, et al. (2014) Technology transfer offices as boundary spanners in the pre-spin-off process: the case of a hybrid model. *Small Business Economics* 43(2): 289–307.

Huyghe A, Knockaert M, Piva E, et al. (2016) Are researchers deliberately bypassing the technology transfer office? An analysis of TTO awareness. *Small Business Economics* 47: 589–607.

Kalantaridis C and Küttim M (2020) University ownership and information about the entrepreneurial opportunity in commercialisation: a systematic review and realist synthesis of the literature. *The Journal of Technology Transfer* 2020: 1–27.

Kaufmann A and Tödtling F (2002) How effective is innovation support for SMEs? An analysis of the region of Upper Austria. *Technovation* 22/3: 147–159.

Kenney M and Patton D (2009) Reconsidering the bayh-dole act and the current university invention ownership model. *Research Policy* 38: 1407–1422.

Kim Y-C, Rhee M and Kotha R (2019) Many hands: the effect of the prior inventor-intermediaries relationship on academic licensing. *Research Policy* 48: 813–829.

Kodama T (2008) The role of intermediation and absorptive capacity in facilitating university-industry linkages-An empirical study of TAMA in Japan. *Research Policy* 37: 1224–1240.

Kolf RC (1982) Sea grant - a new university-industry cooperative program for development of ocean technology. *The Journal of Technology Transfer* 6: 21–26.

Lee K and Jung HJ (2021) Does TTO capability matter in commercializing university technology? Evidence from longitudinal data in South Korea. *Research Policy* 50: 104133.

Leitch CM and Harrison RT (2005) Maximising the potential of university spin-outs: the development of second-order commercialisation activities. *R & D Management* 35: 257–272.

Leonchuk O and Gray DO (2019) Scientific and technological (human) social capital formation and industry–university cooperative research centers: a quasi-experimental evaluation of graduate student outcomes. *The Journal of Technology Transfer* 44: 1638–1664.

Li J, Gong Y and Li H (2024) Looking back to move forward: bibliometric and visual analysis of knowledge transfer in university-industry collaboration. *IEEE Access* 12: 32278–32297.

Lockett A and Wright M (2005) Resources, capabilities, risk capital and the creation of university spin-out companies. *Research Policy* 34: 1043–1057.

Lockett A, Wright M and Franklin S (2003) Technology transfer and universities' spin-out strategies. In: *Small Business Economics*. Springer. DOI: 10.1023/A:1022220216972.

Lundqvist MA (2014) The importance of surrogate entrepreneurship for incubated Swedish technology ventures. *Technovation* 34: 93–100.

Macho-Stadler I, Pérez-Castrillo D and Veugelers R (2007) Licensing of university inventions: the role of a technology transfer office. *International Journal of Industrial Organization* 25/3: 483–510.

Markman GD, Phan PH, Balkin DB, et al. (2005) Entrepreneurship and university-based technology transfer. *Journal of Business Venturing* 20: 241–263.

Martin BR and Johnston R (1999) Technology foresight for wiring up the national innovation system: experiences in britain, Australia, and New Zealand. *Technological Forecasting and Social Change* 60/1: 37–54.

Mathisen L and Jørgensen EJB (2021) The significance of knowledge readiness for co-creation in university industry collaborations. *Innovation: Organization and Management* 23/4: 534–551.

McAdam R, Miller K, McAdam M, et al. (2012) The development of university technology transfer stakeholder relationships at a regional level: lessons for the future. *Technovation* 32: 57–67.

Mendonça S (2014) National adaptive advantages: soft innovation and marketing capabilities in periods of crisis and change. *Structural Change, Competitiveness and Industrial Policy: Painful Lessons from the European Periphery*. Routledge, 133–150.

Micozzi A, Iacobucci D, Martelli I, et al. (2021) Engines need transmission belts: the importance of people in technology transfer offices. *The Journal of Technology Transfer* 46: 1551–1583.

Miller K, Mcadam M and Mcadam R (2014) The changing university business model: a stakeholder perspective. *R & D Management* 44: 265–287.

Mosey S, Westhead P and Lockett A (2007) University technology transfer: network bridge promotion by the medici fellowship scheme. *Journal of Small Business and Enterprise Development* 14: 360–384.

Mukherji N and Silberman J (2021) Knowledge flows between universities and industry: the impact of distance,

technological compatibility, and the ability to diffuse knowledge. *The Journal of Technology Transfer* 46: 223–257.

Nasirov S and Joshi AM (2023) Minding the communications gap: how can universities signal the availability and value of their scientific knowledge to commercial organizations? *Research Policy* 52: 104870. DOI: 10.1016/j.respol.2023.104870.

Neal JW, Posner S and Brutzman B (2023) Understanding brokers, intermediaries, and boundary spanners: a multi-sectoral review of strategies, skills, and outcomes. *Evidence & Policy* 19: 95–115.

Noack A and Jacobsen H (2021) Transfer scouts: from intermediation to co-constructors of new knowledge and technologies in Germany. *Research Policy* 50: 104209.

Ozdemir S, Carlos Fernandez de Arroyabe J, Sena V, et al. (2023) Stakeholder diversity and collaborative innovation: integrating the resource-based view with stakeholder theory. *Journal of Business Research* 164: 113955.

O'Kane C (2018) Technology transfer executives' backwards integration: an examination of interactions between university technology transfer executives and principal investigators. *Technovation* 76–77: 64–77.

O'Kane C, Mangematin V, Geoghegan W, et al. (2015) University technology transfer offices: the search for identity to build legitimacy. *Research Policy* 44/2: 421–437.

O'Kane C, Cunningham JA, Menter M, et al. (2020) The brokering role of technology transfer offices within entrepreneurial ecosystems: an investigation of macro–meso–micro factors. *The Journal of Technology Transfer* 2020: 1–31.

O'Shea RP, Allen TJ, Morse KP, et al. (2007) 'Delineating the anatomy of an entrepreneurial university: the Massachusetts Institute of Technology experience'. *R & D Management* 37: 1–16.

Panagopoulos A and Carayannis EG (2013) A policy for enhancing the disclosure of university faculty invention. *The Journal of Technology Transfer* 38: 341–347.

Parrilli MD and Heras HA (2016) STI and DUI innovation modes: scientific-Technological and context-specific nuances. *Research Policy* 45/4: 747–756.

Phongthiya T, Malik K, Niesten E, et al. (2022) Innovation intermediaries for university-industry R&D collaboration: evidence from science parks in Thailand. *The Journal of Technology Transfer* 47: 1885–1920.

Ramaciotti L and Rizzo U (2015) The determinants of academic spin-off creation by Italian universities. *R & D Management* 45: 501–514.

Ratinho T, Amezcua A, Honig B, et al. (2020) Supporting entrepreneurs: a systematic review of literature and an agenda for research. *Technological Forecasting and Social Change* 154: 119956.

Resende DN, Gibson D and Jarrett J (2013) BTP - best transfer practices. A tool for qualitative analysis of tech-transfer offices: a cross cultural analysis. *Technovation* 33: 2–12.

Rodríguez-Gulías MJ, Rodeiro-Pazos D, Fernández-López S, et al. (2018) The role of venture capitalist to enhance the growth of Spanish and Italian university spin-offs. *The International Entrepreneurship and Management Journal* 14/4: 1111–1130.

Rossi F, Rosli A and Yip N (2017) Academic engagement as knowledge co-production and implications for impact: evidence from knowledge transfer partnerships. *Journal of Business Research* 80: 1–9.

Rossoni AL, de Vasconcellos EPG and de Castilho Rossoni RL (2023) Barriers and facilitators of university-industry collaboration for research, development and innovation: a systematic review. In: *Management Review Quarterly*. Institute for Ionics. DOI: 10.1007/s11301-023-00349-1.

Ruess AK, Müller R and Pfotenhauer SM (2023) Opportunity or responsibility? Tracing co-creation in the European policy discourse. *Science and Public Policy* 50/3: 433–444.

Santos AB, Bogers MLAM, Norn MT, et al. (2021) Public policy for open innovation: opening up to a new domain for research and practice. *Technological Forecasting and Social Change* 169: 120821.

Santos AT and Mendonça S (2022) 'Do papers (really) match journals' "aims and scope"? A computational assessment of innovation studies. *Scientometrics* 127(12): 7449–7470.

Santos TN, Dias JG and Mendonça S (2023) University–industry cooperation: a taxonomy of intermediaries. *Science and Public Policy* 50(3): 457–490.

Schmiedel T, Müller O and vom Brocke J (2018) Topic Modeling as a Strategy of Inquiry in Organizational Research: A Tutorial With an Application Example on Organizational Culture. *SAGE Publications* 22/4: 941–968. DOI: 10.1177/1094428118773858.

Segarra-Blasco A and Arauzo-Carod JM (2008) Sources of innovation and industry-university interaction: evidence from Spanish firms. *Research Policy* 37(8): 1283–1295.

Teirlinck P and Spithoven A (2012) Fostering industry-science cooperation through public funding : differences between universities and public research centres. *The Journal of Technology Transfer* 37: 676–695.

Temel S, Dabić M, Murat Ar I, et al. (2021) Exploring the relationship between university innovation intermediaries and patenting performance. *Technology in Society* 66: 101665. DOI: 10.1016/j.techsoc.2021.101665.

Theeranattapong T, Pickernell D and Simms C (2021) Systematic literature review paper: the regional innovation system-university-science park nexus. *The Journal of Technology Transfer* 46: 2017–2050.

Trune DR and Goslin LN (1998) University technology transfer programs: a profit/loss analysis. *Technological Forecasting and Social Change* 57: 197–204.

Vázquez MA, Pereira-Delgado J, Cid-Sueiro J, et al. (2022) Validation of scientific topic models using graph analysis and corpus metadata. *Scientometrics* 127/9: 5441–5458.

Villani (2013) How external support May mitigate the barriers to university-industry collaboration. *Economia e Politica Industriale* 40/4: 117–145.

VillaniRasmussen EE, Grimaldi R and Grimaldi R (2017) How intermediary organizations facilitate university–industry technology transfer: a proximity approach. *Technological Forecasting and Social Change* 114: 86–102.

Weckowska DM (2015) Learning in university technology transfer offices: transactions-focused and relations-focused approaches to commercialization of academic research. *Technovation* 41–42: 62–74.

Wehrheim L (2019) Economic history goes digital: topic modeling the journal of economic history. *Cliometrica* 13: 83–125.

WIPO (2017) *World Intellectual Property Report 2017 – Intangible Capital in Global Value Chains*. Geneve, Switzerland. Retrieved June 26, 2021, from: https://www.wipo.int/publications/en/details.jsp?id=4225&plang=EN

Wright M, Lockett A, Clarysse B, et al. (2006) University spin-out companies and venture capital. *Research Policy* 35: 481–501.

Xu Z, Parry ME and Song M (2011) The impact of technology transfer office characteristics on university invention disclosure. *IEEE Transactions on Engineering Management* 58: 212–227.

Yusuf S (2008) Intermediating knowledge exchange between universities and businesses. *Research Policy* 37: 1167–1174.

Ziedonis AAV, Nelson RR and Sampat BN (2020) *Ivory Tower and Industrial Innovation. Ivory Tower and Industrial Innovation*. Stanford University Press. DOI: 10.1515/9780804796361.

Appendix

Table A1. The most representative paper in each topic.

Topic	Most representative paper	Journal's quartil*	Journal's disciplinary areas
1	Del Campo et al. (1999) The transfer and commercialisation of university-developed medical imaging technology: Opportunities and problems, IEEE Transactions on Engineering Management.	1	Electrical and Electronic Engineering Strategy and Management
2	Lundqvist (2014) The importance of surrogate entrepreneurship for incubated Swedish technology ventures, Technovation.	1	Engineering (miscellaneous) Management of Technology and Innovation
3	Segarra-Blasco and Arauzo-Carod (2008) Sources of innovation and industry-university interaction: Evidence from Spanish firms, Research Policy.	1	Engineering (miscellaneous) Management Science and Operations Research Management of Technology and Innovation Strategy and Management
4	Hellmann (2007) The role of patents for bridging the science to market gap, Journal of Economic Behavior and Organization.	1	Economics and Econometrics Organisational Behavior and Human Resource Management
5	O'Kane et al. (2015) University technology transfer offices: The search for identity to build legitimacy, Research Policy.	1	Engineering (miscellaneous) Management Science and Operations Research Management of Technology and Innovation Strategy and Management
6	Gray et al. (2022) A policy mix experiment to promote start-up success: exploratory evaluation of the NSF Small Business Innovation Research (SBIR)/Industry University Cooperative Research Center (IUCRC) membership supplement, Journal of Technology Transfer.	1	Engineering (miscellaneous) Accounting Business and International Management
7	Mukherji and Silberman (2021) Knowledge flows between universities and industry: the impact of distance, technological compatibility, and the ability to diffuse knowledge, Journal of Technology Transfer.	1	Engineering (miscellaneous) Accounting Business and International Management
8	Albats et al. (2022) Traditional, virtual, and digital intermediaries in university-industry collaboration: exploring institutional logics and bounded rationality, Technological Forecasting and Social Change.	1	Applied Psychology Business and International Management Management of Technology and Innovation

*Extracted from SCIMAGOJR – Data Source: Scopus.

Table A2. Bibliometric information on the Topics.

Topic	# of papers	Publication year (Average)	Publication year (Median)	Top journals
1	26	2003.96	2006	• *The Journal of Technology Transfer* • *International Journal of Technology Management*
2	18	2009.78	2008	• *The Journal of Technology Transfer* • *Research Policy*
3	17	2010.41	2008	• *Research Policy* • *The Journal of Technology Transfer*
4	16	2011.63	2011	• *The Journal of Technology Transfer* • *Research Policy*
5	12	2015.33	2015	• *The Journal of Technology Transfer* • *Technovation*
6	7	2010.25	2016	• *The Journal of Technology Transfer* • *Technological Forecasting and Social Change* • *IEEE Transactions on Engineering Management*
7	33	2014.85	2016	• *The Journal of Technology Transfer* • *Research Policy* • *Technovation*
8	19	2016.53	2018	• *Technological Forecasting and Social Change* • *The Journal of Technology Transfer* • *Technovation*

Table A3. Papers for each topic that have a γ (gamma) larger or equal to 0.5.

Topic	Paper with γ larger or equal to 0.5
1	Carr (1992)
	Collins & Wakoh (2000)
	Del Campo et al. (1999)
	Kolf (1982)
	Trune & Goslin (1998)
2	Franklin et al. (2001)
	Leitch & Harrison. (2005)
	Lockett et al. (2003)
	Lundqvist (2014)
	Wright et al. (2006)
3	Bodas Freitas (2013)Cabral (1998)
	Fukugawa (2017)
	Kaufmann & Tödtling (2002)
	Kodama (2008)
	Segarra-Blasco and Arauzo-Carod (2008)
	Teirlinck & Spithoven (2012)
	Theeranattapong et al. (2021)
4	Arqué-Castells et al. (2016)
	Hellmann (2017)
	Kalantaridis & Küttim (2020)
	Kenney & Patton (2009)
	Kim et al. (2019)
	Macho-Stadler et al. (2007)
	Panagopoulos & Carayannis (2013)
5	Fitzgerald & Cunningham (2016)
	McAdam et al. (2012)
	Miller et al. (2014)
	O'Kane et al. (2020)
	O'Kane (2018)
	(O'Kane et al., 2015; Weckowska 2015)
6	Boardman & Ponomariov (2014)
	Davis & Bryant (2010)
	Leonchuk & Gray (2019)
	Gray et al. (2022)
7	Algieri et al. (2013)
	Barra & Zotti (2018)
	Caldera & Debande (2010)
	Chapple et al. (2005)
	Gerbin & Drnovsek (2016)
	Giuri et al. (2018)
	Hülsbeck et al. (2013)
	Lee & Jung (2021)
	Micozzi et al. (2021)
	Mukherji & Silberman (2021)
	Ramaciotti & Rizzo (2015)
	Xu et al. (2011)
8	Good et al. (2019)
	Noack & Jacobsen (2021)
	Resende et al. (2013)
	Villani et al. (2017)
	Chan et al. (2022)
	Delorme (2023)
	Albats et al. (2022)
	Phongthiya et al. (2022)