

Models for R+D+i+e interaction between the university and its context. A Literature Review

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Abstract– *The interaction of the university and its context determines the policies to ensure that research and development (R+D) have a positive impact on society. However, innovation and entrepreneurship (I+E) have been generating new scenarios and policies in the university. The aim of this study is to identify models for R+D+i+e interaction between the university and its context. In this research, a systematic mapping study (SMS) was performed in five digital libraries. In the process, 13,561 articles were obtained and 336 articles selected as primary studies. In the literature, 17 interaction models for R+D+i+e interaction between the university and its context were identified. The most reported models are: Industrial University, Triple Helix, Entrepreneurial University, Open Innovation and Stakeholders. Likewise, the main types of activities linked to the identified models are: research, innovation and the combination of research and development. In contrast, there are few for experimental development and entrepreneurship.*

Keywords– *university; research; development; innovation; entrepreneurship.*

I. INTRODUCTION

The university was born in Europe, in Bologna in 1088 [1], as an institution influenced by the papacy and with the aim of promoting scientific and humanistic knowledge [2]. The Universities' existence is based on quality, measured through pillars such as education, their role in society and the research they conduct [3]. In particular, research, in turn, makes a substantial contribution to the intellectual capital of society. So, for any university is vital to have a close relationship with the social environment [4]. Also, on the basis of research, it is possible to generate experimental development, aimed at producing new products or processes, or to improve existing ones [5], promoting innovation to generate patents and useful industrial models [6].

At present, there are different kinds of efforts to promote innovation and entrepreneurship in universities [7]. These efforts are made by generating an entrepreneurial culture, with development programs based on the search for the national, social and economic reality for entrepreneurship [8]. In this respect, the interaction of the university and its context, aims to promote the articulation of research with industry, in order to generate innovation and impact on socioeconomic development [9].

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Likewise, over time, various models of interaction between universities and others have evolved, such as: i) Triple Helix, University-Industry-Government, which explains economic development based on knowledge [10]; ii) Quadruple Helix, University -Industry-Government-Civil Society, which focuses on adapting innovation to society's needs. [11]; iii) Quintuple Helix, University-Industry-Government-Civil Society-Natural Environment, aimed at driving innovation for sustainable development [12] and, iv) Multihelix, which adapts the Triple Helix model to promote social innovation, by including entrepreneurs and other social stakeholders [13]. These models incorporate innovation and entrepreneurship, which have been promoting big changes and generating new scenarios in the academic environment and society at large; causing transformations in the university and its governance. These models and their transformations have been collected in various studies that need to be identified and systematized.

This study identifies models for research, development, innovation and entrepreneurship (R+D+i+e) interaction between the university and its context. For this purpose, a systematic mapping study (SMS) was carried out, following a methodology proposed by [14], answering seven research questions. The following sections have been considered: in Section 2, the background and related works; in Section 3, the applied research method; in Section 4, the results and discussion; and, in Section 5, the conclusions.

II. BACKGROUND

This section provides an overview of relevant aspects of this study, such as research, experimental development, innovation and entrepreneurship (R+D+i+e) concepts, and the R+D+i+e interaction between the university and its context, and related works.

A. Research, Experimental Development, Innovation and Entrepreneurship

R+D+i+e concepts are presented from a more globally accepted perspective in this section. The UNE 166000 standard [15] defines R+D+i as activities that are related to Research, Technological Development, and Innovation. Subsequently, the Frascati Manual, published by the Organization for Economic Cooperation and Development (OECD) [5], establishes that: i) R+D is the set of activities linked to Research and Experimental Development (R+D); and, ii) R+D activities have to meet five criteria: novelty, creativity, uncertainty, systematization and

repeatability. This complements the criteria of creativity, novelty, use of the scientific method and generation of new knowledge, established by the United Nations Educational, Scientific and Cultural Organization (UNESCO) [16]. The concepts are:

1) *Research*. Research is an original and planned inquiry, seeking to discover new knowledge and a better understanding of science and technology [15]. It is classified into basic and applied research.

2) *Experimental development*. Experimental Development is a term that is more recent than Technological Development, and is more widely accepted in international organizations. Therefore, the two terms appear in reverse order. Technological Development is the application of results research. It can be a plan or prototype, for the manufacture or design of new products, processes or systems or for the substantial improvement of existing ones, before their production or commercialization [15]. Experimental Development, according to [5], broadens the definition of Technological Development including even the validation of the prototype, in real operating conditions, or its commercialization, or for demonstration [17].

3) *Innovation*. Innovation [15], [18], is defined as the activity that seeks to obtain new products or processes, or improving existing ones significantly.

4) *Entrepreneurship*. Entrepreneurship is the act of creating value by creating or expanding economic activities based on new products, processes, or markets. [19].

B. R+D+i+e interaction between the university and its context

Countries are presently implementing policies that promote the transfer of knowledge from science and industry, promoting innovation and the creation of new companies [20]. These policies are related to the university and industry collaboration models [21], [22], [23], which promote innovation and intersectoral collaboration for entrepreneurship. Other interaction models that are related to the university and its context, including Educational Collaborative, Academic Entrepreneurship, and Research Collaboration [24], can be complemented with government support [25]. On the other hand, it is necessary to develop and focus research and innovation on the needs of industry, for a smart specialization [26] whose benefit will be tangible to the extent that the interaction between the university and its context is enhanced in all countries [27].

C. Related work

On R+D and R+D+i, several works have been found from different perspectives; however, none of them is a literature review (or similar) on the R+D+i+e interaction between the university and its context.

In particular, some literature reviews identified covers: financial support for innovation [28], benefits and critical factors [29], demand-driven innovation [30], and types of

motivation of researchers and their influence on R+D are related [31].

III. LITERATURE REVIEW

Systematic mapping study (SMS) is a methodological study that aims to provide an overview of a research area on a particular topic and learn about the existing evidence [14]. The stages are [14]: planning, conducting and reporting. The planning is developed in the rest of Section 3. The conducting is presented in Section 4. Finally, the report is the full article. Planning is an iterative process that is built, based on the level of domain knowledge and search model (SMS).

A. Identification and scope of the need

The scope of this study is to examine the breadth of existing publications of models for R+D+i+e interaction between the university and its context, with the purpose of documenting the lines and the level of research, from the research activity to entrepreneurship. For the SMS, six research questions have been defined:

- RQ-1. In which media have the publications regarding models for R+D+i+e interaction between the university and its context been done?
- RQ-2. When were these publications published?
- RQ-3. Which types of research have been published?
- RQ-4. Which types of contributions have been published?
- RQ-5. Which are the models for R+D+i+e interaction between the university and its context?
- RQ-6. What are the publication trends?

The search string was developed using the criteria, according to [14], of (P) Population {governance and (university OR "Higher Education")} and (I) Intervention {research OR development OR innovation OR entrepreneurship}. The search was carried out on 6 relevant digital databases: Scopus, Science Direct, Proquest, Ebsco, IOP Science and Web of Science, only in English, without time limit. Where the database allowed it, the wildcard "*" was used in: resear*, develop*, innovat* and entrepr*.

For the selection process, according to [14], a set of inclusion (IC) and exclusion (EC) criteria was established:

- IC.1. Studies that belong to the data bases selected.
- IC.2. Studies from journal articles, conferences, and chapters of book series.
- IC.3. Studies that report interaction models of the university and its context, as well as the trends and contribution about R+D+i+e regarding that field.
- EC.1. Duplicate articles
- EC.2. Studies that their titles are not linked to the interaction of the university and its context for R+D+i+e.
- EC.3. Studies that, despite having relevant words on their titles or abstract, they are not linked to the subject of study.
- EC.4. Studies which whole content is not available.

Likewise, based on [14], it was established not to carry out the evaluation of quality considering that the studies were

obtained from indexed digital databases, which store journals and conferences that have gone through a peer review process.

B. Selection, extraction and classification of data

The data selection, extraction and classification, according to [14], implies: the definition of the set of steps to follow, starting with the metadata obtained from each database considered; the definition of a set of topic-independent (generic) classifiers and a set of topic-specific classifiers.

In the selection process, a spreadsheet format was defined to support the process. Each record includes: author, year, title, abstract and the database from which the data were obtained. Six stages were defined, including the inclusion and exclusion criteria, which are presented below:

- First stage – The search string is executed, considering the inclusion criteria IC.1, IC.2 and IC.3. The wildcard character (*) is used to broaden the search results, with the exception of the Science Direct database, which does not allow its use.
- Second stage - All the records obtained from the digital database are placed on a single sheet, excluding duplicate studies (EC.1), with the help of a conditional function of the spreadsheet applied to the titles.
- Third stage - The titles are read and those that do not refer to the subject under study are rejected (EC.2). In case of doubt, the article is conditional accepted to be reviewed in the next stage.
- Fourth stage. - The abstracts of the accepted articles are read, and those that do not contain the topic of interest in the abstract are rejected (EC.3). In case of doubt, the article is conditional accepted to be reviewed in the next stage.
- Fifth stage - Studies whose full content is not available are excluded (EC.4).
- Sixth stage – The content is reviewed and those studies that are not relevant are rejected (EC.3).

In addition, as part of the planning, a pilot iteration (“iteration 0”) was carried out in the selected digital databases for: (i) refine the search string; (ii) evaluates whether the selected articles, 20 preliminary studies, answer the research questions; and, (iii) determine if the questions can be answered adequately, using the defined classifiers.

Also, a spreadsheet format, for data extraction, was established, whose structure is presented in Table I.

In [14], topic-independent classifiers are defined as those that can be applied to different domains. In this study, some independent classifiers of the topic are adapted from [14], such as: (i) in Table II, the classification of documents according to the means of publication; (ii) in Table III, the classification of documents by type of research; and, (iii) in Table IV, the classification of research methods for evaluation research and validation research. Finally, also was used, in Table V, the classification of documents by type of contribution from [32].

For the specific classification of the topic, keywords and revised concepts were identified in related studies, in order to define a classification scheme, which is based on the interaction

TABLE I
STRUCTURE OF THE DATA EXTRACTION.

Data	Details	Relevance
Study identifier	Identifier created to SMS	General
Bibliographic references	Title, author	General
Publication	Name of the publication analyzed	RQ-1
Type of Publication	Classification of the type of publication: journal, book series or conference	RQ-1
Year of publication	Year of the publications	RQ-1
Type of research	Type of research of the publications	RQ-2
Research method	Research method to evaluate or validate	RQ-3
Type of contribution	Type of contribution of the publications	RQ-4
Interaction models of the university and its context	Interaction models of the university and its context included in the study	RQ-5
Public trends	Trends of the publications regarding R+D+i+e activities and the interaction of the university and its context	RQ-6

TABLE II
CLASSIFICATION OF PUBLICATIONS ADAPTED FROM [14].

Publication	Description
Journal	Studies published in high quality research journals and listed in databases.
Book series	Studies published in numbered books
Conferences	Studies that were presented in congresses or meetings about specific topics.

TABLE III
TYPES OF RESEARCH ADAPTED FROM [14]

Criteria	Description
Evaluation research	Studies that show the causal relationships of the interaction of the university and its context in R+D+i+e activities.
Research proposal	Studies that propose solutions to problems related to R+D+i+e activities based on the interaction of the university and its context, but which have not been evaluated or validated.
Research validation	Studies that show the causal relationships between the interaction of the university and its context in R+D+i+e activities, using simulation methods.
Philosophy article	Studies that reflect new ways of seeing the interaction of the university and its context or R+D+i+e activities.
Opinion piece	Studies where there are opinions about strengths or opportunities for improvement, regarding the interaction of the university and its context and the carrying out of R+D+i+e activities.
Experience article	Studies that show lessons learned about the interaction of the university and its context and R+D+i+e activities.

models of the university and its context for the deployment of R+D+i+e and the tendencies of the published studies. Table VI presents the interaction models of the university and its context to be considered in the SMS.

In Table VII, reference is made to the R+D+i+e activities included in the publications, which are related to the interaction of the university and its context. From “iteration 0”, it was identified: (i) that the main activities are research, experimental development, innovation and entrepreneurship; and (ii), that

combinations of the previous ones are presented. As indicated, a classifier was established that takes each individual activity and the aggregate combination of them, as a specific classifier of the topic.

TABLE IV
RESEARCH METHODS ADAPTED FROM [14]

Type of research	Research method	Description
Evaluation research	Industrial study case	Studies that describe the relationship among the interaction of the university and its context, as well as R+D+i+e actions in a real situation in the industry.
	Controlled experiments in internship experiences	Studies that have results of experiments in internship experiences about the interaction of the university and its context, as well as, R+D+i+e activities.
	Surveys	Studies that have results of surveys on the interaction of the university and its context, and R+D+i+e.
	Action research	Studies where researches about R+D+i+e were carried out.
	Ethnography	Social studies about R+D+i+e based on the interaction of the university and its context.
Research validation	Simulation	Studies that show realities related to R+D+i+e regarding the interaction of the university and its context.
	Laboratory experiments	Studies that have results of controlled experiments with students, about the interaction of the university and its context, as well as, R+D+i+e activities.
	Prototyping	Studies that show models or prototypes related to the interaction of the university and its context, as well as, R+D+i+e activities.
	Mathematical models	Studies that use mathematical analysis to link the interaction of the university and its context, as well as, R+D+i+e activities.
	Academic case studies	Studies that describe the relationship between the interaction of the university and its context, as well as, R+D+i+e actions, regarding an academic situation.

TABLE V
TYPES OF CONTRIBUTION ADAPTED FROM [32].

Model	Description
Model	Studies that show models or interaction styles between the university and its context for R+D+i+e activities.
Theory	Studies that show interaction relationships between the university and its context and their effect on R+D+i+e.
Workbook	Studies that show methods related to interaction of the university and its context, as well as R+D+i+e activities.
Guide	Studies that have a list of tips about the interaction of the university and its context and R+D+i+e activities.
Lessons learned	Studies that strengthen lessons learned about the interaction of the university and its context regarding R+D+i+e activities.
Recommendations	Studies that include recommendations for implementing interaction models between the university and its context to promote R+D+i+e activities.
Tools	Studies that refer to the use of databases, tutorials, metrics and indicators regarding the interaction of the university and its context for R+D+i+e activities.

C. Validity Threat Analysis

The validity threat analysis followed that defined by [33], who used three categories: (i) validity of the selection of studies, which includes threats such as the selection of digital libraries, the construction of chains of search and study selection bias; (ii) data validity, such as data collection bias and publication bias; and, (iii) validity of the research, which considers the generalization and coverage of the research questions, among others.

- Validity of study selection - To ensure that the selection process is carried out properly, a search protocol is followed using the criteria established above, related to: relevant databases, study selection strategy, search string, inclusion and exclusion criteria and, finally, the review and discussion of all the advances, criteria and decisions that have been made. In the process, approximately 3% of relevant primary studies were obtained from the total number of studies found in the databases.
- Data validity - In this SMS, 4 researchers participated, in order to avoid bias in data extraction, in addition, a descriptive statistical analysis was carried out, in order to interpret the results of the research questions.
- Research Validity - Four researchers have participated in the SMS, documenting the review protocol, the same that allowed to determine if the research questions raised encompass all the necessary aspects of this study. As well, if the questions are well-motivated and there are related studies to compare and discuss the findings. The choice of the SMS is adjusted to the objectives and questions of this study. At the same time, it provides information that can serve to propose future research on related topics.

TABLE VI
MODELS FOR R+D+i+e INTERACTION BETWEEN THE UNIVERSITY AND ITS CONTEXT.

Models for R+D+i+e	Reference
Triple helix	[10]
Quadruple helix	[11]
Quintuple helix	[12]
Multiple helix	[13]
Academic self-governance	[37]
Anglo-American inspiration	[37]
Hybrid governance	[37]
Open Innovation (OI)	[18]

TABLE VII
CLASSIFICATION OF STUDIES BY R+D+i+e ACTIVITY TYPE.

R+D+i+e activities regarding the interaction of the university and its context	Reference
Research activities	[15], [16]
Experimental development activities	[5], [17]
Innovation activities	[15], [41]
Entrepreneurship activities	[19]
R+D activities	[5], [41]
R+D+i activities	[15]
R+D+i+e activities	[42]

IV RESULTS

This section presents results and discuss the answers to the research questions based on the 336 selected studies. The search strings (governance AND (university OR “Higher Education”) AND (resear* OR develop* OR Innovat* OR entrepr*)) have been executed in selected databases. Table VIII shows the databases consulted and the total number of studies found.

The selection of primary studies was carried out in accordance with the established procedure. For the extraction of relevant data, we proceeded as established in Section 3, in order to answer the research questions.

TABLE VIII
SEARCH RESULTS.

Database	Date of search	Studies
Scopus	First round:	9,969
Science Direct	01/2023	492
Proquest		246
Ebsco	Second round:	90
Web of Science	01/2024	2,764
Total		13,561

A. *RQ-1. In which media have the publications regarding models for R+D+i+e interaction between the university and its context been done?*

From the primary studies, the following were identified: the authors published 296 (88%) studies in indexed journals, 23 (7%) studies at conferences; and, 17 (5%) studies in serial books. In addition, Table IX shows a list of journal titles where 3 or more articles have been published. In Appendix A, the list of primary studies is presented. The magazines that show the most publications in the search are: Science and Public Policy, oriented to public policies on science, technology and innovation. Sustainability, a magazine on environmental, economic and social sustainability of human beings, also stands out. Research Policy magazine specializes in economic studies of science, technology and innovation. Another magazine is Prevision Tecnológica y Cambio Social, dedicated to studies of the interrelation of social, environmental and technological factors. Additionally, the magazine of higher education, which examines global educational advances in universities and polytechnics.

B. *RQ-2. When were these publications published?*

The publications on models for R+D+i+e interaction between the university and its context were published from 1994 to date. Fig. 1, shows that the publication of these studies maintains a growing trend, with noticeable drops in the years 2006, 2015 and 2021. To determine the trend, the polynomial curve of order 3 was used, as it had data with more than one hill or valley with an R2 indicator of 0.7639, a statistical measure that indicates that the data is reliable because it is close to 1.

C. *RQ-3. Which types of research have been published?*

The types of research identified in the primary studies are presented in Fig. 2, where it is observed that evaluation research

TABLE IX
MAIN JOURNALS WHERE THE STUDIES WERE PUBLISHED.

Journal	Qty	Articles published
Science and Public Policy	14	S011, S086, S094, S111, S123, S141, S158, S163, S165, S236, S264, S277, S298, S332
Sustainability	9	S065, S067, S175, S182, S216, S272, S286, S293, S334
Research Policy	8	S026, S057, S064, S140, S193, S211, S237, S324
Technological Forecasting and Social Change	8	S006, S015, S104, S117, S232, S279, S294, S314
Higher Education	7	S003, S116, S186, S251, S291, S318, S329
Higher Education Policy	7	S022, S024, S029, S046, S059, S148, S161
Journal of Technology Transfer	7	S009, S056, S105, S110, S214, S271, S274
Studies in Higher Education	7	S162, S187, S209, S217, S266, S284, S322
Industry and Higher Education	5	S069, S106, S221, S228, S265
Higher Education Quarterly	4	S076, S280, S299, S302
Journal of the knowledge economy	4	S002, S051, S088, S176
Minerva	4	S090, S107, S134, S300
Tertiary Education and Management	4	S156, S239, S257, S297
Procedia - Social and Behavioral Sciences	3	S139, S205, S222
Innovation-The European Journal of Social Science Research	3	S075, S169, S305
International Journal of Innovation Management	3	S007, S269, S287
International Journal of Technology Management	3	S036, S085, S202
Journal of Higher Education Policy and Management	3	S183, S210, S323
Triple Helix	3	S043, S171, S296

(199), opinion articles (66), validation research (65), among other studies have been published. Likewise, Fig. 3, and Fig. 4, show the number of publications based on the research method [14], whether it is an evaluation or validation. In terms of evaluation methods, industrial case studies are most often used (42%), as well as surveys (32%) and action research (26%) and Regarding validation methods, there have been more publications of mathematical models (84%) and Academic case study (13%), which generally seek to test hypotheses through correlations.

D. *RQ-4. Which types of contributions have been published?*

The types of contributions most often used in primary studies, see Table X, are: Tools (70%), Model (42%), Lessons learned (25 %) and Recommendations (23%). The relationship between types of research and type of contribution (see Table X) shows that the most five important topics are: evaluation research and tools (147), evaluation research and models (81), validation research and tools (44), validation research and models (32) and experience and lesson learned (32).

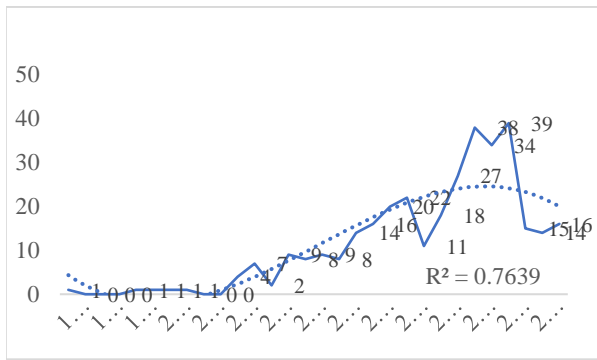


Fig. 1. Number of studies published.

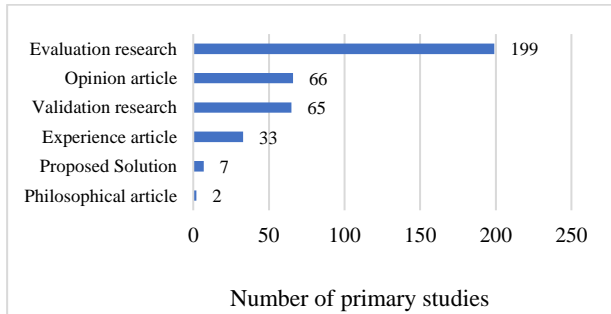


Fig. 2. Types of research in primary studies.

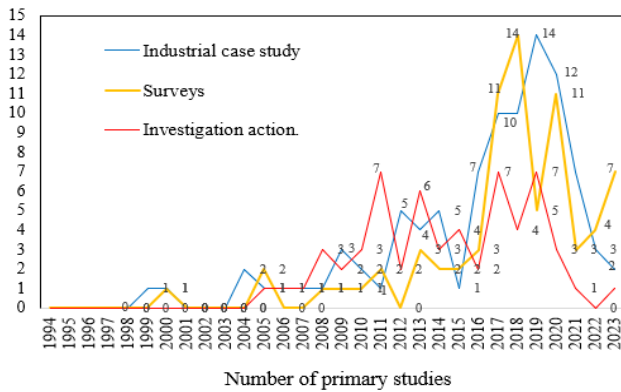


Fig. 3. Evaluation research methods.

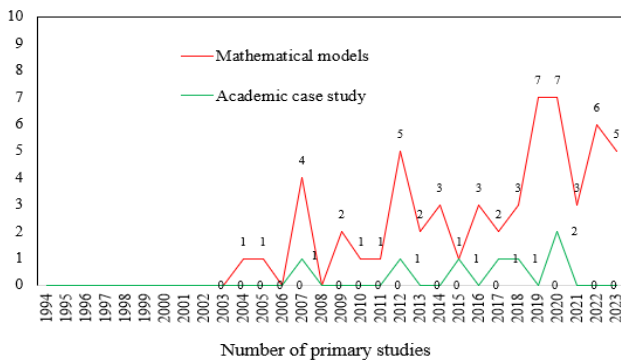


Fig. 4. Validation research methods.

TABLE X
TYPE OF PUBLICATIONS CONTRIBUTIONS BY TYPE OF RESEARCH

	Model	Theory	Workbook	Guide	Lessons learned	Recommendations	Tools	Total	%
Evaluation research	81	2	0	3	27	34	147	294	88
Proposed Solution	5	0	0	0	0	5	10	20	6
Validation research	32	1	0	0	7	8	44	92	27
Philosophical article	1	0	0	0	0	0	0	1	0
Opinion article	20	1	0	0	19	23	24	87	26
Experience article	3	0	0	0	32	8	9	52	15
Total	142	4	0	3	85	78	234	Primary studies: 336	
%	42	1	0	1	25	23	70		

Regarding the types of contribution of the studies over time, it was determined that from 2003 the number of publications of Tools, Recommendations, Lessons Learned and Models increased, with falls in the years 2003, 2006, 2015 and 2021, this is visualized in Fig. 5. The trend of publications by type of contribution is growing and is presented in Fig. 6. In contrast, the Theory, Guide and Workbook contributions have almost horizontal and very low trends, with ratios of 0.1, 0.1 and 0.0 articles published per year, respectively.

E. RQ-5. Which are the models for R+D+i+e interaction between the university and its context?

Based on primary studies, 162 studies explicitly refer to models for R+D+i+e interaction between the university and its context. This information is presented in Fig. 7, highlighting, due to the Pareto principle [34], the Industrial University (28%), Triple Helix (21%), Entrepreneurial University (17%), Open Innovation (7%) and Interested Parties (6%). These models are in line with the studies of [21], which linked the Industrial University model to innovation and collaboration for entrepreneurship.

Likewise, [10] studied the Triple Helix Model, in order to generate wealth between the parties, based on knowledge; [35] showed the role that governments can play in financing, legislation and innovation, establishing alliances with the other Triple Helix actors; and, [28] addressed the Triple Helix model as a type of public support for innovation.

On the other hand, the Stakeholders and Entrepreneurial University models were studied by [36], as well as the hybrid models, which relate research to innovation, as note by [37]. The Quadruple Helix model is explained by [11], who suggest a knowledge system that is both adaptable and innovative to meet society's needs; and, the Open Innovation model is explained by [38], which involves the use of knowledge flows

to accelerate internal and external innovation, specifically in new markets. For his part, [39], studied the role played by the actors of the quadruple helix in technological entrepreneurship, based on education.

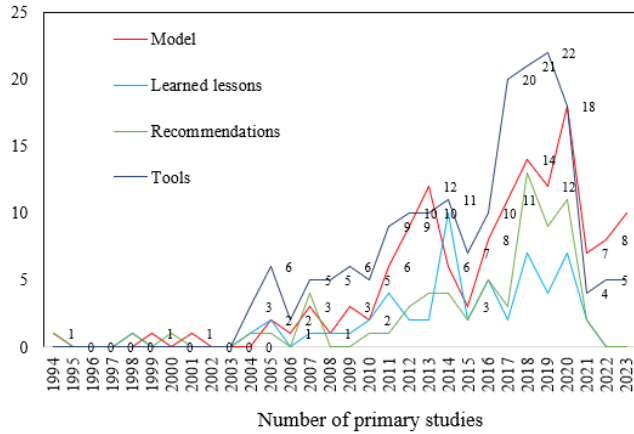


Fig. 5. Types of publications contributions.

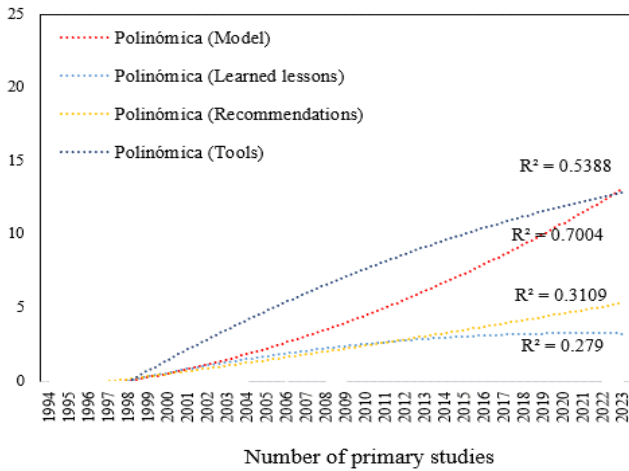


Fig. 6. Trend of the types of publications contributions.

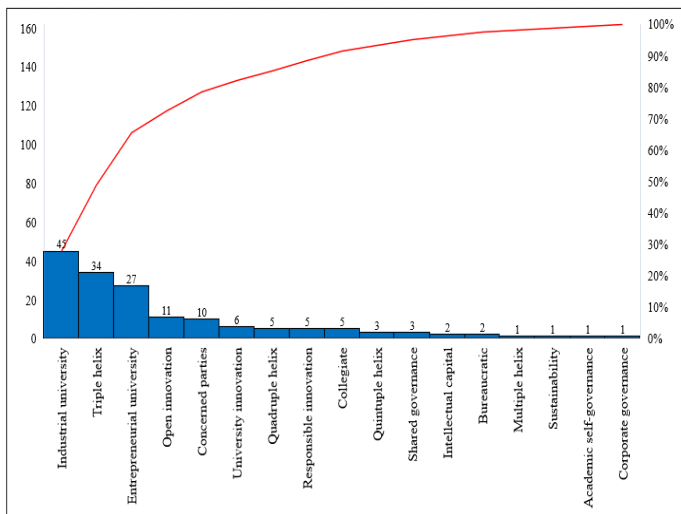


Fig. 7. Pareto diagram of the models for R+D+i+e interaction between the university and its context.

In Table XI, identifies the articles which contain the models for R+D+i+e interaction between the university and its context activities. Fig. 8 shows the number of publications that refer to the main models, year by year, according to Fig. 7; while in Fig. 9, the data is shown using the trend perspective. Note that between Fig. 7 and Fig. 9, the models are ordered differently; and, the annual ratios of the publications that contain the main models of university interaction, between

TABLE XI
MAIN INTERACTION MODELS OF THE UNIVERSITY AND ITS CONTEXT FOR R+D+i+e ACTIVITIES

Models	Qt y	%	Studies
University-Industry	45	27	S009, S030, S057, S084, S089, S091, S092, S098, S099, S104, S107, S123, S124, S128, S131, S140, S153, S156, S168, S175, S176, S192, S204, S212, S214, S215, S218, S225, S226, S227, S228, S229, S246, S263, S264, S265, S269, S281, S283, S293, S294, S309, S317, S326
Triple helix	34	21	S034, S038, S043, S056, S065, S069, S080, S086, S088, S103, S106, S108, S111, S117, S119, S126, S137, S139, S141, S165, S171, S172, S173, S185, S196, S202, S211, S221, S243, S253, S279, S296, S327, S334
Entrepreneurial University	27	16	S036, S046, S068, S076, S079, S082, S101, S115, S136, S146, S149, S157, S158, S164, S190, S199, S203, S208, S238, S244, S254, S285, S291, S313, S316, S324, S329
Open innovation	11	7	S006, S007, S048, S051, S067, S178, S235, S287, S305, S308, S314
Interested parties	10	6	S039, S074, S101, S146, S216, S220, S222, S223, S275, S295
University innovation	6	4	S005, S035, S072, S085, S127, S323
Quadruple helix	5	3	S051, S138, S151, S301, S307
Collegiate	5	3	S029, S033, S101, S146, S290
Responsible innovation	5	3	S094, S138, S207, S236, S303
Quintuple helix	3	2	S001, S051, S336
Shared governance	3	2	S073, S179, S260
Bureaucracy	2	1	S101, S146
Intellectual capital	2	1	S242, S321
Corporate governance	1	1	S109
Sustainability	1	1	S024
Multiple helix	1	1	S209
Academic self-governance	1	1	S008
Total	162	100	

1994 and 2023, are: Industrial University (1.5), Triple Helix (1.1), Entrepreneurial University (0.9), Open innovation (0.4), Stakeholders (0.3); While, if the analysis is done taking into account the last 5 years, the ratios of the main models are: Industrial University (4.2), Entrepreneurial University (2.4), Triple Helix (1.8), Open Innovation (0.8), Quadruple Helix, Stakeholders and Responsible Innovation, the latter three, with an average of 0.6. The data reveal that the Triple Helix model went from second place in the annual ranking to third place in the ranking of the last 5 years, however, the Entrepreneurial University model rose to second place; Finally, the Quadruple Helix and Responsible Innovation models, in the last 5 years, grew in publications. This information paves the way for future research related to emerging models of university interaction and invites us to analyze why other models are losing validity, such as the Triple Helix.

F. RQ-6. What are the publication trends?

The classification of the studies by type of R+D+i+e activities related to the interaction of the university and its

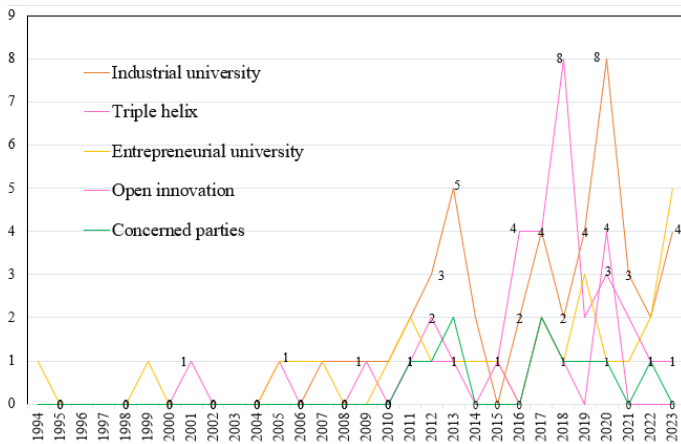


Fig. 8. Main models for R+D+i+e interaction between the university and its context.

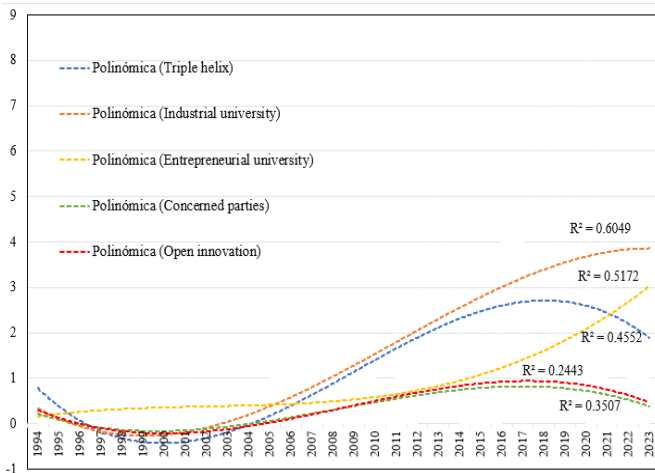


Fig. 9. Trend of publications of models for R+D+i+e interaction between the university and its context.

context is presented in Fig. 10, In this figure, 37% of the publications address research activities, 32% refer to innovation activities, and 17% are studies on R+D. Also, 10% of the studies deal with entrepreneurship issues, 2% combine R+D+i, and another 2% mention experimental development activities. None of primary studies refer to the combination of R+D+i+e activities, which shows that it is an emerging combination, to be addressed in future research.

The number of publications on R+D+i+e, from 1994 to 2023, is presented in Fig. 11, where it is observed that the increase begins in 2005. Likewise, the Research and Innovation activities had a decrease in 2015 and a maximum peak in 2018 and 2020 respectively, while R+D activities had a decrease in 2016 and a maximum peak in 2020. On the other hand, entrepreneurship does not present very high peaks, which coincides with the study by [39] in which he does not explicitly relate technological entrepreneurship with the interaction of the university and its context, linking it only in the academic field.

According to the publication trends, in Fig. 12, it can be seen that in recent years, the number of research publications exceeds the number of innovation publications. According to [40], research should be allowed to be marketable and sustainable (innovation) through collaboration with industry.

Publications on university interaction and its context for experimental development activities began in 2005, maintaining to date less than 1 publication per year. Likewise, in 2007, studies on university interaction and its context for the deployment of R+D+i began to be published, with a ratio of less than 1 publication per year. In [29], the SLR lists the benefits of this type of collaboration between university and industry, categorizing them as strategic, economic, operational and social. Furthermore, the SLR of [28] states that the financing of R+D activities, development through innovation, support for sectoral programs and the Triple Helix are public activities that support innovation. However, [28] also states that, under this approach, no recent publications have been found that consolidate Open Innovation, as has been found for the interaction approach of the university and its context.

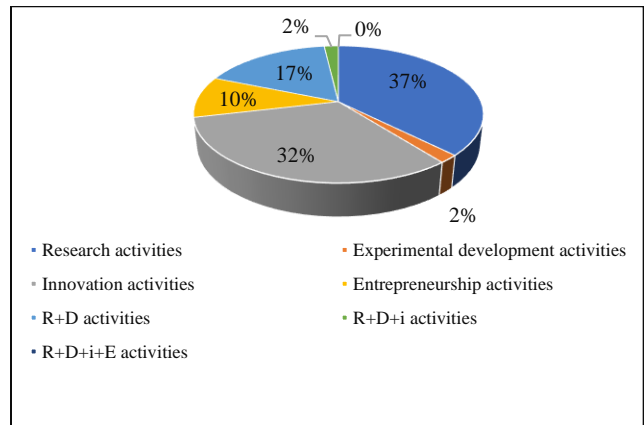


Fig. 10. R+D+i+e activities referred to in the published studies.

V. CONCLUSIONS

This research conducted a systematic mapping study (SMS) on articles published about R+D+i+e, answering the 6 research questions. The selection process for the primary studies was based on a search string, which returned 13561 articles from the Scopus, Web of Science, Science Direct, Proquest, and Ebsco. Following the inclusion and exclusion criteria, 336 paper were obtained that are considered as primary studies.

Based on primary studies, it was established that: (i) the majority of the studies (88%) were published in indexed journals; (ii) between 1994 and 2023, publications maintained a growing trend until 2020, with notable falls in the years 2006, 2015, and from 2021 to 2023; (iii) the types of research reported most frequently are evaluation research (199), opinion articles (66) and validation research (65); (iv) the most frequently reported research methods are case studies (42%), surveys (32%) and action research (26%); (v) the most reported validation methods are mathematical models (84%); and (vi) the most frequently reported contribution types are Tools (70%), Models (42%), Lessons Learned (25%), and Recommendations (23%).

In this study, 17 models for R+D+i+e interaction between the university and its context were identified. When applying the Pareto principle, it was found that the Industrial University, Triple Helix, Entrepreneurial University, Open Innovation and Stakeholders models are the most widespread.

The trend of publications by type of contribution is increasing and the tree that is more notable are Tools, Models, and Recommendations.

As regards the number of publications relating to R+D+i+e activities, it was noted that: research activities (37%), followed by innovation activities (32%) and R+D activities with 17%. In addition, there has been a rise in the trend between 1994 and 2023. Also, since 2019, the trend in innovation publications is slightly above the research trend. In fourth place are entrepreneurship activities (10%), followed by R+D+i and experimental development, both with 2% of the total publications. These terms have not yet been placed in the group

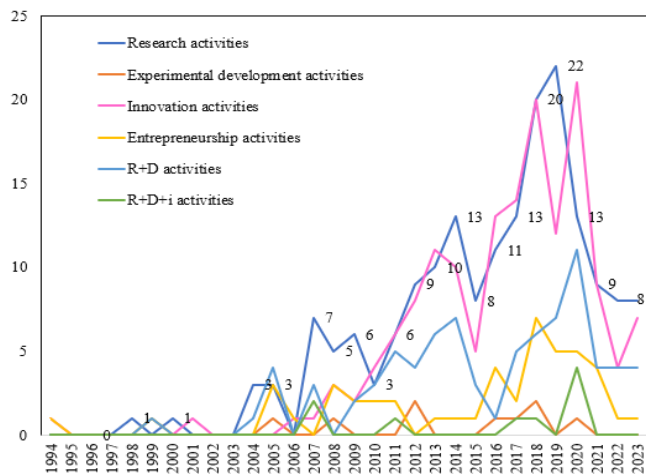


Fig. 11. Publications regarding R+D+i+e activities per year.

of activities promoted by the interaction models of the university and its context.

In the future, the influence of the interaction between the university and its context for the deployment of R+D+i+e activities could be investigated, since there is no study identify in this study.

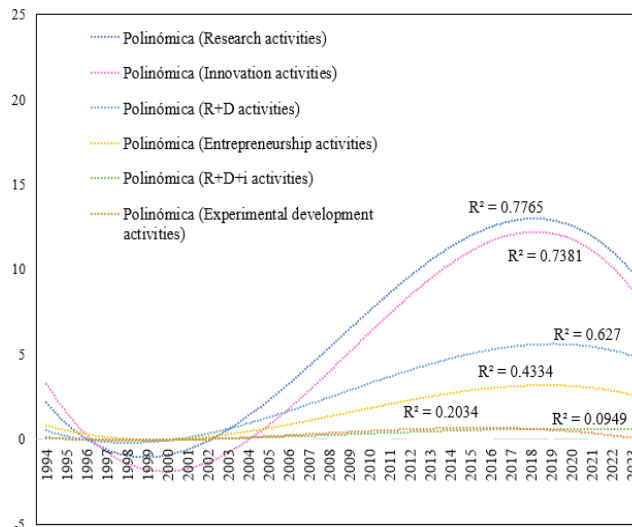


Fig. 12. Trend of publications regarding R+D+i+e activities.

APPENDIX

Appendix A. Primary studies selected. [URL](#)

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