40 years of excellence: An overview of *Technovation* and a roadmap for future research

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ABSTRACT

The International Journal of Technological Innovation, Entrepreneurship and Technology Management (*Technovation*) is a flagship journal in the fields of management and technological innovation. This renowned position is largely a result of academic interest, as demonstrated by the large number of citations received from other prestigious journals, as well as downloads from across the globe. This study honors the 40th anniversary of *Technovation* and provides an overview of the journal's accomplishments since its conception in 1981 using Thomson Reuters Web of Science Core Collection database, complemented by both the Elsevier Scopus and EBSCO Business Premier databases, as well as the journal's webpage. This study highlights the main contributors (i.e. authors, universities, countries accountable for the journal's high ranking), the most cited articles, and the thematic profile of the journal through an extensive bibliometric analysis of *Technovation* publications. Finally, this study outlines growing research trends and proposes trajectories for future research.

1. Introduction

This article commemorates the 40th anniversary of *Technovation – The International Journal of Technological Innovation, Entrepreneurship and Technology Management*. The journal launched its inaugural issue in February 1981, under the editorship of Wayne S. Brown (Brown and Bowen, 1981), who remained editor in charge until 1983. In 1984, George Hayward began chairing and, under his editorship, the journal changed its name from *Technovation – an International Journal of Technological Innovation and Entrepreneurship* to *Technovation – The International Journal of Technological Innovation, Entrepreneurship and Technology Management*, remaining committed to the areas of interest, scope, and aims of technology and management (Hayward, 1996). In 2005, George Hayward transferred the role of editor-in-chief to Jonathan Linton and then, more recently, Wim Vanhaverbeke and Stelvia Matos became the new editors in January 2020.

Technovation is the leading academic interdisciplinary journal for the fields of management and technological innovation. The journal seeks to advance the knowledge of technological innovation and provide insights on new technological trends.[1] Since the beginning of 1981, it has been published by the Elsevier Scientific Publishing Company, starting with irregular issues: on average 4 numbers per year with 5 articles per volume. From 1996, the journal moved to a more regular publishing basis, with around 10 numbers per year and 5 papers per volume. From 2000 onwards, *Technovation* was published monthly, with an average of 6 papers per volume. From 2017 onwards, the journal changed its publishing policy to 10 numbers per year with an average of 5 papers per number. Over the years, the journal has become highly recognised worldwide and is ranked as a 3-star journal on the Chartered Association of Business Schools-Academic Journal Guide (CABS-AJG) classification list, with a Clarivate Analytics Impact Factor of 5.729 for 2019 and Q1 Scimago classification for both Management of Technology, Innovation, and Engineering.

In light of *Technovation*'s 40th anniversary, it seems appropriate to

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[1] https://www.journals.elsevier.com/technovation.

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summarize the journal's accomplishments, offer a synthesis of key contributions, and provide recommendations for future development. Furthermore, the provision of a bibliometric overview is common practice for a journal when celebrating an anniversary and/or acknowledging a change in its editorial team (e.g. Callon et al., 1999; Linstone, 1999; Marzi et al., 2020a; Merino et al., 2006). An additional motivation behind this bibliometric overview lies in the continuous increase of the existing knowledge base, which challenges scholars' attempts to remain up to date on all relevant studies published in their research fields and journals. This study therefore highlights the structural changes, topic shifts, and new approaches within the field, serving as an important resource for scholars interested in developing their understanding of the future of research into entrepreneurship, management, and technological innovation. With this in mind, this paper offers those looking to publish their research in Technovation a comprehensive overview of the journal's underyling structure, facilitating these researchers' familiarization with recent trends and perspectives developed through contributions to this journal.

To outline Technovation's contribution to academia and update prior bibliometric research in the field (Merino et al., 2006; Linton, 2011), we have performed a bibliometric analysis using the 1905 articles and reviews published in Technovation between 1981 and 2019. We conducted the analysis using the Visualization of Similarities (VOS) technique (van Eck and Waltman, 2010) and Multiple Correspondence Analysis (MCA) (Hoffman & Leuw, 1992) together with a review of key contributions published on Technovation (Tranfield et al., 2003). This approach allowed us to explore and identify structures in the relationships between the key research themes, assess its boundaries, and propose some trajectories for future research (Rousseau et al., 2008; Marzi et al., 2020a, 2020b; Dabić et al., 2020).

This study contributes to the fields of management and technological innovation by providing a detailed picture of Technovation's publications and their contributions to the innovation management field. In doing so, we outline the journal's hitherto predominant focus on research themes such as "innovation processes and knowledge"; "institutional support to innovation"; "the strategic management of innovation"; "customer innovation adoption"; "product innovation and development"; "intellectual property"; and "innovation implementation", providing scholars with foundational knowledge from which they can develop new domains of expertise (Snyder, 2019).

We organize the remainder of the article as follows. In the next section, we provide an overview of the method used. In Section Three, we examine the accomplishments of *Technovation* since its foundation, followed by the journal's positioning in the research field and its thematic focus over time. We then offer guidelines for further investigation, seeking to assist authors in preparing their submissions and enabling readers to discover more information concerning specific topics and the overall contributions of *Technovation*'s publications. Finally, in last section, we summarize the main contributions of this study.

2. Methodology

In order to provide a comprehensive overview of *Technovation,* simultaneously highlighting the key research themes within the journal, our analysis adopted a hybrid approach based on bibliometric indicators, supported by an in-depth review of *Technovation* publications. This hybrid approach has been effectively employed in previous research seeking to analyse the content of a specific journal (Bellucci et al., 2020; Marzi et al., 2020a) or a specific research area, such immigrant entrepreneurship (Dabić et al., 2020), cross-border mergers and acquisitions (Kiessling et al., 2019), and the development of new products (Marzi et al., 2020b). The combination of bibliometric indicators and in-depth reviews allows researchers to offer a robust overview of the data under study, together with a detailed analysis of the results emerging from the quantitative bibliometric analysis (Zupic and Čater, 2015). As such, using a combination of different approaches and techniques allowed us to balance the pros and cons for each method (Zupic and Čater, 2015).

The methodological foundations of bibliometric analysis considers *citation analysis* to be the primary measure of impact for publications, facilitating the recognition of documents and authors that are influential within a specific area - in this case, the *Technovation* journal (Marzi et al., 2020b; Zupic and Čater, 2015). The *keyword analysis* allowed us to explore the frequency with which specific terms occurred in the titles, abstracts, and authors' keywords of each paper. Thus, the *keyword analysis* provided a graphical summary, highlighting the relationships between the intellectual and cognitive structures of the topics published in *Technovation* (Bellucci et al., 2020). Accordingly, the *keyword analysis* enables representsation of keywords (i.e., content) which can be regarded as "the knowledge generalization of the full text in a corresponding literature and help[s] readers to quickly grasp the core idea, core technique, or core methodology" (Hu et al., 2018, p. 1031). The literature review (Tranfield et al., 2003) grounded on the results of the *citation analysis* (Kiessling et al., 2019; Marzi et al., 2020a) allowed us to unveil the intellectual structure of papers published in *Technovation* over the last 40 years. In doing so, we examined the theoretical background, the methodologies, the findings, and the limitations of studies published in the journal. This allowed us to form a retrospective picture of *Technovation's* contributions and the accomplishments of the scholars published in the journal, while also revealing the potential for the future advancement of topics covered by *Technovation*.

It is worth noting that there are other methodological and bibliometrical approaches that could be used to fulfil the aim of this study. For example, a systematic literature review focusing on a shorter period of time or on a specific topic covered by *Technovation* could be a viable alternative method. In addition to this, Hierarchical Cluster Analysis or Metric Multidimensional Scaling could be used as an alternative to VOS and MCA (Samiee and Chabowski, 2012). However, as several authors have pointed out, the key element of a reliable and comprehensive bibliometric and literature analysis is not the method itself but the combination of different methods that reinforce and reconfirm the emerging findings (Ding et al., 2016; Marzi et al., 2020b; Samiee and Chabowski, 2012; Zupic and Čater, 2015). In this study, we used bibliometric activity indicators, VOS analysis, MCA analysis, and an in-depth literature review. We opted for a solution that allowed for a comprehensive overview of the journal, highlighting to scholars the areas explored by *Technovation*. In doing so, the readers who approach this paper may find a starting point for their autonomous exploration of a specific topic discussed in the journal. It is worth noting that a large volume of data was collected in order to perform this analysis. Overall, this paper offers a roadmap that could guide scholars in exploring the domain of *Technovation*. However, this research is not the territory itself, but rather a portrait that summarizes a massive amount of information, outlining the main trajectories of the journal.

During the process of data collection and analysis, we collected all of the papers published from 1981 in *Technovation* and indexed in the primary scientific databases. We selected Thomson Reuters Web of Science Core Collection database as it offers a valuable and high-impact collection of data and is recognised as a reliable database for bibliometric studies (Falagas et al., 2007). The research query was IS=(0166–4972), where "IS" was the ISSN number of the target journal. The selection was restricted to "Article" and "Review" document types to avoid editorials, notes, and corrections (Ding et al., 2016; Vlačić et al., 2021).

On the date of the data extraction (23rd March 2020), we retrieved 1905 peer-reviewed papers published from 1981 to 2019 from the Web of Science Core Collection. In order to ensure the inclusion of all relevant data, cross-validation was conducted with Elsevier Scopus and EBSCO Business Premier databases.

For the bibliometric analysis, we used a combination of approaches and software, such as VOSviewer v1.6.10, QDA Miner v5, Wordstat v8, and IBM SPSS v26. Firstly, we outlined a series of bibliometric activity

indicators in order to identify the most cited papers, the most cited authors, the most prolific institutions, and the most prolific countries (Ding et al., 2016; Persson et al., 2009). Next, we proceed with a more in-depth analysis of the journal by applying advanced analysis methods to the dataset (Zupic and Čater, 2015).

In order to answer "*Which authors had the biggest influence on the research in a journal? Which journals and disciplines had the most impact on a research stream? What is the 'balance of trade' between journals/disciplines? Who are the experts in a given research field?* and *What is the recommended 'reading list' for a specific area?",* we performed a citation analysis using VOSviewer, covering the period between 1981 and 2019 (Zupic and Čater, 2015, p. 432).

The VOSviewer analysis plots the distance between items, which can be interpreted as an indication of their relatedness: the smaller the distance between the items, the stronger they are related to each other (van Eck and Waltman, 2014). Furthermore, the cluster analysis highlights the diversity of the knowledge base in an aggregate way. Articles belonging to the same cluster are strongly linked as a group, indicating a stream of research. Finally, the size of a point represents the relative importance of the plot (van Eck and Waltman, 2014).

Next, we performed a Multiple Correspondence Analysis (MCA) using the keywords outlined (which can range from single words to phrase) to identify research themes (Hoffman and De Leeuw, 1992). Keywords were considered to capture the core of a research paper (Su and Lee, 2010). This approach allowed us to further explore the content and identify structures in the relationships between the presence/absence of keywords in the included studies and map research themes (Kiessling et al., 2019; Dabić et al., 2020). To map *Technovation's* intellectual structure, we initiated MCA by building a codebook of keywords based upon prior reviews of the field (Merino et al., 2006; Linton, 2011) and extending it by building our sample, which consisted of 277 keywords (full list available in supplementary material) grouped into seven major research themes. Building upon the stepwise procedure presented by López-Duarte and colleagues (2016) and using QDA Miner v.5 and Wordstat v.8, we extracted the key content and classified it in order to form a reduced list of key terms (i.e., core descriptors). Then, we merged thematically similar descriptors into meaningful research themes in terms of their content and frequency. Next, we clustered the research themes into seven broad themes according to their characteristics and topics: innovation process and knowledge; institutional support of innovation; strategic management of innovation; customer innovation adoption; product innovation and development; intellectual property; and innovation implementation process. The illustrated map (see Fig. 4) summarizes prior research and allows for the identification of the relationships between the research themes. Each dimension of the map jointly accounts for 53.5% of the explained variance, which exceeds the threshold of 50% (Hoffman and De Leeuw, 1992; Kiessling et al., 2019), and 3.03 keywords per article, which exceeds the threshold of 1 (Hair et al., 1998), guarding against the potentially misleading effect of MCA variance explained through two dimensions.

To gather relevant information concerning the journal and the evolution of the research field, the authors present *Technovation*'s journal accomplishment indicators, outlining the potential trajectories of future research into management and technological innovation.

3. *Technovation* accomplishment indicators

In this section, we present the results of the *Technovation* bibliometric activity indicators from the dataset of 1905 papers published and indexed between 1981 and 2019. As Table 1 and Fig. 1 show, the number of papers published by *Technovation* has increased slowly but steadily since 1981, with an average growth rate of +16% until 2005 and an average rate of 45 papers published per year. 2005 and 2006 recorded a peak in the number of published papers because of several special issues in both years. From 2006 onwards, the number of published papers decreased (−4% with an average of 56 papers per year). The availability of data gathered throughout the series of Community Innovation Surveys (CIS) can partially explain the peak recorded in Europe from 1991 to 2001, which became available in 2004 (Becheikh et al., 2006). While the first two columns reflect the data of Fig. 1, we can see that the Times Cited/Number of Publications (TC/NP) ratio steadily increases over the years. The TC/NP ratio represents the growing influence of *Technovation* in the field of innovation through its growing Impact Factor (see Fig. 1).[2] The average times cited per year (ΔTC/Y) ratio shows a steady increase, with papers cited over 200 times mainly concentrated between 2003 and 2011. The high concentration of frequently cited papers over these years could signify, on the one hand, an overall growth in number of authors and academic contributions and, as such, potential opportunities for citation growth; or, on the other hand, it could show that *Technovation* became a highly recognised journal around the mid-90s, adopting a stronger focus on new product development (Nieto and Santamaría, 2007) and open innovation (van de vrande et al., 2009). There may also have been a delay period for recently published articles prior to their recognition and citation within the academic community.

As presented in Fig. 1, *Technovation* has recorded a notable increase in Impact Factor, particularly in the last few years (2.243 in 2015; 3.265 in 2016; 4.802 in 2017; 5.250 in 2018; 5.729 in 2019). The five-year Impact Factor is 6.925, with an Eigenfactor[3] of 0.00301 in 2019. In the Scientific Journal Rankings, which measures the average prestige per article and the scientific influence of journals, *Technovation* was given 2.795, showing a constant increase from 1999, in which it was 0.291, to 2009, when it reached 1.140.

Since its foundation, *Technovation* has published a series of papers and findings considered seminal to the field of Innovation and Management. An analysis of the most impactful studies (see Table 2 below and Figure A1, available in the Appendix) highlights the nature of the studies published by *Technovation*. The papers presented show the attitude that *Technovation* has regarding the collaborative element of innovation; from open innovation to academic/industry links and collaborative networks. Other topics, such as R&D, customers, and technology, are central, but links to the collaborative side of innovation are often made, even if they are not explicitly mentioned.

The journal has published seminal papers on open innovation. For example, Van de Vrande, De Jong, Vanhaverbeke, and De Rochemont (2009) explored if and how open innovation practices are applied in SMEs and what the motivations and perceived challenges are for small companies when open innovation is implemented. Accordingly, SMEs primarily adopt open innovation because of market-related pressure, such as meeting customer demands or matching with competitors (Lüthje, 2004). Compared to small firms, medium-sized firms are more heavily involved in open innovation, with no differences in their services or manufacturing processes. With this in mind, Huizingh (2011) clarified the content of open innovation, its context dependency, and the process of open innovation. The author summarised and interpreted the findings of eight years' worth of studies by offering a precise analysis of how open innovation is a valuable and profitable approach for many firms and contexts and is gradually becoming an established practice in innovation management.

Similarly, Nieto and Santamaría (2007) empirically show the importance of collaboration networks for product innovation. The authors outlined that the most significant benefit - in terms of product

[2] Impact Factor measures the yearly average number of citations that articles published in a journal have received in the last two years. Impact Factor is a good a proxy with which to measure the importance of a journal within its field.

[3] Eigenfactor is a further assessment of the importance of a scientific journal within its field. A journal is classified according to the number of incoming citations, where citations from high level journals are weighted in order to give a greater contribution to the Eigenfactor score than those from low level journals.

Table 1
Citation structure of *Technovation* between 1981 and 2019.

							Papers with citations (TC) ≥				
Year	NP	%ΔNP	TC	ΔTC/Y	NCP	TC/NP	NP/NCP	200	100	50	25	1
1981	11	–	26	0.06	n/a	2.36	n/a	0	0	0	0	9
1982	10	−10%	65	0.17	n/a	6.50	n/a	0	0	0	1	6
1983	5	−100%	19	0.10	n/a	3.80	n/a	0	0	0	0	4
1984	13	+62%	60	0.13	n/a	4.62	n/a	0	0	0	0	10
1985	24	+46%	98	0.12	370	4.08	15.42	0	0	0	1	16
1986	33	+27%	182	0.16	n/a	5.52	n/a	0	0	0	2	25
1987	32	−3%	243	0.23	n/a	7.59	n/a	0	0	0	3	27
1988	34	+6%	213	0.20	n/a	6.26	n/a	0	0	0	3	26
1989	35	+3%	233	0.21	n/a	6.66	n/a	0	1	1	1	24
1990	34	−3%	276	0.27	n/a	8.12	n/a	0	0	1	3	27
1991	31	−10%	536	0.60	n/a	17.29	n/a	0	2	2	6	29
1992	35	+11%	353	0.36	n/a	10.09	n/a	0	1	1	4	32
1993	33	−6%	382	0.43	n/a	11.58	n/a	0	0	2	3	29
1994	46	+28%	557	0.47	n/a	12.11	n/a	0	2	3	6	36
1995	37	−24%	805	0.87	n/a	21.76	n/a	0	1	5	11	34
1996	49	+24%	1159	0.99	1494	23.65	30.49	1	2	4	10	45
1997	56	+13%	1008	0.78	1489	18.00	26.59	0	1	5	12	54
1998	57	+2%	1808	1.44	1682	31.72	29.51	2	3	6	17	54
1999	57	0%	1638	1.37	1661	28.74	29.14	0	4	10	17	54
2000	63	+10%	1372	1.09	1675	21.78	26.59	0	0	7	18	62
2001	69	+9%	1852	1.41	2317	26.84	33.58	0	5	10	25	67
2002	70	+1%	2331	1.85	1857	33.30	26.53	0	8	16	30	68
2003	77	+9%	2597	1.98	2432	33.73	31.58	1	6	15	29	77
2004	82	+6%	3701	2.82	2694	45.13	32.85	3	9	23	35	82
2005	131	+37%	6361	3.24	4918	48.56	37.54	3	20	37	70	130
2006	123	−7%	5902	3.43	4966	47.98	40.37	5	11	37	76	122
2007	60	−105%	4151	5.32	3237	69.18	53.95	2	14	26	40	60
2008	71	+15%	4284	5.03	4085	60.34	57.54	4	14	28	48	71
2009	72	+1%	4853	6.13	4312	67.40	59.89	3	13	30	50	72
2010	57	−26%	3253	5.71	3927	57.07	68.89	2	6	22	42	57
2011	56	−2%	3522	6.99	4297	62.89	76.73	1	8	19	35	56
2012	59	+5%	2242	4.75	4233	38.00	71.75	0	2	14	40	59
2013	36	−64%	1192	4.73	2683	33.11	74.53	0	2	6	18	36
2014	67	+46%	1634	4.06	4956	24.39	73.97	0	0	6	26	66
2015	46	−46%	1220	5.30	3795	26.52	82.50	0	1	6	19	46
2016	40	−15%	976	6.10	2989	24.40	74.73	0	1	5	16	39
2017	28	−43%	333	3.96	2166	11.89	77.36	0	0	0	4	28
2018	31	+10%	153	2.47	2570	4.94	82.90	0	0	0	0	26
2019	35	+11%	59	1.69	3322	1.69	94.91	0	0	0	0	23
Totals	1905	–	61649	2.74	74127	–	–	27	137	347	721	1788

Abbreviations: NP = number of papers published; TC = times cited; NCP = number of total cited references in a paper. Please note that not all information is available for all years within the Web of Science Core Collection. When NCP was not available, 'n/a' was listed.

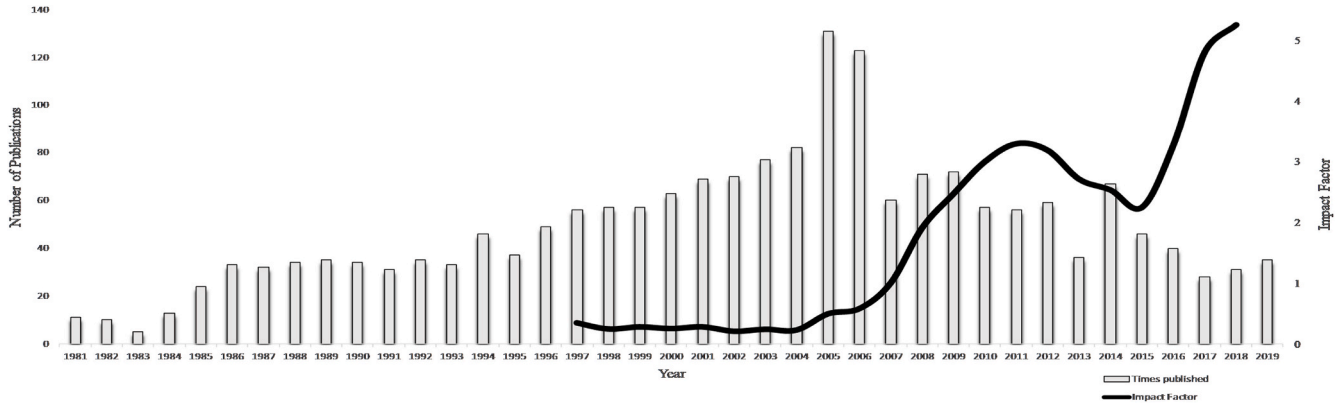

Fig. 1. Evolution of *Technovation* Impact Factor and number of publications per year (according to Web of Science).

innovation - emerges from collaborations with suppliers, clients, research organisations, and different partners. Conversely, collaborations with competitors - *co-petition* - can harm the novelty of innovation. Zeng, Xie, and Tam (2010) further expand upon the findings of previous studies by exploring inter-firm cooperation and cooperation with research institutions, showing that cooperation with government research institutions is not linked to the significance of impact for the innovation performance of SMEs. On the contrary, vertical and horizontal integration plays a significant role in SMEs' innovation performance.

Several articles in *Technovation* have seminally contributed to the exploration of integrating knowledge sources when attempting to improve innovation performance in regard to different types of innovations. Caloghirou, Kastelli, and Tsakanikas (2004) explored how

Table 2
The 50 most cited *Technovation* publications.

R.	TC	Title	Authors	Year	C/Y
1	732	Open innovation in SMEs: Trends, motives and management challenges	van de Vrande et al.	2009	66.55
2	635	Open innovation: State of the art and future perspectives	Huizingh	2011	70.56
3	551	The importance of diverse collaborative networks for the novelty of product innovation	Nieto & Santamaria	2007	42.38
4	420	How to make product development projects more successful by integrating Kano's model of customer satisfaction into quality function deployment	Matzler & Hinterhuber	1998	19.09
5	419	Internal capabilities and external knowledge sources: complements or substitutes for innovative performance?	Caloghirou	2004	26.19
6	402	Relationship between cooperation networks and innovation performance of SMEs	Zeng	2010	40.20
7	343	Lessons from innovation empirical studies in the manufacturing sector: A systematic review of the literature from 1993 to 2003	Becheikh	2006	24.50
8	309	Measuring technological change through patents and innovation surveys	Archibugi & Pianta	1996	12.88
9	307	A system failure framework for innovation policy design	Woolthuis	2005	20.47
10	299	Small firms, R&D, technology and innovation in the UK: a literature review	Hoffman et al.	1998	13.59
11	289	Eco-innovation and new product development: understanding the influences on market performance	Pujari	2006	20.64
12	274	Benefits, obstacles, and future of six sigma approach	Kwak & Anbari	2006	19.57
13	266	Assessing the impact of organizational learning capability on product innovation performance: An empirical test	Alegre & Chiva	2008	22.17
14	265	Incubator best practice: A framework	Bergek & Norrman	2008	22.08
15	262	R&D collaboration by SMEs: new opportunities and limitations in the face of globalisation	Narula	2004	16.38
16	259	Innovative capability and export performance of Chinese firms	Guan & Ma	2003	15.24
17	250	Do different types of innovation rely on specific kinds of knowledge interactions?	Tödtling	2009	22.73
18	237	Organizational innovation: The challenge of measuring non-technical innovation in large-scale surveys	Armbruster et al.	2008	19.75
19	230	Business incubators and new venture creation: an assessment of incubating models	Grimaldi & Grandi	2005	15.33
20	224	Drivers of innovativeness and performance for innovative SMEs in South Korea: Mediation of learning orientation	Rhee, Park, & Lee	2010	22.40
21	220	Shopping motivations on Internet: A study based on utilitarian and hedonic value	To, Liao, & Lin	2007	16.92
22	213	What's in it for me? Creating and appropriating value in innovation-related coopetition	Ritala & Hurmelinna-Laukkanen	2009	19.36
23	212	Characteristics of innovating users in a consumer goods field - An empirical study of sport-related product consumers	Lüthje	2004	13.25
24	211	Which resources matter the most to firm success? An exploratory study of resource-based theory	Galbreath	2005	14.07
25	209	Challenges to global RFID adoption	Wu et al.	2006	14.93
26	208	Action-based entrepreneurship education	Rasmussen	2006	14.86
27	202	The role of internationalization in explaining innovation performance	Kafouros et al.	2008	16.83
28	194	Collaboration and innovation: a review of the effects of mergers, acquisitions and alliances on innovation	De Man & Duysters	2005	12.93
29	194	Absorptive capacity, technological opportunity, knowledge spillovers, and innovative effort	Nieto & Quevedo	2005	12.93
30	193	An approach to discovering new technology opportunities: Keyword-based patent map approach	Lee et al.	2009	17.55
31	191	Targeting innovation and implications for capability development	Francis & Bessant	2005	12.73
32	189	Organizational modes for Open Innovation in the bio-pharmaceutical industry: An exploratory analysis	Bianchi et al.	2011	21.00
33	189	TQM and innovation: a literature review and research framework	Prajogo & Sohal	2001	9.95
34	187	Cooperation, competition, and innovative capability: a panel data of European dedicated biotechnology firms	Quintana-Garcia & Benavides-Velasco	2004	11.69
35	186	Innovating through strategic alliances: moving towards international partnerships and contractual agreements	Narula & Hagedoorn	1999	8.86
36	183	Initiatives to promote commercialization of university knowledge	Rasmussen et al.	2006	13.07
37	183	An evolutionary model of continuous improvement behaviour	Bessant et al.	2001	9.63
38	182	Sources of information as determinants of novelty of innovation in manufacturing firms: evidence from the 1999 Statistics Canada Innovation Survey	Amara & Landry	2005	12.13
39	180	An investigation into the acceptance of online banking in Saudi Arabia	Al-Somali	2009	16.36
40	177	Assessing technology incubator programs in the science park: the good, the bad and the ugly	Chan & Lau	2005	11.80
41	174	Building absorptive capacity to organize inbound open innovation in traditional industries	Spithoven, Clarysse, & Knockaert	2010	19.33
42	173	The Open Innovation Journey: How firms dynamically implement the emerging	Chiaroni, Chiesa & Frattini	2011	19.22

(*continued on next page*)

Table 2 (*continued*)

R.	TC	Title	Authors	Year	C/Y
		innovation management paradigm			
43	173	Reconfiguring the innovation policy portfolios for Taiwan's SIP Mall industry	Huang, Shyu, & Tzeng	2007	13.31
44	173	Understanding the process of knowledge transfer to achieve successful technological innovation	Gilbert & Cordey-Hayes	1996	7.21
45	171	The entrepreneurial university: Examining the underlying academic tensions	Philpott et al.	2011	19.00
46	169	A proposed model of e-trust for electronic banking	Yousafzai	2003	9.94
47	168	Absorptive capacity, its determinants, and influence on innovation output: Cross-cultural validation of the structural model	Murovec & Prodan	2009	15.27
48	168	The antecedents of SME innovativeness in an emerging transition economy	Radas & Božić	2009	15.27
49	168	Integration of market pull and technology push in the corporate front end and innovation management-Insights from the German software industry	Brem & Voigt	2009	15.27
50	168	Determining technology trends and forecasts of RFID by a historical review and bibliometric analysis from 1991 to 2005	Chao, Yang, & Jen	2007	12.92

Ranking according to TC. Abbreviations: R = rank; TC = times cited; C/Y = citations per year.
Note: References to the 50 most cited *Technovation* publications are available in the supplementary material.

and to what extent the level of a firm's innovativeness is affected by the relationship between its internal capabilities and its external sources of knowledge. There is a robust relationship between the extent of a firm's innovation and its R&D intensity and the qualifications of its personnel. Tödtling, Lehner, and Kaufmann (2009) have further explored how different types of innovation rely on different knowledge inputs, sources, and links. Products new to the market are better supported through knowledge interactions between research organisations and universities, while incremental changes to products rely more on the absorptive capacity of the firms.

Technovation actively contributes to the field of new product development and product innovation by offering tools that actively help managers and academics to extend research on practices to make product development projects more successful. For example, Matzler and Hinterhuber (1998) developed a tool based on Kano's model of customer satisfaction (Kano, 1984) to explore and classify specified and unspecified customers' needs, offering a decision instrument for managers and new product development staff. In a similar vein, Pujari (2006) focused his attention on the role of eco-innovation for new product development, showing that designs for environment/life-cycle analysis and supplier involvement in terms of environmental responsiveness are linked to superior market performance. Finally, another cornerstone study by Becheikh et al. (2006) summarised ten years of good practices for managers and academics regarding innovation in the manufacturing sector.

For the analysis of the most prolific authors, the results presented in Table 3 show Chihiro Watanabe as a leading author in studies related to R&D, Manufacturing, and Technology Management. The second most prolific author, Elias G. Carayannis, focuses his attention on Technology Management and its connection with various aspects of Entrepreneurship, from education to incubators and spin-offs. Finally, the third author on the podium, Amrik Sohal, focuses his attention mostly on the technical side of innovation, such as Total Quality Management (TQM), Environmental Management System (EMS), and Supply Chain.

In Fig. 2 and Figure A2 (see in Appendix), we analyse influential authors by identifying the most productive authors in terms of the number of citations they have received within the context of their year of publication. The size of the circle reveals the number of publications per author. This double logarithmic graph, presented in Fig. 2, reflects *Technovation*'s tendency to publish high-quality contributions, providing scholars with a prominent and influential outlet for their

Table 3
Most productive authors in *Technovation*.

R.	NP	Author	University	Country	TC	h-index	C/P
1	34	Watanabe, C.	U. of Jyväskylä	Finland	515	13	15.15
2	22	Carayannis, E. G.	George Washington U.	USA	984	16	44.73
3	20	Sohal, A. S.	Monash U.	Australia	817	12	40.85
4	17	Ilori, M. O.	U. of Lagos	Nigeria	115	7	6.76
5	13	Foxall, G. R.	Cardiff U.	UK	432	10	33.23
6	12	Bessant, J.	U. of Brighton	UK	1042	9	86.83
7	11	Hitomi, K.	Osaka Gakuin U.	Japan	30	3	2.73
8	11	Kumar, S.	U. of St Thomas Minnesota	USA	294	7	26.73
9	10	Corsten, H.	U. of Kaiserslautern	Germany	58	4	5.8
10	9	Barbiroli, G.	U. of Bologna	Italy	68	5	7.56
11	9	Griffy-Brown, C.	Pepperdine U.	USA	184	8	20.44
12	9	Lee, J.	Wayne State U.	USA	287	8	31.89
13	9	Sanchez, A. M.	U. of Zaragoza	Spain	249	7	27.67
14	9	Snaddon, D. R.	U. of Witwatersrand	South Africa	31	3	3.44
15	8	Gunasekaran, A.	U. of Massachusetts	USA	298	7	37.25
16	8	Khare, A.	Athabasca U.	Canada	315	6	39.38
17	8	Ottosson, S.	Uppsala U.	Sweden	153	5	19.13
18	7	Burton, R. M.	U. of Leicester	UK	6	1	0.86
19	7	Gupta, Y. P.	Lehigh U.	USA	45	4	6.43
20	7	Hobday, M.	U. of Brighton	UK	104	4	14.86
21	7	Holt, K.	Norwegian U. of Science & Technology	Norway	27	3	3.86
22	7	McAdam, R.	Ulster U.	UK	414	7	59.14
23	7	Oyebisi, T. O.	Obafemi Awolowo U.	Africa	75	4	10.71
24	7	Park, Y.	Seoul National U.	South Korea	437	7	62.43
25	7	Wonglimpiyarat, J.	Thammasat U.	Thailand	118	6	16.86

Ranking According to NP. Abbreviations: C/P = citations per publications.
Full list of abbreviations available in Tables 1 and 2

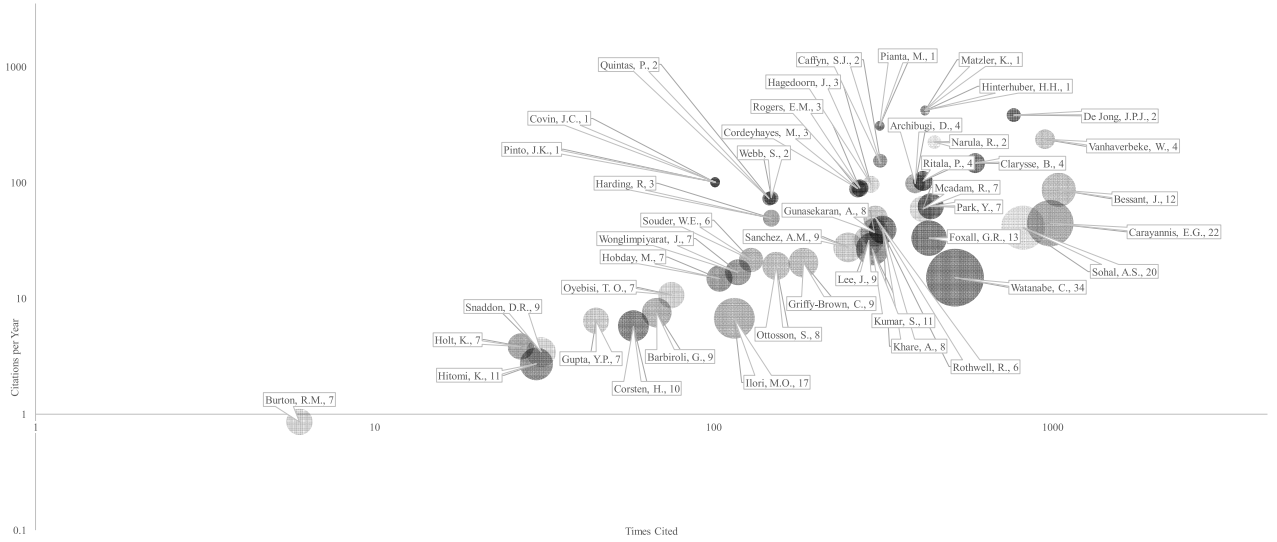

Fig. 2. *Technovation's* most prominent and influential authors.

findings.

We used Normalised Total Citation (TCN) to rank the scholars that received a relevant number of citations when relative to the years of the papers' publication (Havemann and Larsen, 2015). Table 4, in line with Fig. 2, shows that authors such as Hagedoorn, J., Caffyn, S. J., and Pinto, J. K. are ranked among the top 25 rising influential authors, despite their small numbers of total citations and times published, as they have been constantly and repeatedly cited in recent times.[4]

Since its conception, authors from various universities and countries have published their works in *Technovation*. Our analysis shows that *Technovation,* although global in scope, is a Europe-centric journal, with most of its contributions coming from the UK and EU countries (see Figure A3 and Figure A4 in the Appendix). However, countries such as the Republic of China and Nigeria have emerged on the list of most prolific countries. In terms of citations collected by each country, we can see that the USA and China are the most engaged, as shown in Table 5. Technovation's publications and contributions to academia have been continuously well regarded and accredited by journals within the field of technology innovation management (Linton and Embrechts, 2007), such as *Technological Forecasting and Social Change, Technology Analysis Strategic Management,* the *International Journal of Technology Management* and *R&D Management,* as well as other fields, such as international business and entrepreneurship, through the *International Business Review*, the *Journal of Small Business Management*, and the *International Entrepreneurship and Management Journal,* among others.

As shown in Table 5 and Fig. 3, *Technovation* is an international journal with a significant spread of global readership and strong relationships between countries/regions. Fig. 3 presents an overview of *Technovation*'s full-text articles, downloaded from ScienceDirect from the last five full calendar years (2015–2019), as displayed by country/region. The number of downloads includes many types of access except robot usage and other artificial traffic. The frequency of downloads further supports the higher interest of the UK and the EU in *Technovation* publications.

Having identified the accomplishment indicators of *Technovation*, analysed its characteristics, and mapped the most prolific contributors (authors, universities, and countries), we have built upon this information and have analysed the evolution of the research field of *Technovation*.

[4] Please note that Tables 3 and 4 show the most updated authors' affiliations based on what authors indicated in their last published paper.

4. Mapping the fields of management and technology innovation

Research topics published in *Technovation* have developed over time because of the dynamic changes in the research field and authors' significant role in shaping it. To identify the core of the publications that appear in the *Technovation* journal and assess how they have developed over time, Table 6 presents the top ten most common keywords (i.e., single words and phrases) selected by authors in the journal from a global time perspective, simultaneously considering four consecutive periods: 1981–1990; 1991–2000; 2001–2010; and 2011–2019. Besides providing interesting insights into the journal's content and its research orientation, our analysis also reveals insights into the evolution of *Technovation*'s research themes. Altogether, 10,554 different single words and phrases were used by authors to describe the contents of their studies in the period 1981–2019. Table 6 lists the top ten most frequent content descriptors used to portray *Technovation's* research across different time periods. Notably, *Technovation* has remained on track since its foundation, fulfilling its research as illustrated through the ranking of the most frequently used terms: Innovation; Technology; Product Development; and Technology Transfer. The results presented in Table 6 illustrate how *Technovation* publications represent the trendsetter for several important areas of management and technology innovation. For example, open innovation is one of the topics within technology innovation and management literature and highly cited papers, such as van de vrande et al., 2009 and Huizingh (2011), are core contributions to this research field. Similarly, the current understanding of customers as co-creators in new product developments is strongly influenced by a paper written by Füller and Matzler (2007).

Although extensive literature review tables are valuable, they must be organised in such a way that their insights are easily understood by the reader. To synthesise large bodies of literature and outline the evolution of *Technovation* as a flagship journal of this research field, we performed a homogeneity analysis by alternating least squares (HOMALS) (Hoffman and De Leeuw, 1992). This approach enables the identification of the underlying structure of the research field (Gifi, 1990), and has been used to map the research fields of strategic management (González-Loureiro et al., 2015), immigrant entrepreneurship (Dabić et al., 2020), cross-border mergers and acquisitions (Kiessling et al., 2019), among others.

The most cited *Technovation* articles are shown in Table 2. These studies can be considered to make up the intellectual foundations of the research field as they comprise foundational theories and serve as a basis

Table 4
Rising influential authors in *Technovation*.

R.	TCN	Author	University	Country	TC	TP	C/P
1	40.17	Bessant, J.	U. of Brighton	UK	1042	12	86.83
2	30.74	Rothwell, R.	U. of Sussex	UK	300	6	50
3	27.75	Carayannis, E. G.	George Washington U.	USA	984	22	44.73
4	26.63	Sohal, A. S.	Monash U.	Australia	817	20	40.82
5	18.62	Hagedoorn, J.	Maastricht U.	Netherlands	291	3	97
6	17.52	Archibugi, D.	CNR/Birkbeck College	Italy/UK	393	4	98.25
7	17.31	Caffyn, S. J.	U. of Brighton	UK	310	2	155
8	16.17	Watanabe, C.	U. of Jyväskylä	Finland	515	34	15.15
9	15.75	Foxall, G. R.	Cardiff U.	UK	432	13	33.23
10	15.17	Covin, J. C.	Indiana U.	USA	101	1	101
11	15.17	Pinto, J. K.	Penn State U.	USA	101	1	101
12	14.74	Vanhaverbeke, W.	U. of Surrey	UK	949	4	237.25
13	13.91	Rogers, E. M.	U. of New Mexico	USA	270	3	90
14	13.82	Clarysse, B.	ETHZ	Switzerland	591	4	147.75
15	13.73	Cordeyhayes, M.	Cranfield U.	UK	266	3	88.66
16	13.24	Hinterhuber, H. H.	U. of Innsbruck	Austria	420	1	420
17	13.24	Matzler, K.	U. of Innsbruck	Austria	420	1	420
18	13.06	Pianta, M.	Scuola Normale Superiore	Italy	309	1	309
19	12.30	Harding, R.	Independent Researcher	–	148	3	49.3
20	12.30	Webb, S.	U. of Brighton	UK	148	2	74
21	12.28	Narula, R.	U. of Reading.	UK	448	2	224
22	11.51	Ritala, P.	Lappeenranta U. of Technology	Finland	414	4	103.5
23	11.42	Quintas, P.	Open U.	UK	146	2	73
24	11.39	De Jong, J. P. J.	Utrecht U.	Netherlands	768	2	384
25	11.27	Souder, W. E.	U. of Alabama	USA	129	6	21.5

Ranking According to TCN. Abbreviations: TCN = Normalised Total Citations.
Full list of abbreviations available in Tables 1 and 2.

for further knowledge development (Zupic and Čater, 2015; Rialp et al., 2019). The illustrated map (see Fig. 4) facilitates a deeper understanding of the *Technovation* domain as it is focused on the top 50 articles (available in Table 2) that make significant contributions to the research fields of management and technological innovation (Garfield, 1990). This map provides a summary of the prevalent themes emerging from the highly cited articles in *Technovation* from 1981 to 2019. Although *Technovation* publications cover more aspects of innovation and management than those outlined here, these seven research themes have been a source of inspiration for many scholars.

This analysis highlighted seven clusters. Our review of the contributions inside each cluster allowed us to identify the following predominant topics that have been covered by *Technovation* over the last 40 years. In identifying these, we present a brief review of the exemplary pieces of research within each cluster, together with a set of representative keywords and notable references (see Table 7).

For the topic of 'Innovation Process and Knowledge', most contributions were related to the focus of the innovation process on knowledge diffusion and collaboration. Within this cluster, relevant studies explore the findings of open innovation and potential challenges for the years ahead (Huizingh, 2011), the emerging trends for open innovation in specific geographical contexts (Hoffman et al., 1998), or a specific group of companies, such as SMEs (Rothwell, 1991; van de vrande et al., 2009). For open innovation, an extensive body of knowledge focuses on the role of networks of collaboration without explicitly mentioning the open innovation approach. Furthermore, through the lens of dynamic capabilities and resource-based views, several studies within the area of 'Innovation Process and Knowledge' explore the impact of knowledge and knowledge networks on performance (Caloghirou et al., 2004), the ability to integrate technology from a different context (Hadjimanolis, 1999; Liu and White, 1997), the capacity to absorb knowledge from the environment and from networks (Nieto and Quevedo, 2005), and the type of knowledge interaction needed for successful innovation (Tödtling et al., 2009).

'Institutional Support to Innovation' is the second cluster. This focuses on the role of institutions, universities, and academic bodies in fostering innovation and technology transfer. An extensive amount of research explores how science parks are forges for innovation diffusion and development (Felsenstein, 1994; Quintas et al., 1992; Vedovello, 1997). Another large body of knowledge within this cluster focuses on the role of university spin-offs and incubators in fostering the development of highly innovative firms (Bruneel et al., 2012; Mian, 1994; Pauwels et al., 2016; Rogers, 1986) and the best practices for managing and creating successful incubators and spin-offs (Bergek and Norrman, 2008; Grimaldi and Grandi, 2005; Ndonzuau et al., 2002). Regarding universities and innovation, another sub-topic explores the ccommercialisation of university knowledge (Rasmussen et al., 2006), and the interaction between the government, universities, and companies (Carayannis et al., 1998). Finally, an extensive set of papers are dedicated to entrepreneurship, with a focus on academics as entrepreneurs (Samsom and Gurdon, 1993; Visintin and Pittino, 2014), entrepreneurial education seeking to foster the creation of high-tech ventures (Rasmussen and Sørheim, 2006), and the relationship between entrepreneurs and investors (Tyebjee and Bruno, 1984). Finally, a consistent body of knowledge looks at innovation for the entire industry or sector by exploring the role of national innovation systems and innovation policies at a regional level (Chung, 2002; Del Brío and Junquera, 2003; Woolthuis et al., 2005).

The publications within the 'Strategic Management of Innovation' classification focus mainly on strategic issues related to innovation and technology management. Within this cluster, we find studies with a focus on the importance of collaborations and the benefits that can emerge from strategic alliances (De Man and Duysters, 2005; Narula and Hagedoorn, 1999). Several papers explore the importance of specific managerial approaches and capabilities in fostering innovation outcomes such as TQM (Perdomo-Ortiz et al., 2006; Prajogo & Sohal, 2001, 2004) and six-sigma (Kwak and Anbari, 2006).

The 'Customer Innovation Adoption' research theme explores the links between innovation, markets, and users. A common theme within this cluster is innovation adoption and diffusion among users and its effect on company performance (Lin and Lin, 2008; Matzler and Hinterhuber, 1998; Pujari, 2006). Several cases are presented to explore the issues faced by companies when introducing new products or services to the market. For example, the lack of trust in online banking (Al-Somali et al., 2009; Yousafzai et al., 2003), RFID adoption issues (Wu et al., 2006), and resistance against electronic payment methods (Szmigin and

Table 5
Citing articles in *Technovation*: Country, University, and Journals.

R.	Country	TCA	University	TCA	Journal	TCA
1	United States of America	4344	U. of London	318	Technological Forecasting and Social Change	757
2	China	4328	Zhejiang U.	285	Research Policy	544
3	England	3557	Chinese Academy of Sciences	261	Sustainability	495
4	Spain	2474	U. of Manchester	258	J. of Cleaner Production	437
5	Taiwan	2163	U. of Cambridge	257	Technology Analysis Strategic Management	417
6	Italy	1916	Polytechnic U. of Milan	222	International J. of Technology Management	379
7	Germany	1658	U. System of Georgia	218	R&D Management	341
8	Netherlands	1458	U. Polytechnic De Valencia	212	J. of Business Research	300
9	Australia	1293	Lappeenranta U. of Technology	210	J. of Technology Transfer	296
10	South Korea	1219	National Chiao Tung U.	209	International J. of Production Research	259
11	Sweden	1188	Lund U.	201	Scientometrics	254
12	France	1130	Harbin Institute of Technology	196	International J. of Production Economics	235
13	Canada	1043	Islamic Azad U.	195	Industrial Marketing Management	219
14	Brazil	963	Tsinghua U.	193	International J. of Innovation Management	216
15	Finland	951	Delft U. of Technology	187	J. of Product Innovation Management	212
16	India	926	Utrecht U.	187	Management Decision	212
17	Malaysia	897	Indian Institute of Technology System	180	Expert Systems with Applications	200
18	Turkey	692	Aalto U.	178	Energy Policy	179
19	Portugal	665	Hong Kong Polytechnic U.	176	Industrial Management Data Systems	174
20	Iran	627	National Cheng Kung U.	176	Total Quality Management Business Excellence	170
21	Denmark	608	The French National Centre for Scientific Research	173	International J. of Operations Production Management	165
22	Japan	558	U. of Sussex	172	J. of Engineering and Technology Management	159
23	Norway	487	The Pennsylvania State System of Higher Education	170	Small Business Economics	155
24	South Africa	458	U. De Sao Paulo	167	European Planning Studies	153
25	Belgium	417	State U. System of Florida	166	J. of Knowledge Management	148
26	Switzerland	411	Chalmers U. of Technology	164	IEEE Transactions on Engineering Management	130
27	Poland	377	Seoul National U.	164	Industry and Innovation	130
28	Austria	376	Wageningen U. Research	160	Production Planning Control	128
29	Scotland	369	U. of Southern Denmark	155	Science and Public Policy	128
30	Greece	335	U. of Twente	155	Creativity and Innovation Management	122
31	Russia	292	U. of North Carolina	153	J. of Small Business Management	120
32	Thailand	282	U. Malaya	151	Regional Studies	117
33	Indonesia	258	U. Teknologi Malaysia	151	International Entrepreneurship and Management J.	114
34	Ireland	258	U. of Valencia	151	Asian J. of Technology Innovation	110
35	Mexico	243	National Taiwan U.	150	Service Industries J.	109
36	Singapore	243	Erasmus U. Rotterdam	149	International J. of Innovation and Technology Management	104
37	New Zealand	226	U. of Nottingham	148	Innovation Organization Management	99
38	Wales	225	Linkoping U.	146	International J. of Project Management	99
39	Romania	224	U. of Texas System	144	African J. of Business Management	98
40	Slovenia	208	U. of California System	143	European J. of Innovation Management	95
41	Czech Republic	204	U. of Padua	143	International J. of Information Management	95
42	Colombia	192	U. of Granada	141	J. of Business Industrial Marketing	95
43	Pakistan	189	Spanish National Research Council	140	Entrepreneurship and Regional Development	94
44	United Arab Emirates	178	U. of Tehran	137	Renewable Sustainable Energy Reviews	93
45	Saudi Arabia	168	Georgia Institute of Technology	132	International Business Review	88
46	Nigeria	157	Massachusetts Institute of Technology	132	International J. of Advanced Manufacturing Technology	84
47	Croatia	129	Eindhoven U. of Technology	131	International Small Business J. Researching Entrepreneurship	79
48	North Ireland	128	Monash U.	131	Business Strategy and the Environment	78
49	Israel	115	Korea Advanced Institute of Science Technology	130	J. of Business Ethics	74
50	Chile	112	National U. of Singapore	129	Benchmarking: an International J.	74

Rank according to TCA. Abbreviations: TCA = Times citing articles within *Technovation*.
Full list of abbreviations available in Tables 1 and 2

Foxall, 1998). Another stream of research within this cluster focuses on the involvement of users in developing innovative products (Biemans, 1991; Rothwell and Gardiner, 1985), considering the characteristics of leading users (Foxall, 1995; Lüthje, 2004), and the use of virtual experiences (Füller and Matzler, 2007).

The 'Product Innovation and Development' theme covers product innovation and development as well as project management and technology management. Within this domain, several pieces of research explore how firms can implement new product development processes (Bessant and Francis, 1997), focusing specifically on the cost of manufacturing (Irani et al., 1997), the need for continuous improvement (Bessant et al., 1994), and the critical factors affecting the success of a new project (Kwak and Stoddard, 2004; Pinto and Covin, 1989). Some contributions also explore specific issues emerging in product innovation and development, such as cross-cultural organizational characteristics (Lee et al., 2000), R&D investment decisions (Coldrick et al., 2005), the role of collaborative networks (Nieto and Santamaría, 2007), client/supplier relationships throughout the new product development process (Wognum et al., 2002), and risk management issues in new product development (Mu et al., 2009). In connection with new product development, scholars have explored product portfolio management (Cormican & O'Sullivan, 2004; Mikkola, 2001) and the relationship between mass customization and product platforms (Jiao et al., 2003). Finally, scholars have explored the broader field of technology management within firms (Drejer, 1997; Shehabuddeen et al., 2006), with a particular focus on measurement and selection tools (Brady et al., 1997; Ehrnberg, 1995) and the approach of dynamic capabilities (Cetindamaret al., 2009).

The 'Intellectual Property' cluster focuses on patent analysis and patenting strategies. Most of the contributions measure technological change and assess innovation via patent analysis (Abraham and Moitra, 2001; Archibugi and Pianta, 1996; Ritala et al., 2015). In doing so, scholars have tried to perform keyword analyses on patents (Lee et al., 2009) and citation networks (Shibata et al., 2008) or offer descriptive statistics regarding the patent industry (Watanabe et al., 2001). Patents are also analysed from a strategic perspective, looking at the link

Rank	Country	No. of Downloads (2015-2019)
1	United Kingdom	421,273
2	China	329,299
3	United States	217,568
4	Germany	157,694
5	Netherlands	138,343
6	Australia	113,558
7	Brazil	94,429
8	South Korea	80,350
9	Sweden	61,596
10	Italy	53,144
11	Taiwan	51,095
12	Malaysia	50,896
13	Turkey	50,633
14	Canada	48,281
15	Spain	47,272
16	Russia	46,969
17	South Africa	46,471
18	France	38,821
19	India	35,305
20	Denmark	34,943

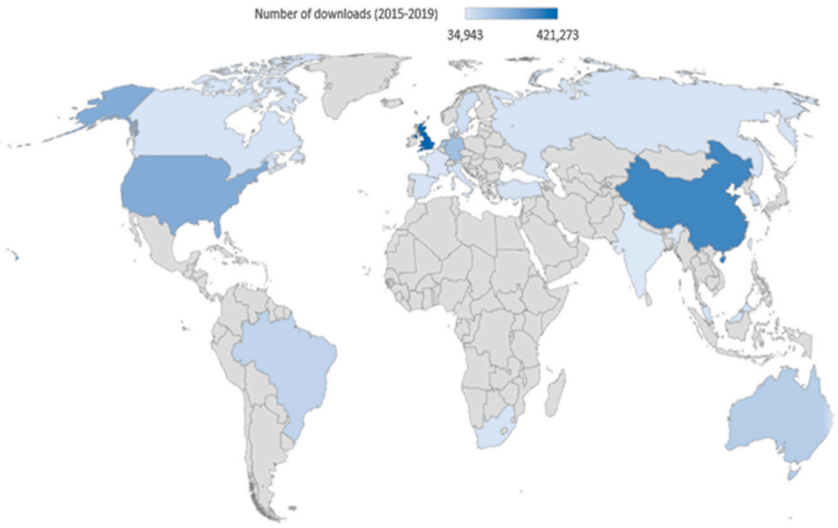

Fig. 3. *Technovation* Worldwide downloads over the last 5 years (2015–2019).

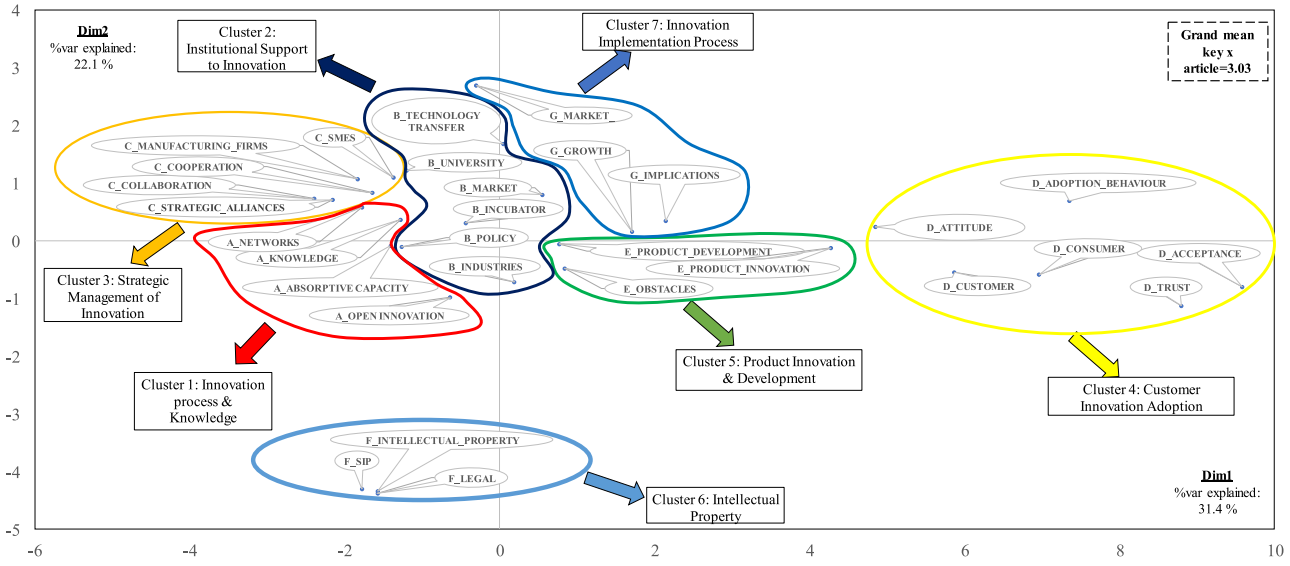

Fig. 4. Multiple Correspondence Analysis showing major research themes.

between company performance and a high correlation between the rate of valid patents/highly cited patents and the economic performance of the company (Ernst, 1995). Lastly, the importance of patents is analysed in terms of cooperation networks, co-opetitive strategies (Quintana-García and Benavides-Velasco, 2004), and the performance of an entire supply chain (Watanabe et al., 2000).

Finally, the 'Innovation Implementation Process' cluster is multi-disciplinary, collecting several empirical pieces of evidence from topics covered in the previous clusters related to innovation implementation and performance. In this cluster, studies focus on the pivotal role of cooperation networks for SMEs when increasing the firm's performance (Zeng et al., 2010) and innovative capabilities related to export performance (Guan and Ma, 2003). Chiaroni et al. (2011) noted that implementing innovation depends on top managerial capabilities and change with regard to the managerial levers on which the implementation depends.

In summary, the bibliometric and content analysis confirms that the topics covered by *Technovation* revolve around its scope, with studies focusing predominantly on new product development, technology management, and forecasting among others topics. This finding is in line with the longitudinal keyword analysis used as a proxy to identify the most common research topics or themes, as historically revealed in *Technovation* (Merino et al., 2006; Linton, 2011).

5. Discussion: implications and future research streams

This study provides a bibliometric review of the 1905 contributions published in *Technovation* since its conception in 1981. Building upon previous work published in the journal, we derive a number of implications and avenues for future research.

5.1. Implications

Technovation has been a prominent outlet for publishing research in

Table 6
Overview of the most frequent keywords (single words and phrases) for 1981–2019.

Global			1981–1990		1991–2000		2001–2010		2011–2019	
R	Keyword	Freq	Keyword	Freq	Keyword	Freq	Keyword	Freq	Keyword	Freq
1	Innovation	3487	Innovation	53	Technology	784	Innovation	1610	Innovation	1372
2	Technology	3015	Technology	51	Firm	487	Technology	1473	Technology	707
3	Firm	2399	Industry	36	Innovation	452	Firm	1184	Firm	705
4	Development	1574	Development	23	Development	446	Development	796	Product	358
5	Product	1434	Organizational	27	Industry	377	Management	627	Performance	341
6	Industry	1404	Firm	23	Product	313	Product	750	Industry	325
7	Process	1160	Change	21	Process	259	Industry	666	Knowledge	323
8	Management	886	Productivity	14	Management	259	Process	634	Development	309
9	Knowledge	878	Policy	17	Manufacturing	219	Knowledge	555	Process	267
10	Performance	798	Product	13	Strategic	174	Performance	457	Market	255
R	Phrase	Freq	Phrase	Freq	Phrase	Freq	Phrase	Freq	Phrase	Freq
1	Product Development	369	Technological Change	14	Technology transfer	121	Product Development	212	Open Innovation	124
2	Technology Transfer	317	Technology Transfer	9	Product Development	81	Technology Transfer	123	Product Development	74
3	Product Innovation	177	Technological Innovation	8	Decision-making	40	SMEs	95	Product Innovation	74
4	Open Innovation	154	Product Innovation	6	Technological Innovation	37	High Tech	83	Absorptive Capacity	72
5	High Tech	151	High Technology	5	Venture Capital	36	Innovation Process	77	Innovation Performance	69
6	Innovation Performance	128	Public Policy	4	Competitive Advantage	34	Information Technology	73	Technology Transfer	64
7	Technological Innovation	128	Technological Development	4	Technology Policy	34	Product Innovation	71	High Tech	48
8	Innovation Process	117	University-Industry Relationship	3	Information Technology	33	Competitive Advantage	65	Intellectual Property	47
9	Absorptive Capacity	114	SMEs	3	Product Innovation	29	Knowledge Management	65	Radical Innovation	44
10	SMEs	110	Venture Capital	3	Life Cycle	28	Technology Management	65	Spin Offs	38

Ranking according to frequency.

technological innovation and technology management. Our analysis revealed that highly cited contributions are concentrated in the years between 2003 and 2011. This may be due to the fact that Technovation became a highly recognised journal around the mid-'90s, focusing on topics such as new product development and open innovation following the publication of Chesbrough's books in 2003 and 2006. Secondly, the impact factor analysis shows that *Technovation* has been publishing pivotal studies in the respective research fields, as demonstrated by a notable increase in the number of citations and downloads around the globe. Thirdly, a review of the authors shows that *Technovation* has a strong European base, although this has been subject to change recently, with more contributions coming from Asian and North American scholars.

Authors intending to publish in *Technovation* might consider aligning their manuscripts with one or more of the major research themes depicted in this analysis; namely, "innovation processes and knowledge"; "institutional support to innovation"; "strategic management of innovation"; "customer innovation adoption"; "product innovation and development"; "intellectual property"; and "innovation implementation". This clustering of research themes makes it easy to track prior research in a specific field. This can prove to be instrumental in guaranteeing that references to prior work in *Technovation* are properly covered.

Scholars might also derive meaning from our work by focusing on key contributions in *Technovation*, as identified by the citation analysis. Studies referred to in many subsequent publications are important as they have shaped the course and direction of their research field. Knowing and taking inspiration from the key studies emerging in our citation analysis might prove to be fruitful when exploring new research opportunities (see Tables 2 and 7). Furthermore, the evidence from this study, in line with the work of Merino et al. (2006), shows that entrepreneurship-focused studies have received less attention over the past 40 years. As entrepreneurship and technology studies and innovation management studies are closely related to each other, analysing the intersection of innovation, technology, and entrepreneurship may be an area that warrants more scholarly attention.

5.2. Limitations

As the focus of the study was on the synthesis of the scientific production of *Technovation* over the last 40 years in an attempt to offer general guidelines, losses and omissions in terms of the theoretical, empirical, and practical richness of each study could be evident. Additionally, we would like to reiterate that this paper is a map: it is a summary of a large knowledge base and a simplification of a highly complex domain. Consequently, the roadmap offered in this manuscript may assist in providing a direction, but it does not show all of the possible trajectories that may be relevant when exploring a new research topic. Additionally, our study shows the research topics and trends of the past. Having an overview of prior research is useful, but it would be erroneous to assume these trends will continue in the future and consider them guidelines for future research.

Next, the data collection narrowed down by Web of Science and cross-validated using Scopus and EBSCO Business Premier may set certain boundaries. The inclusion of other sources such as ABI/Inform or INSPEC may alter results. Moreover, further insights might be obtained through in-depth semistructured interviews with the authors of seminal papers and members of the editorial board regarding their views of the journal's evolution and its future development (Marzi et al., 2020a). New research topics scarcely connected to past research themes may become major research themes in *Technovation* over the next decade. Similarly, themes that have recently been developed in other journals and research fields – those not captured by our study – may become major research themes in the future. Finally, despite the assistance of computer-powered tools for data analysis, the methodological procedure may suffer from authors interpretative and subjectivity biases

Table 7
Main research themes according to the 50 most cited publications in *Technovation*.

R.	Research Theme/ Topic	Representative Keywords (Content)	Notable References
1	Innovation Process & Knowledge	Open Innovation, Absorptive Capacity, Knowledge Diffusion, Learning Orientation, Inbound Open Innovation, Open Innovation Practice (s).	van de vrande et al. (2009); Huizingh (2011); Hoffman et al. (1998); Caloghirou et al. (2004),
2	Institutional Support to Innovation	Science park(s), Spin(−) Off(s), Country(ies), Market, Incubator(s), University(ies), Innovation Policy.	Bergek and Norrman (2008); Grimaldi and Grandi (2005); Rasmussen and Sørheim (2006); Rasmussen et al. (2006); Chan and Lau (2005).
3	Strategic Management of Innovation	Cooperation, Firm(s), SME (s), Strategic Management, Strategic Importance, Internationalization.	Kafouros et al., 2008; Narula (2004); De Man and Duysters, 2005; Quintana-García and Benavides-Velasco, 2004; Narula and Hagedoorn (1999).
4	Customer Innovation Adoption	Customer(s), Purchase Intention Consumer Behaviour; User Characteristics; User Innovation, Customer Satisfaction, Trust.	Matzler and Hinterhuber (1998); Wu et al. (2006); To et al. (2007); Lüthje (2004); Al-Somali et al. (2009).
5	Product Innovation & Development	Product(s), Product Development, Product Innovation, New Product Development, Life(−) Cycle, Novelty of Innovation.	Nieto and Santamaría, 2007; Alegre and Chiva (2008); Pujari (2006); Amara and Landry (2005); Brem & Voigt, 2009; Chao et al., 2007.
6	Intellectual Property	Intellectual Property, Design and Re-use, Sources of Information, Patent(s), Patent Map, Legal, IP.	Archibugi and Pianta (1996); Lee et al. (2009).
7	Innovation Implementation Process	Managerial Levers, Performance(s), Innovation Performance, Productivity Growth Rate, Profit(s).	Zeng et al. (2010); Guan and Ma (2003).

(Furrer et al., 2020). However, in spite of the above-mentioned limitations, this manuscript provides a resourceful piece for scholars interested to gain some perspective regarding the positioning of their own future entrepreneurship, management and technological innovation research.

5.3. Future research

A review of similar journals, along with a study of recent paper submissions or special calls for papers, could be used to identify expanding streams of research within the field. *Technovation* could have considerable potential for future growth if the journal were to encourage submissions in these new areas.

We can divide newly emerging areas into four categories: theoretical expansions; new methodologies; new applications; and new domains of expertise or colleges/schools from which submissions originate. The current study shows that the development of new conceptual and theoretical approaches is important. Open innovation, for example, has been one of the most innovative conceptual approaches of the last 15 years (Obradović et al., 2021). In the future, we may see similar developments in emerging areas of research including Frugal Innovation, Crowd Sourcing, Ecosystem Thinking, or Social Innovation. The common theme here is the identification of stakeholders other than just the shareholders and the focus on the need to define innovation that can benefit the interests of all stakeholders. Theory testing through hypothesis development and testing has also been widely used. Major topics in Technology Management are Technology Assessment and Technology Forecasting, as well as Technology Roadmapping. Research in these areas includes the development of models validated through practical applications. Future research could address the influence of the COVID-19 pandemic on technological innovation (Guderian et al., 2021), knowledge transfer, and the future role of inpatriates and expatriates on organizational innovation developement and leapfrogging.

The field of innovation management should remain open to diverse methodologies in order to uncover new knowledge. For example, the adoption of qualitative comparative analysis (QCA) (e.g., crisp set QCA (csQCA), multi-value QCA (mvQCA) or fuzzy-set QCA (fsQCA)) or necessary condition analysis might reveal a set of conditions necessary and sufficient for specific outome(s), shedding new light on theory building and testing (Dul, 2016; Pappas and Woodside, 2021; Ragin, 1987). Powerful data analytical tools currently assist in the analysis of big data (Lewis et al., 2013). Data applicable to our field includes patents, publications, research funding, litigations, news, and social media. Thus, the integration of machine learning in innovation management studies has the potential to deliver completely new insights. Consequently, advances in thematic analysis (Hannigan et al., 2019) as well as artificial intelligence (Lee et al., 2020) enables the assessment of large datasets with higher levels of reliability, validity, and efficiency when it comes to assessing various types of content (ranging from written text, speeches, images, audio, and videos to hypertext).

The third area covers applications. As technology becomes a more integrated part of our lives, scholars should explore technological innovation across all aspects of life. These applications include education, health, energy, finance, sports, urban planning, and entertainment. Some of these areas have been drastically changed by emerging technologies, such as Artificial Intelligence and Machine Learning, Blockchain, or the Internet of Things. Sport, for instance, might be an interesting area of further research in terms of how technological innovation could bring about change, as well as how companies such as Adidas, Nike, and many others seek to innovate. Similarly, the entertainment industry is a huge application area for new technologies. Movies and games are highly dynamic application areas for new technologies, offering unique opportunities for innovation management researchers. Agriculture, healthcare, energy, and mobility are other areas in which digital technologies have begun to have a significant impact.

In the past, business schools were the dominant source of publications in the research fields of management and technological innovation. Engineering schools have also been well represented alongside business schools. Currently, we see medical schools, urban planning, policy schools, and even law schools joining the research community. Innovation and technology management research could benefit from welcoming these insights, methods, and approaches. We can definitely learn from each other and integrate different approaches in order to provide a better understanding how to manage technologies and innovations. Authors are increasingly located in more countries around the globe. Three decades ago, papers were mainly written by scholars from Europe, Japan, and the U.S. About two decades ago, we saw an explosion of publications coming from China. Today, we are witnessing new waves of publications from India, Turkey, Iran, and Eastern European and African countries. Welcoming diversity in management approaches from around the globe will certainly help us to broaden and deepen our research field.

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