

*Original Research*

## **Analyzing Review Studies and Bibliometrics of University-Industry Interaction Using Scoping Review<sup>1</sup>**

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### **Abstract**

With the increase in studies in the field of university-industry cooperation, the need to integrate studies that have investigated the research process of this interaction has become more apparent. In this regard, the present study analyzed reviews and bibliometric studies on the interaction between universities and industry using a scoping review. The guide by Daudt, Van Mossel, and Scott (2013) serves as the basis for conducting the scoping review. We used international databases, and 2,590 articles were retrieved. After sampling according to the PRISMA diagram and using the JBI Institute to assess the quality of the selected sources, 64 articles were selected for the final analysis. A review of studies analyzing university-industry interaction showed that research publications in this field have grown despite random fluctuations. Various factors account for the growth of studies in this field, including transforming the missions and activities of universities by moving towards entrepreneurship and the commercialization of research, the formation of entrepreneurial universities, the expansion of technology transfer offices, the growth of university inventions, and the expansion of research collaborations. The most crucial obstacle to university-industry alliances is the difference in their goals and missions. Intermediary institutions, especially science parks and incubators, are essential for effective communication between universities and industry. Some of the most critical topics in University-Industry Interaction are innovation, economic development, sustainable development, science parks and incubators, start-ups, spin-offs, knowledge transfer, technology transfer, entrepreneurship, and research commercialization.

**Keywords:** Review Studies, Bibliometrics, University-Industry Interaction, Scoping Review.

### **Introduction**

The importance of knowledge exchange among organizations, especially universities and private organizations, has been widely recognized as essential. A look at the economic and innovation situation in developed countries shows that their progress and efficiency can be due to the production of knowledge and its use in industries (Chen, Ye, Huang, Wang, Cai, Deng & Ren, 2023) and consequently achieving competitive advantages in global markets (Leydesdorff & Meyer, 2006; Enkel, Gassmann & Chesbrough, 2009; Freitas, Geuna & Rossi, 2013). For this reason, university-industry collaboration is considered a source for the production and transfer of knowledge, a driver of progress in new technologies and of economic

competitiveness and innovation development (Bishop, D'Este & Neely, 2011; D'Este, Guy & Iammarino, 2013). This collaboration includes joint research, research contracts, or consulting, the results of which can be implemented in technology transfer for commercialization purposes (Perkmann et al., 2013; Leydesdorff, Park & Lengyel, 2014; Berbegal-Mirabent, Sa´nchez Garcı´a & Ribeiro-Soriano, 2015).

Different companies and organizations follow a vital path to achieve innovation: investing in research and development (R&D); innovative activities are strongly related to joint research and development projects (Belussi, Sammarra & Sedita, 2010). Previous studies have highlighted the positive relationship between research and development investments and innovation performance (Faems, De Visser, M Andries & Van Looy, 2010). Therefore, since universities are a permanent source of knowledge production, they have become an essential partner for research and development companies. Through this collaboration, knowledge from the production sector is used to develop or improve products and processes. To this end, it is necessary to study the relationship between universities and industries as a way to enhance innovation through the exchange of knowledge and technology (Etzkowitz & Leydesdorff, 2000; Ankrah & Al-Tabbaa, 2015) and to use the achievements and results of this relationship to cope with economic and social challenges (Salter & Martin, 2001; Perkmann et al., 2013; Lehmann & Menter, 2016; Skute, Zalewska-Kurek, Hatak & Weerd-Nederhof, 2019).

University-industry collaboration has always interested policymakers and planners of governments and universities, given that it can result in effective outcomes for sustainable development, particularly in knowledge and technology production. Studies have increased in this area, along with a better understanding of the consequences and benefits of university-industry collaboration. Therefore, university-industry partnerships have become essential for researchers, policymakers, and investors (Murashova & Loginova, 2017). This growing interest can be attributed to the recognition of various benefits of collaboration, such as innovation, competition, and economic progress (Skute et al., 2019). The growth of research in this area has provided an opportunity to examine and analyze the evolution of these studies. Thus, studies with the aim of text analysis began along with an increase in research in the field of university-industry interaction. The primary studies of university-industry collaboration using different approaches, such as systematic review (Ankrah & Al-Tabbaa, 2015; Arenas & González, 2018; Nsanzumuhire & Groot, 2020; Pesti, Tamášová, Lajčín & Bodonyi 2021), meta-analysis (Sjöö & Hellström, 2019), and bibliometrics (Mascarenhas, Ferreira & Marques, 2018; Skute et al., 2019; Bastos, Sengik & Tello-Gamarra, 2021; Borges et al., 2022) have analyzed the trend of scientific outputs of university-industry interaction. Attention has also been paid to researching the studies conducted in this field. Collaboration between universities, industry, and government is increasingly crucial for producing new knowledge and promoting innovation. This is evident in the significant increase in studies examining the topic from different perspectives (Ankrah & Al-Tabbaa, 2015). However, exploring the factors that drive collaboration dynamics is worth considering. While these studies have provided important insights into various aspects of university-industry interaction, the present research aims to examine studies that analyze the content, structure, and trends of the field of university-industry interaction using review and bibliometric methods through a scoping review. The results of this research can help develop research in this field and overcome the barriers to university-industry collaboration and, consequently, contribute to economic development.

### Research objectives

The current research was conducted to analyze review and bibliometric research on university-industry interaction to identify the publication process and format, approaches and methods, the source of research data, and thematic areas. In addition, this research has examined the most influential factors and significant obstacles affecting university-industry cooperation.

### Materials and Methods

The present research used a scoping review method. For this purpose, the guide by Daudt et al. (2013) served as the basis for conducting the scoping review. In their study, the researchers used the framework proposed by Arksey and O'Malley (2005). The advantage of studies performed using the scoping review method is that in a relatively shorter period (compared to a full systematic review), they accurately and transparently show the types of key concepts and existing evidence in a specific field (ibid). One limitation of scoping review studies is that they do not assess the quality of the sources under analysis. In subsequent studies, various researchers expressed concern about the framework proposed by Arksey and O'Malley's inability to assess the quality of sources in scoping reviews. They suggested that quality assessment using valid, standardized tools should be an essential part of scoping review studies, and that this should be considered in the framework proposed by Arksey and O'Malley (Levac, Colquhoun & O'Brien, 2010; Daudt et al., 2013). Therefore, in the present research, the quality assessment of the selected works was conducted using the JBI critical appraisal checklist (designed by the Joanna Briggs Institute-JBI), a standard tool for evaluating research (Aromataris, Fernandez, Godfrey, Holly, Kahlil & Tungpunkom, 2015). Each question on this checklist includes four options: yes, no, unclear, and not applicable.

Based on the evaluation results, the studies were categorized into three groups: strong (score greater than 75%), moderate (score greater than 50%), and weak (score less than 50%). Based on the guide of Arksey and O'Malley (2005), the steps of conducting the present research were as follows:

**A. Developing research objectives:** The present research was conducted to analyze review and bibliometric studies of university-industry interaction in terms of publication trend, publication format, approaches, and methods, data sources of research, the most critical barriers and factors affecting university-industry collaboration, the benefits of this partnership, and the most important thematic axes of research in this field.

**B. Identifying relevant sources:** ScienceDirect, Emerald, EBSCO, Scopus, Web of Science, and Springer were searched to retrieve relevant studies. Existing glossaries, expert opinions, and a review of keywords assigned to articles in this field were used to select the search terms. The articles under analysis were first searched and retrieved by visiting each database and searching the title, subject, keyword, and abstract fields in the advanced search function. Table 1 shows the search strategy.

*Table 1*

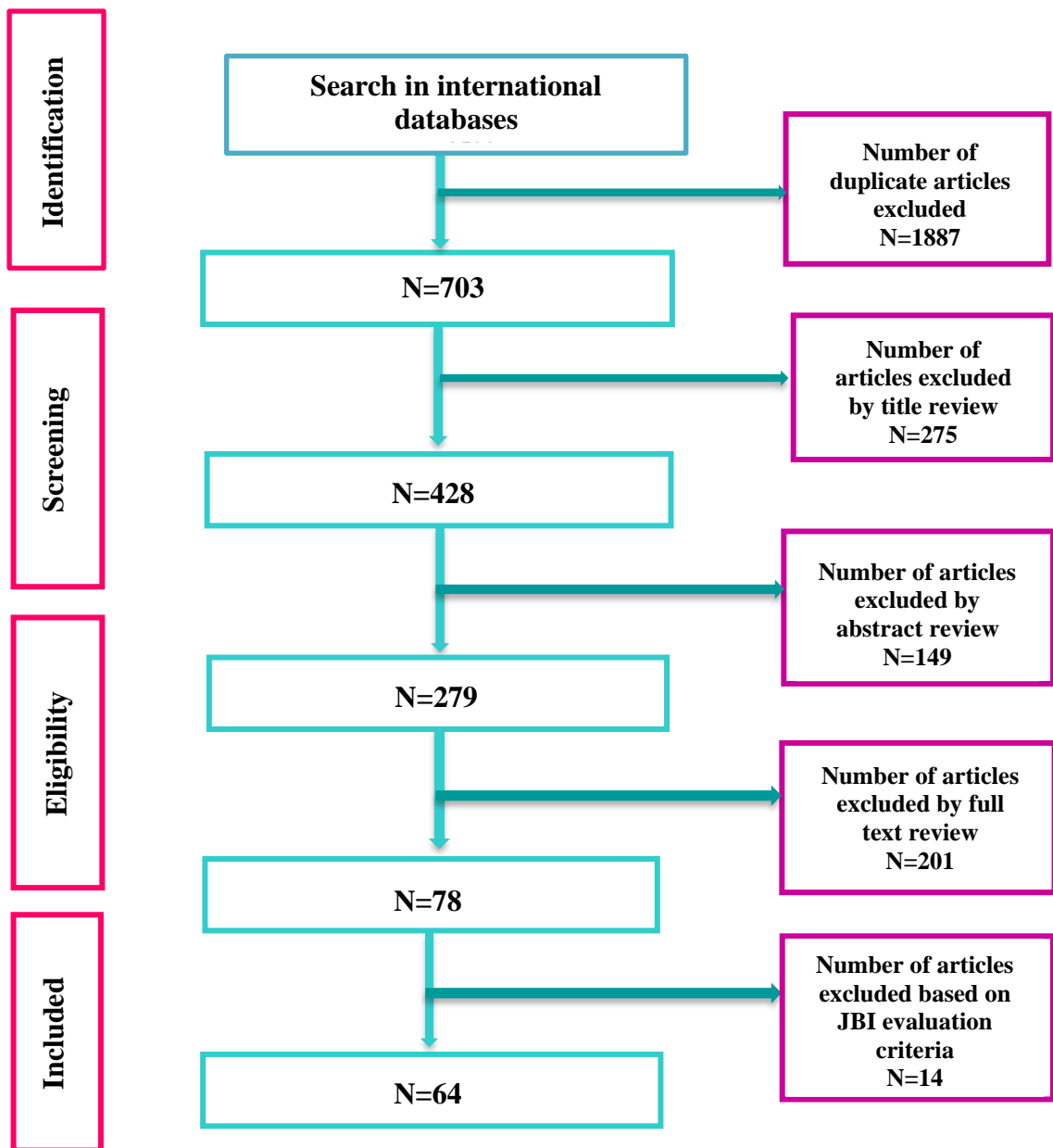
*Search strategy in databases*

("university" OR "academy" OR "higher education institution") AND ("business" OR "industry" OR "firm" OR "company" OR "enterprise" OR "science park" OR "innovation park" OR "technology park" OR "incubation center" OR "spin-off" OR "start-up") AND ("collaboration" OR "cooperation" OR "interaction" OR "link\*" OR "partnership" OR

"relation\*" OR "agreement") AND ("bibliometric\*" OR "scientometric\*" OR "literature review" OR "systematic review"))

After applying the search strategy, 2,590 records from international English-language databases were retrieved. No time limit was applied to the search and retrieval of information from databases to ensure the present research was comprehensive (the last search was conducted on May 4, 2023).

**C. Selecting sources:** The PRISMA diagram was used for the sampling and data selection. Accordingly, the list of sources obtained from searching English databases was examined from different aspects: identifying and removing duplicate titles; examining the relevance of the titles of the works to the objectives of the present study; determining the significance of the abstract to the objectives of this study; examining the full text of the research and their relationship with the objectives of the article; and examining the suitability of the works with the defined criteria for entering the review of studies. The criteria for selecting works in the present research are a) research that focuses on analyzing research on university-industry interaction with review and bibliometric approaches, and b) sources published in English at the international level. The criteria for removing articles from the study are: a) research that has addressed different aspects of university-industry interaction without examining the texts in this field; b) works that lacked an abstract and their full text was not available; c) translated sources, reports, abstracts, sessions, and editorials; and d) researches that had weaknesses according to JBI checklist and did not have sufficient competence. In total, 78 articles were identified as relevant for review. Based on the research evaluation results, 14 works were excluded from the review process because they did not meet the required quality according to JBI indicators. Finally, after applying quality assessment indicators, 64 articles were selected for final analysis (Figure 1).



*Figure 1: PRISMA diagram-based search steps and final selection of analyzed studies for reviewing studies*

Table 2 shows the retrieved sources from each database and the number of selected sources for final analysis.

Table 2

*Number of Retrieved and Selected Resources for Final Analysis*

Databases	Number of retrieved articles after applying the search strategy
Scopus	1072
Web of Science	482
ScienceDirect	463
Emerald	290
Springer	189
EBSCO	94
Total	2,590
Number of selected articles for final analysis	64

**D. Information extraction:** In this stage, based on the study's objectives, the required data were extracted from the analyzed research text, and the key topics and themes were described (Arksey & O'Malley, 2005). In the present study, a checklist was prepared, and information on the selected research to be included in the study was recorded. The inventory included bibliographic details (such as article title, author names, year of publication, journal title, etc.), study objectives, research methods, and a summary of findings and results related to the objectives of the present study. Each study was reviewed, and the sections about the current research objectives were selected and included in the checklist. Then, similar and overlapping topics were merged, and each author's findings were presented under each objective.

**E. Discussion and analysis of information and presentation of results:** Conceptual review studies aim to provide an overview of all the topics reviewed. Tables or charts display this information (Arksey & O'Malley, 2005). In the present research, data extracted from the sources' texts and their findings are presented in tables, images, and charts.

## Results

### Analysis of Review and bibliometrics Studies on university-industry Interaction: Examining the Trends and Publication Format, Approaches, Methods, and Research Data Sources

Various studies have analyzed research conducted on university-industry collaboration using review and bibliometrics methods at the international level. The main objectives of analyzing studies in this field include examining the interaction channels, mechanisms, operational stages, and processes of university-industry collaboration (Ankrah & Al-Tabbaa, 2015; Nsanzumuhire & Groot, 2020; Baleeiro Passos, Valle Enrique, Costa Dutra & Schwengber ten Caten, 2023), presenting a method, model or system for evaluating university-industry collaborations (Piva & Rossi-Lamastra, 2013; Chen, Zhang, Jin & Wang, 2022; Chen, Jin, Wang & Xiong, 2022); challenges, benefits, consequences and factors affecting the success of collaborations between universities and industries (Prigge, 2005; Thune, 2009; Ankrah & Al-Tabbaa, 2015; Garousi, Petersen & Ozkan, 2016; Rybnicek & Königgruber, 2019; Marinho, Silva & Santos, 2020; Barbosa, Fernandes & Tereso, 2023).

Researchers have used review approaches, qualitative content analysis, and bibliometrics methods, especially co-citation and keyword analysis, to examine various aspects of research in this field (including the growth trend of studies, topic trends through analysis of the most commonly used keywords, most influential authors, most participating countries in research, top published journals, prominent educational and research institutions, most cited studies, etc.) (Valentin & Sánchez, 2002; Tijssen, van Leeuwen & van Wijk, 2009; Teixeira & Mota, 2012; Feng, Zhang, Du & Wang., 2015; Mascarenhas, Ferreira & Marques, 2018; Skute et al. 2019; Bastos et al., 2021; Borges et al., 2022). Some of these studies have analyzed various aspects of research on university-industry collaboration in a particular country, such as examining university-industry collaborations in Britain (Calvert & Patel, 2003; Minguillo, Tijssen & Thelwall, 2015; Vick & Robertson, 2018), Italy (Abramo, D'Angelo, Di Costa & Solazzi, 2009; Abramo, D'Angelo & Solazzi, 2012), the United States (Zhou, Tijssen & Leydesdorff, 2016), China (Lei, Zhao, Zhang, Chen, Huang & Zhao, 2011; Fang, Zhang & Kim, 2021), Spain (Gomez, Antonia & Perandones, 2015); the Baltic Sea (Murashova & Loginova, 2017); South Africa (Zavale & Langa, 2018) and Denmark (Woltmann & Alkærsg, 2018). The bibliographic information of studies that have used review and bibliometrics methods in analyzing the content, structure, and thematic trends of research on university-industry interaction is presented in the table in the appendix.

According to the findings of this study, 64 articles were published at the international level to analyze and review studies on university-industry interaction from 2000 to early 2023. Figure 2 shows the time range and frequency of research publications in this field during different years. According to Figure 2, 2001 can be considered the starting point for these studies. Along with the growth of studies on university-industry collaboration in the past two decades (Bastos et al., 2021; Burbridge & Morrison, 2021), attention has been paid to review and bibliometrics studies in this field. As shown in Figure 2, the publication trend of these studies has increased. Most studies were conducted in 2018 and 2022.

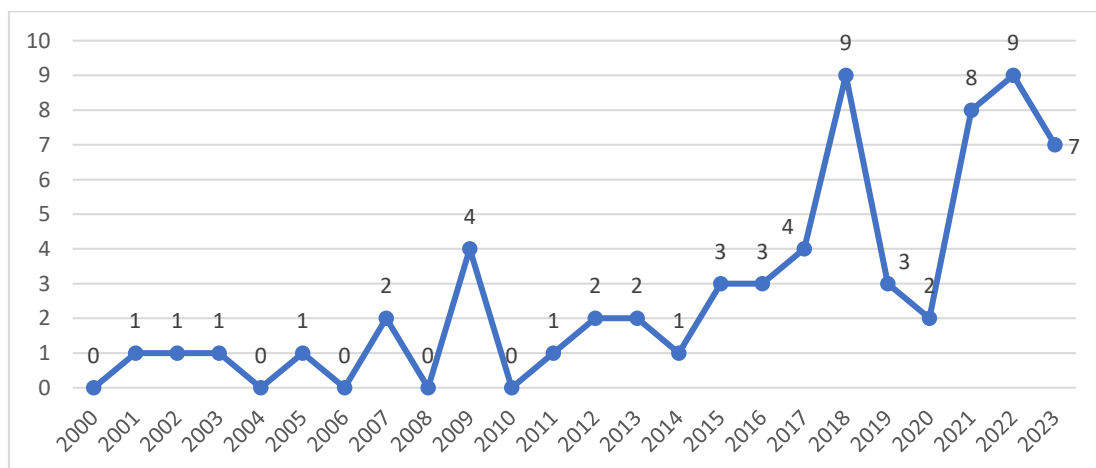


Figure 2: The period and frequency of research publications to analyze and review studies on university-industry interaction at the international level

The review of research approaches used to analyze and review studies on university-industry interaction shows that these studies have used various quantitative, qualitative, and mixed-methods approaches. Figure 3 shows the approaches in international studies in this field

during different periods. The chart shows that most studies have used qualitative methods to review and analyze texts in this regard. Mixed-methods approaches have received attention in recent years, and their use is increasing.

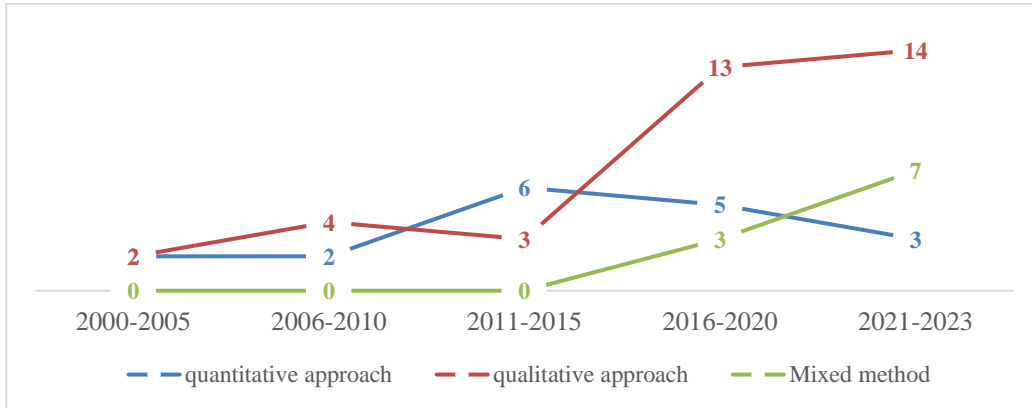


Figure 3: The approaches used in research studies to analyze and review research on university-industry interaction at the international level

The methods used in studies in this field are depicted in Figure 4. The most commonly used methods are systematic reviews based on full-text research analysis. The frequency of bibliometric methods based on the analysis of bibliographic features such as year of publication, authors and their organizational affiliations, citations, titles, abstracts, keywords, journals, countries, etc., is also significant. This is because patent analysis and critical review methods have been less considered than other methods. The appendix on the methods used in studies of content analysis of university-industry collaboration research shows that researchers used more valid and critical review methods in the early years of attention to this issue. In subsequent years, as understanding the importance of systematic approaches has increased, systematic review methods have been used more frequently, along with an increase in the volume of scientific production and the need to analyze large datasets. Bibliometrics methods have also been combined with systematic review methods to analyze and review studies in this field.



Figure 4: The methods used in research studies to analyze and review research on university-industry interaction at the international level

The most critical resource used to review studies on university-industry interaction is articles (84.37%). In contrast, other resources, such as patent data, books, book chapters, reports, notes,

and reviews, were used only minimally. A total of 64 articles were examined in this study to facilitate a comprehensive review and bibliometric analysis of university–industry interaction. The literature was retrieved from multiple scholarly databases, with the following distribution: Web of Science (21 articles, 32.8%), Scopus (16 articles, 25%), ScienceDirect (7 articles, 10.9%), ProQuest (5 articles, 7.8%), EBSCO (4 articles, 6.3%), Springer (4 articles, 6.3%), Google Scholar (4 articles, 6.3%), and Emerald (3 articles, 4.6%).

### **The most important thematic areas of study on university-industry interaction**

Since the beginning of studies on university-industry collaboration, subcategories and related subtopics in this field have received greater attention and are continually expanding. This led researchers to use bibliometric and systematic review tools to analyze subtopics, including innovation, knowledge transfer, technology transfer, entrepreneurship, and the commercialization of academic research. The main objectives of these studies are to review studies related to innovation, including identifying the driving or facilitating factors of collaborative innovation between universities and industries and providing a roadmap for fostering relationships between universities and industries with an *innovation* perspective (Perkmann & Walsh, 2007; Faisal, Chong & Voon Yee, 2017; Sjöo & Hellström, 2019; Pesti et al., 2021; Neves, Costa & Reis, 2021; Pujotomo, Syed Hassan, Ma'aram & Sutopo, 2023). Reviews are done of studies related to various aspects of *knowledge transfer* from university to industry, including knowledge transfer models, knowledge transfer process, obstacles and methods for facilitating knowledge transfer and presenting a new way for knowledge transfer (Agrawal, 2001; Geuna & Muscio, 2009; Faisal et al., 2017; Vick & Robertson, 2018; Woltmann & Alkær sig, 2018; de Wit-de Vries, Dolfsma, van der Windt & Gerkema, 2019; Figueiredo & Fernandes, 2020). The studies related to various dimensions of *technology transfer*, including qualitative subjects, processes, mechanisms and essential elements of technology transfer and the success factors and barriers of technology transfer from university to industry have been investigated in many researches (Miller, McAdam & McAdam, 2018; Cunningham, Menter & Young, 2017; Olvera, Berbegal-Mirabent & Merigo, 2018; Arenas & González, 2018; Brings, Daun, Brinckmann, Keller & Weyer, 2018; Lima, Torkomian, Pereira, Oprime & Hashiba, 2021; Pujotomo, Syed Hassan, Ma'aram & Sutopo 2023). The dominant and latent trends in decision-making studies, *university entrepreneurship*, green entrepreneurship, and entrepreneurial universities have been identified and analyzed in many studies (Rothaermel, Agung & Jiang, 2007; Miller, Alexander, Cunningham & Albats, 2018; Caputo, Pellegrini & Nikiforou, 2022; Pujotomo et al., 2023; Rossoni, de Vasconcellos & de Castilho Rossoni, 2023). The studies related to university-industry collaborations, university participation, and *commercialization of research* have been investigated in many analyses (Perkmanna et al., 2013; Olvera et al., 2018; Pujotomo et al., 2023).

The key thematic categories identified in studies on the interaction between academia and industry based on previous research (Teixeira & Mota, 2012; Feng et al., 2015; Mascarenhas et al., 2018; Skute et al., 2019; Figueiredo & Fernandes, 2020; Bastos et al., 2021; Neves et al., 2021; Borges et al., 2022; Figueiredo & Ferreira, 2022; Shah & Gillen, 2023; Pujotomo et al., 2023; Rossoni et al., 2023) are depicted in Figure 5.

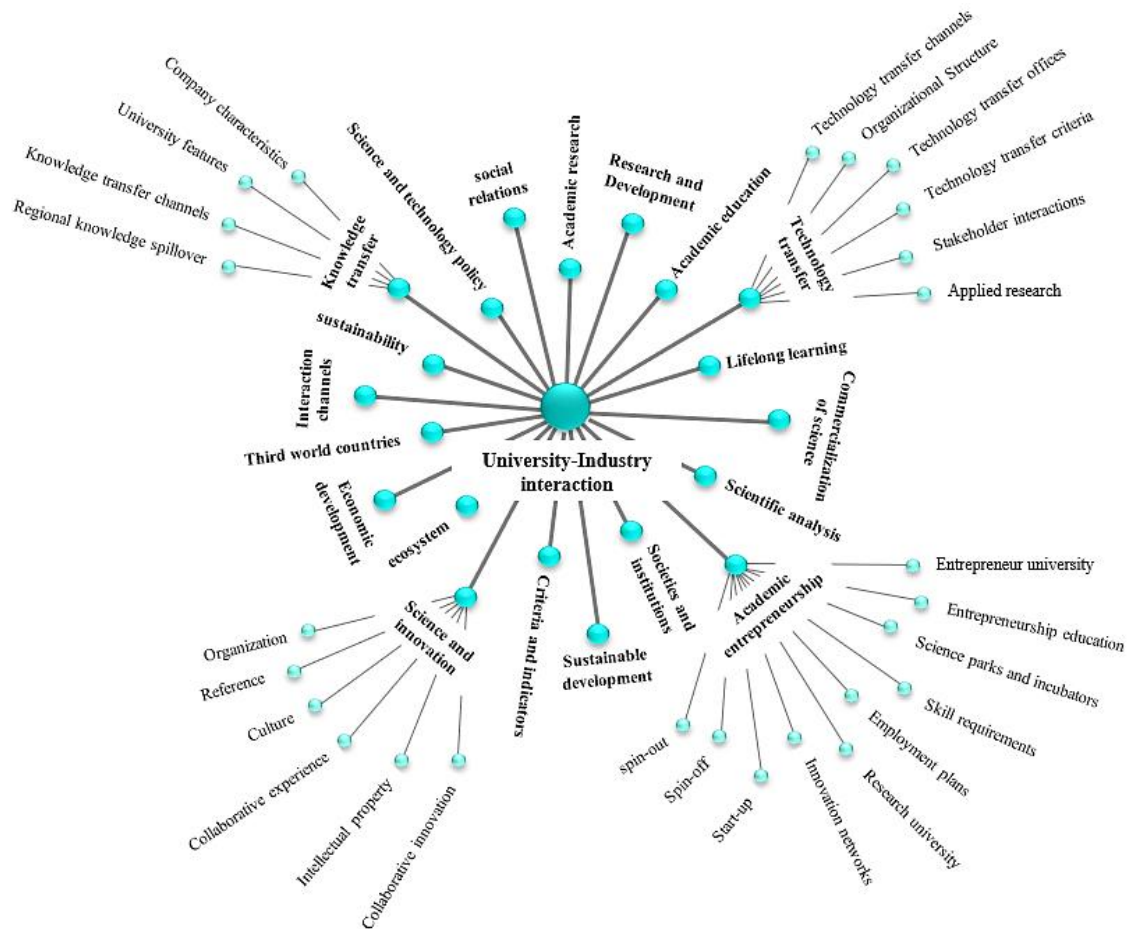


Figure 5: The key thematic categories of research on university-industry interaction

### The most significant barriers and influential factors in the interaction between academia and industry, and the benefits arising from this collaboration

According to the findings obtained from the literature review, the most influential factors on the collaboration between academia and industry are mentioned in Table 3 (Thune, 2009; Minguillo et al., 2015; Ankrah & Al-Tabbaa, 2015; Farré-Perdiguer, Sala-Rios & Torres-Solé, 2016; Diez-Vial & Montoro-Sanchez, 2017; Rybnicek & Königsgruber, 2019; de Wit-de Vries et al., 2019; Marinho et al., 2020; Lima et al., 2021; Malik, Bashir & Ali, 2021; Burbridge & Morrison, 2021; Sandoval Hamón, Ruiz Peñalver, Thomas & Fitjar, 2024; Rossoni et al., 2023). It should be noted that the factors listed in Table 3 have been prioritized according to their importance and emphasis in the analyzed sources.

Table 3

*The most influential factors in the collaboration between academia and industry based on previous studies*

<b>Main factors</b>	<b>Secondary factors</b>
Intermediary Institutions	Science parks, research parks, technology parks, innovation parks, incubators, and other science and technology and innovation centers
Institutional, Organizational, and Managerial Factors	Organizational culture, organizational structure, perspectives, and organizational strategies
Communication Management	Working as a team, being flexible and adaptable
Economic Factors	Budget, infrastructure, investment, and income generation, adequate human resources and facilities, and the emergence of new companies (start-ups and spin-offs)
Social Factors	Skills, qualifications, reputation, and credibility
Environmental Factors	Geographic proximity
Political Factors	Policies, legislation, and support factors such as tax credits
Legal factors and contractual mechanisms	Intellectual property rights, patents, licensing, contracting policies, and handling confidential information are inflexible university policies.
Professional Ethics	Honesty, commitment, mutual trust
Technology related factors	Development of information and communication tools and virtual networks
Other factors	Experience, motivation, awareness, and alertness

These collaborations can provide financial support for universities in their educational, research, and service missions. Additionally, students and faculty have experience identifying critical issues, fostering regional economic growth, improving business efficiency and value, and increasing student job opportunities (Prigge, 2005).

The benefits of research collaboration between universities and industries can be divided into the following factors (Barbosa et al., 2023):

1. Economic Factors: Optimizing organizational resources, reducing costs, and improving efficiency.
2. Strategic Factors: Planning and decision-making to achieve organizational goals, fostering long-term strategies, and enhancing competitiveness.
3. Technical and Operational Factors: Improving organizational processes, enhancing performance, and exchanging technical knowledge and expertise.
4. Social Factors: Facilitating knowledge transfer to society, promoting public engagement, and addressing societal challenges.
5. Cultural Factors: Improving and enhancing organizational norms and values, fostering a collaborative and innovative culture.

These factors collectively contribute to the advantages of research collaboration between universities and industries. Based on previous studies, the most critical obstacles to cooperation between universities and industries can be classified into five categories (Nsanzumuhire &

Groot, 2020):

1. Lack of Alignment (Inconsistency): Obstacles related to lack of coordination and synchronization between the university and industry.
2. Motivational Obstacles: Obstacles related to the motivation of both parties to engage in collaboration, such as conflicting goals or priorities.
3. Capacity-related Obstacles: Obstacles related to the university's or industry's capabilities and resources, such as limited research infrastructure or the industry's limited capacity to absorb research outcomes.
4. Organizational and Legal Obstacles: Obstacles related to organizational structures, policies, and legal frameworks that hinder collaboration between universities and industries.
5. Contextual Obstacles: Obstacles related to the broader context in which collaboration occurs, such as cultural differences, lack of trust, or limited opportunities for interaction.

The mentioned obstacles in previous studies (Prigge, 2005; Garousi et al., 2016; Brings et al., 2018; de Wit-de Vries et al., 2019; Marinho et al., 2020; Nsanzumuhire & Groot, 2020; Figueiredo & Fernandes, 2020; de Gois Marques, Dallegrave, Barbosa, de Oliveira Rodrigues, 2022; Zhuang & Shi, 2022; de Gois Marques, Dallegrave, de Oliveira, 2023; Rossoni et al., 2023; Fernandes et al., 2023; Cohen, Fernandes & Godinho, 2023) are listed in Table 4.

Table 4

*The most critical obstacles to collaboration between universities and industries based on previous studies*

Main obstacles	Secondary obstacles
Non-alignment obstacles (inconsistencies)	The requirements, expectations, priorities, needs, goals, and different methods of working
	University-industry cognitive distance and mismatch of perceptions
	Distinction in social, cultural, and economic roles causes a lack of mutual understanding.
	Conflicts of interest between university researchers and industry
	Organizational culture differences
	Confidentiality and privacy concerns
	Distrust (concern over possible plagiarism of ideas and the fear of competition from colleagues)
	Differences in organizational structure and rules
	Different trends and directions of university and industry research
	Conflicts over royalties on patents or other intellectual property rights
	Time synchronization problem
	Different programs between the industry and the university
Motivational barriers	Lack of proper communication among researchers
	Students and professors are not motivated to communicate with companies and enterprises.
	Reducing the commitment and lack of interest of companies and industries in cooperating with universities
	Repression of research colleagues' information
	Inadequate incentive mechanisms for sustained participation

Main obstacles	Secondary obstacles
	Insufficient trust in the local education system
	Professors' working conditions and low salaries
	Funding limitations in collaborative research, whether through university support, government grants, or industry investment
Barriers related to the university-industry ability	Deficiency of skills and knowledge
	Lack of experience
	Neglecting education and conducting seminars and workshops
	Problems in presenting and integrating new solutions
	Not allowing for continuous feedback and opportunity to learn during the collaboration process.
	Inadequate organizational support
	Infrastructure-related problems
	An inadequate understanding of the industry
Barriers arising from organizational and legal issues	Inadequate linkages between universities and companies (lack of collaborative infrastructure)
	The undermining of academic standards
	Change resistance and inflexibility.
	Organizational instability and inconsistency
	The complexity of research procedures (e.g., purchasing equipment and resources)
	The burden of bureaucracy
	Conversational difficulties
The absence of specific university rules	
Background obstacles	Inadequate control mechanisms and ineffective communication channels
	Insufficient government support
	Little government investment in the collaboration process
	Inability to identify suitable experts
	Inability to identify innovative companies
	Geographically large distances
	Market damage and government policies such as economic risk
	Inadequate supportive governing bodies
Low government intervention in the coordination of relations between universities and companies	

### Discussion

Interaction between university and industry is responsible for socio-economic effectiveness. Industry-university collaborations have thrived in the competitive environment and global economy. In the current situation, intertwining university and industry cooperation is one of the missions of these two pillars of sustainable development. Collaboration between leading researchers and highly qualified professionals in private companies will drive local economic growth by leveraging their skills (Yu, Zhang, & Yuizono, 2021). In this regard, identifying available documents in a subject area, clarifying concepts, identifying features and key factors related to concepts, identifying research methods, determining the primary precursor of university-industry collaboration, and identifying and analyzing knowledge gaps are essential. For this reason, we conducted the current study.

The present study's findings indicate that the publication trend of studies analyzing

university-industry research collaborations showed a somewhat increasing fluctuation. The topic of university-industry interaction emerged at the international level in the late 1960s, and the first studies in this field were published between 1969 and 1979. Factors such as increased technology transfer in universities and industries, expansion of research collaborations (Mowery & Sampat, 2004), the growing number of universities with technology transfer offices, increased inventions and patents in universities during the 1980s and 1990s (Mowery, Sampat & Ziedonis, 2001; Mowery & Sampat, 2004), the transformation of university missions and activities towards entrepreneurship and commercialization of research, the emergence of entrepreneurial universities (Sadlak, 1992; Dill, 1995), and social and economic development (Lee, 1996; Etzkowitz, 1998; Mitra, Kumar & Wyn, 1999) have led researchers to pay more attention to the topic of university-industry interaction. The number of studies published in this field, particularly since 2012, has increased. This indicates that university-industry collaboration is a transforming subject. Despite considerable research in this area and high interest among researchers, many avenues remain to be explored (Borges et al., 2022; Burbridge & Morrison, 2021). Studies focusing on university-industry collaboration have increased, especially in the past two decades (Bastos et al., 2021).

According to the current research results, most studies have predominantly used qualitative approaches to review and analyze texts related to university-industry interaction. Furthermore, in most of these studies, researchers have shown interest in using systematic review methods to analyze the full-text sources under examination. Since systematic review methods facilitate the identification of relevant studies in a specific subject area and enable critical evaluation of the content of the analyzed sources, they can enhance the quality of available evidence, ensure accurate synthesis of findings, and indicate future research directions (Linnenluecke, Marrone & Singh, 2020). Researchers tend to prefer applying systematic review methods more than other approaches in analyzing studies related to university-industry interaction.

The findings showed that articles are the most essential sources analyzed for examining and reviewing studies in university-industry interaction. The focus on articles in these studies may stem from the fact that articles are typically the outcome of research projects, theses, conferences, and other research experiences within each scientific field. Due to limited access to these resources, articles can provide researchers with faster and easier access to the results of these studies. Moreover, articles publish the latest scientific achievements and findings quickly, informing researchers and practitioners about the newest and most credible scientific and research advancements. Therefore, in reviewing and analyzing studies on university-industry collaboration, more attention has been given to articles than to other sources. The results of previous studies that emphasize researchers' focus on exploring the trends of university-industry research through content analysis of articles (Arenas & González, 2018; Skute et al., 2019; Caputo et al., 2022; Borges et al., 2022; Padilla Bejarano, Zartha Sossa, Ocampo-López & Ramírez-Carmona, 2023) are consistent with the current research findings.

The results of the current research indicate that, for the analysis and review of studies in the field of university-industry interaction at the international level, the Web of Science database has been used as the primary source of research data. Web of Science is a citation database encompassing a comprehensive coverage of reputable scientific publications. It is the basis for many systematic review analyses, bibliometric analyses, and text mining. This database has global recognition, and its fundamental features and capabilities in searching, refining, and displaying results have made it a key platform for analyzing scientific data at the

international level, surpassing other databases in this regard (Abdulhayoglu & Thijs, 2018; Birkle, David, Schnell & Adams, 2020; Huang et al., 2022).

The research findings indicate that various and diverse topics have been addressed in university-industry interaction studies over different periods. The most important issues are innovation, economic development, sustainable development, science parks and incubators, start-ups, spin-offs, knowledge transfer, technology transfer, entrepreneurship, and research commercialization. The primary mission of universities has always been education, dating back to the emergence of the first university in Europe. The second mission of universities, research, and establishing research centers, emerged in the 19th century. Therefore, university education and academic research discussions were more focused during this period. In the second half of the 20th century, the third mission of universities emerged, encompassing the production, use, application, efficiency, and exploration of knowledge with external stakeholders and society as a whole. This mission can be accomplished through collaboration between universities and industry (Nsanzumuhire & Groot, 2020). Currently, in many developed and developing societies, significant attention is given to the role of universities in the community's economic activities. Research policymakers strive to maximize the utilization of knowledge and technology produced by universities in the industrial sector and transform theoretical knowledge into practical wisdom. This has led to the addition of an economic role to the traditional roles of education and research in universities.

As a result, universities' primary and traditional roles worldwide as education providers and creators of scientific knowledge have transformed into those of entrepreneurial universities. Universities now have multiple roles in knowledge commercialization and in actively participating in the development of private companies in the local and regional economy (Etzkowitz, 2003, cited in Wong & Singh, 2013). Afterward, the number of universities with technology transfer offices increased (Mowery et al., 2001; Mowery & Sampat, 2004). At this stage, the transformations of universities that no longer solely bear the responsibility for education and research have attracted the attention of researchers. Entrepreneurship and the commercialization of research have been emphasized in studies of this generation as part of university activities (Sadlak, 1992; Dill, 1995) and in social and economic development (Lee, 1996; Etzkowitz, 1998; Mitra et al., 1999). Studies in this field highlight the emerging concept of an "entrepreneurial university," primarily focusing on social and economic development.

Thus, research and development collaboration between universities and industry has been identified as an essential component of universities' third mission. This is because such collaboration can be a source of innovation and technology transfer (D'Este & Patel, 2007; Ambos, Mäkelä, Birkinshaw & D'Este, 2008, cited in Wong & Singh, 2013). Extensive studies examining the relationship between academia and industry have shown that this relationship significantly impacts the economic domain, serving as a critical driver of collaboration (Cannito, 2015). The formation of spin-offs is one of the essential ways of commercializing new knowledge and technology (Wong & Singh, 2013), and it is identified as an effective facilitator of the relationship between academia and industry within the framework of economic factors. With the formation of spin-offs, researchers gain knowledge generated in universities and strive to commercialize it within their organizations (Schartinger, Rammer, Fischer & Fröhlich, 2002). Spin-offs are among the formal channels of communication between academia and industry at the organizational level, and most studies on industry-academia collaborations have focused on this type of relationship (Audrestsch et al., 2010, cited in Tijssen, 2012).

Simultaneously, with the emphasis of governments on establishing and developing a network of collaboration between academia and industry, the creation and implementation of innovation policies, and the development of technology sectors (Freitas et al., 2013; Rajalo & Vadi, 2017), universities have gradually become the core of the knowledge production ecosystem, and their role in innovation has become more critical and diverse (Chen, Huang & Chen, 2013). Furthermore, universities develop new technologies and transfer them to companies (Berbegal-Mirabent et al., 2015). This has led researchers to pay closer attention to knowledge production, knowledge sharing, and technology transfer.

With the growing societal expectations regarding the economic returns of basic research, universities are receiving requests for collaboration from research and development companies. This collaboration is increasingly seen as an innovation-enhancing technology exchange or knowledge transfer. In this sense, university-industry collaboration is one of the various tools currently utilized by industries and companies for innovation (Schartinger, Schibany & Gassler, 2001). Universities attract research and development budgets from companies to advance science and technology and cultivate talent through talent exchange programs. As a result, the industry may increase profits and market share through universities' technical advancements (Feng, Zhang, Du, Ma & Fu, 2012; Cao, Zhang, Feng & Du, 2013). Innovation is the engine of economic development. The interaction between universities and industry is the driving force behind increased innovation through knowledge exchange. As a result, this interaction accelerates innovation (Schumpeter, 1934). Various sources have long studied innovation. In the past decades, it has been directly related to the interaction between universities and industry (Confraria & Vargas, 2019). Based on Figure 1, research on university-industry interaction has centered mainly around goals such as innovation, knowledge transfer, technology transfer, university entrepreneurship, entrepreneurial university, and commercialization of research. These developments have led to a greater diversity of research topics related to university-industry collaboration. The results of the study of Pujotomo et al. (2023) showed that the research trend of university and industry cooperation has shifted from the subject of knowledge-based economy (from 2010 to 2013) towards product development (2014 to 2015), technology commercialization (2016 to 2017), and open innovation (2018 to 2019). The research is currently focusing on green entrepreneurship.

According to the findings, the most significant barrier to communication between universities and companies can stem from differences in goals, expectations, perceptions, norms, and organizational cultures. This issue poses challenges in inter-organizational and interpersonal knowledge transfer (Brings et al., 2018; de Wit-de Vries et al., 2019; Nsanzumuhire & Groot, 2020; Marques et al., 2022; Rossoni et al., 2023; Marques et al., 2023), as indicated in the lack of alignment in Table 4. One challenge in establishing communication between universities and industry is the lack of coordination and alignment between science and industry policies. The goals and missions of universities and industries are often contradictory. For example, one of the goals of universities is to expand knowledge, increase the quantity of scientific output, and enhance faculty academic achievements through publications such as articles and books.

The industry aims to generate profits, increase production, and reduce costs. The time required to complete a project is insignificant for universities, whereas achieving results in the shortest possible time is crucial for industry (Bruneel, D'Este & Salter, 2010; Goel et al., 2017, cited in Albats, Alexander & Cunningham, 2022). In such circumstances, the importance of

focusing on the role of intermediary institutions that can act as a bridging unit to establish communication between universities and industry and facilitate the transfer of knowledge and technology between them becomes more apparent. Industry-university liaison offices, science and technology parks, incubators, and similar entities have expanded to promote alignment between these institutions.

According to the findings of the present research, among the influential factors on the interaction between academia and industry, intermediary institutions such as science parks, research parks, technology parks, incubators, and other parks have a more significant impact compared to other scientific and innovation centers on effective communication between academia and industry and stronger organizational collaboration. These intermediary institutions have the most successful infrastructures for strengthening such alliances. These institutions facilitate knowledge transfer that helps alleviate barriers to these interactions (Minguillo et al., 2015; Ankrah & Al-Tabbaa, 2015; Farré-Perdiguer et al., 2016; de Wit-de Vries et al., 2019; Lima et al., 2021; Burbridge & Morrison, 2021; Sandoval Hamón et al., 2024; Rossoni et al., 2023). Intermediaries can facilitate effective collaborations and foster trust-based relationships between government, academia, and industry (Malik et al., 2021). Moreover, graduate students, especially doctoral students, play a significant role in the relationships between universities and companies. They serve as both knowledge producers and disseminators in joint research projects between universities and companies, and their role is essential in shaping and maintaining networked relationships by configuring the network between them. The facilitating part of students can be observed with the growing number of doctoral students engaging in interactions with companies (Thune, 2009; de Wit-de Vries et al., 2019). Paying attention to the most critical factors affecting cooperation between universities and industry, and the essential obstacles (Tables 3 and 4) in this ecosystem, enables researchers to identify problems and provide appropriate solutions in a timely and proper manner. Geography helps policymakers and planners because management and leadership are noteworthy among the influential factors and obstacles.

A review of the studies conducted in the field of university-industry cooperation shows that researchers' attention to this field of study has increased over time. Simultaneously, with the growing number of studies in the field of university-industry collaboration, the need to integrate research on the research process of university-industry interaction has become more prominent. The significant studies conducted regarding research in university-industry cooperation have analyzed the scientific outputs of university-industry interaction using different approaches, including systematic review, Meta-synthesis, meta-analysis, and bibliometrics. These studies have neglected to review and apply bibliometric research on the interaction between universities and industry. The present study was conducted to fill this gap. The results of this research can provide the basis for the development of research in this field and help to remove the obstacles to university-industry cooperation. In addition, by defining the subject areas and research needs of university-industry interaction, it can be expected that an essential part of research resources and credits will be spent on topics that have importance and priority, and the results of research from these topics will be used to solve problems. Identifying and analyzing the cooperation issues between universities and industry can help university planners, higher education centers, industries, and science and technology policymakers address issues and challenges in this area and develop future cooperation.

### Conclusions

A review of the studies conducted in the field of university-industry cooperation shows that researchers' attention to this field of study has increased over time. This means that the amount of research in this field at the international level has increased dramatically in recent decades, and university-industry cooperation has become a multifaceted and complex field of study. This has inspired researchers to conduct studies on analyzing university-industry interaction research to know the latest developments and draw research directions. Simultaneously, as more studies are performed with these goals, the need to examine the research process of university-industry interaction becomes more apparent. In this regard, the present research, using the scoping review, analyzes the review and bibliometric studies of university-industry interaction in terms of the publication process and format, the approaches and methods used in them, the source of research data, the most critical thematic axes, obstacles, and factors affecting university-industry cooperation, and the benefits of this cooperation.

In general, a reflection on the studies conducted on the analysis of university-industry cooperation research shows that although some studies have analyzed the structure and thematic process of research and have contributed to the expansion of knowledge, it is still necessary to conduct more studies in this field with a view to the future horizon of university-industry interaction research due to the continuous increase of the volume and the scope of studies in this field and the relationship of these researches with other areas and the emergence of new concepts, theories, and methods,. The results of these studies help fill gaps left by previous studies and support strategic planning and policy-making to foster innovation in universities and industries.

### Declaration of Generative AI and AI-assisted technologies

During the preparation of this work, the authors used ChatGPT and Grammarly to improve the accuracy of grammar, spelling, and punctuation in text documents. After using this tool/service, the authors reviewed and edited the content as needed and took full responsibility for the publication.

### Endnote

1. The article is taken from the research project of Dr. Mohammad Reza Ghane, with the assistance of Dr. Farzaneh Ghanadinezhad, titled "Thematic trend of current and future research on university-industry interaction: Text-mining approach" and number 1919/D/1403, which is implemented in ISC.

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