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TECHNOLOGY ENTREPRENEURSHIP – STATE OF THE ART AND FUTURE CHALLENGES†

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Abstract

This article attempts to increase an understanding of technology entrepreneurship phenomenon by presenting state-of-the-art work by scholars. We aimed to map the technology entrepreneurship science using bibliometrics technique. We start with analysis of popularity of the field of technology entrepreneurship as a science. Then, we conduct research by years, journals and citations. Next, we analyze the main themes of technology entrepreneurship. Our findings suggest that there are only three fields of sciences that focus on the area of technology entrepreneurship. Finally we present 8 themes of researchers' interest in the period 1986-2014 and the common trends in 'technology entrepreneurship' research.

Keywords: Technology Entrepreneurship, Bibliometrics

1. Introduction

The phenomenon of technology entrepreneurship is interesting and actual field of research in management sciences. As far as theory of entrepreneurship and innovation theory, already have their own well-established research achievements, their connection in the overall phenomenon of technological entrepreneurship is still a challenge. Previous studies (Beckman *et al.* 2012; Bailetti, 2012; Petti, 2012) have shown that technology entrepreneurship can bridge the gap between entrepreneurship theory and management theory. Analysis of the phenomenon of entrepreneurship can be understood simply as a study of the establishment and evolution of new businesses (Nichols and Armstrong, 2003; Walicka and Czemiel-Grzybowska 2015) or as it was stated by Kordel (2014) can be focused on creating and exploring new opportunities. The phenomenon of technological entrepreneurship points at the process of creating and exploring new opportunities. However, this occurs, in the context of the strong impact of the development of science and technological innovation on the process, and so it should be understood and examined.

The main goal is to map the technology entrepreneurship using bibliometric technique. We conduct our research using Scopus database. First we present the results of bibliometrics

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by the field of science, year, journal publishing and country. Next, we analyze the citation of the most popular articles. Finally, we present the overview of general themes connected to 'technology entrepreneurship' aiming to find the most recent trends in this area. The article ends with discussion and conclusion. We also point some limitation of our research.

2. Methodology Design

Bibliometrics and scientometrics are two closely related approaches of measuring scientific publications and science (Meyer and Schroeder, 2009). In practice, review of literature shows that there should be involved various types of citation analysis, journal types, geographical and detailed field's of science analysis (Buesnitz and Barney, 1997; Bailetti, 2012). This data can provide information about popularity of the topic, trends in science, development of areas of knowledge or networks of scholars, links between them. Bibliometrics and scientometrics research issues include the measurement of impact, reference sets of articles to investigate the impact of journals and institutes, understanding of scientific citations, mapping scientific fields and the production of indicators for use in policy and management contexts (Leydesdorff and Milojevic, 2013). However, there is a significant overlap between scientometrics and other scientific fields such as bibliometrics, information science and science of science policy in the field of technology and innovation. The article contains an extensive analysis of research on 'technology entrepreneurship' using bibliometrics techniques in this field. We define the bibliometrics as a set of research techniques (Porter *et al.* 2007; Klincewicz *et al.* 2012) used for quantitative analysis of publications, including scientific publications (Pritchard, 1969). Typical bibliometrics applications include analyzing technology, entrepreneurship or research and development, conducted in conjunction with the needs of managers of the R&D and formulating science policy and innovation policy. Today we observe the blurring of boundaries between scientometrics (traditionally based on the analysis of publications) and patentometrics (measurement patents) - both approaches use similar analytical techniques and tools, and the term 'scientometrics' now includes also the analysis of patents (Chavarro *et al.* 2014).

In this bibliometrics research we focus on one type of document: article, that was published at well-known journal defined as the one submitted in electronic database. It let to eliminate other, non-scientific types of documents: review, article in regional press, conference review, editorial, note, short survey, and other undefined types. Authors eliminated from this research also such documents as: conference papers, book chapters, books, that are not presented in Scopus database and can not constitute the base of the analysis because of small number of documents of this type listed in database in relation to the actually published books or conference proceedings.

We use one of tools proposed for bibliometrics research by Rafols and Meyer (2010). They state there are three main sources of bibliometric data: Web of Science, Scopus, and Google Scholar. Knowing the fact, that each has certain advantages and limitations which may influence on combination of sources, we tried to match the best one for our research. We found that Web of Science is not equipped with taxonomy of sciences tool, what allow to divide the returned records according to scientific disciplines. Such analysis of disciplines was one of our main objectives in this paper. Finally, we decided to use the Scopus database because of the higher number of searching records received (documents that fully satisfy our criteria). We use following search criteria:

- phrase "technology entrepreneurship" or "technological entrepreneurship",
- scope of field 'Article Title', 'Abstract', 'Keywords',
- research articles (reviewed).

The selection of search terms can be simply justified. Without the quotes score increases but also increases contamination of data collected. Words in the search phrase may be separated by other expressive sequences and thus document may not apply technological entrepreneurship, resulting in the risk of error in the analysis.

We started our research procedure on August 5, 2015 year. We search the data excluding year 2015 due the fact that this year is not over in the date of research and data contained in the database is incomplete. As a result we obtained 131 records to analyze.

3. Research Results

The results of bibliometrics research are presented by the field of science, year, journal publishing and country. We analyze fields of science, which include returned by database records for the study area: technological entrepreneurship phrase technology entrepreneurship or technological entrepreneurship and scope of field Article Title, Abstract, Keywords. We use taxonomy of science that comes from Scopus. As a result we identified 17 fields of sciences that focus on the area of technological entrepreneurship (Table 1).

Table 1. Research Results Due to Field of Science (%)

No	Field of Science*	Number of Documents/Records**	Percentage***
1.	Business, management and accounting	94	71.76
2.	Engineering	40	30.53
3.	Economics, econometrics and finance	33	25.19
4.	Social sciences	21	16.03
5.	Decision sciences	12	9.16
6.	Computer sciences	6	4.58
7.	Arts and humanities	4	3.05
8.	Multidisciplinary	4	3.05
9.	Environmental sciences	3	2.29
10.	Earth and planetary sciences	2	1.53
11.	Medicine	2	1.53
12.	Psychology	2	1.53
13.	Energy	1	0.76
14.	Materials science	1	0.76
15.	Undefined	1	0.76

Notes: *taxonomy of sciences comes from Scopus database, **numbers are not mutually exclusive, one document may be included in several fields, ***the column 'percentage' the total number of articles 131 was taken as 100%.
Source: Based on Scopus, collection date: 05/08/2015.

Academic attention paid to technology entrepreneurship three fields of science: business, management and accounting, engineering, economics, econometrics and finance. Other fields of sciences did not exceed the level 25% of total. This result is supported by previous study (Bailetti, 2012; Kordel, 2014) which concluded that other fields such as social sciences and decision sciences are still not well explored. Shane and Venkatamaran (2001) stated that technology entrepreneurship is building walls between the fields of entrepreneurship and strategic management but instead feel that the field of entrepreneurship needs to create its own conceptual framework that is different from frameworks in other fields such as organizational behavior, operations management, and strategic management.

The first Symposium on Technical Entrepreneurship was held at Purdue University in 1970. The documents from that event were published and now are stored at Library of Congress (Number 72177979//r883). Although the symposium was significant for science, the papers are not available at open access system. The first article noted at Scopus database was published by Segal in 1986 year in Technovation (Segal, 1986).

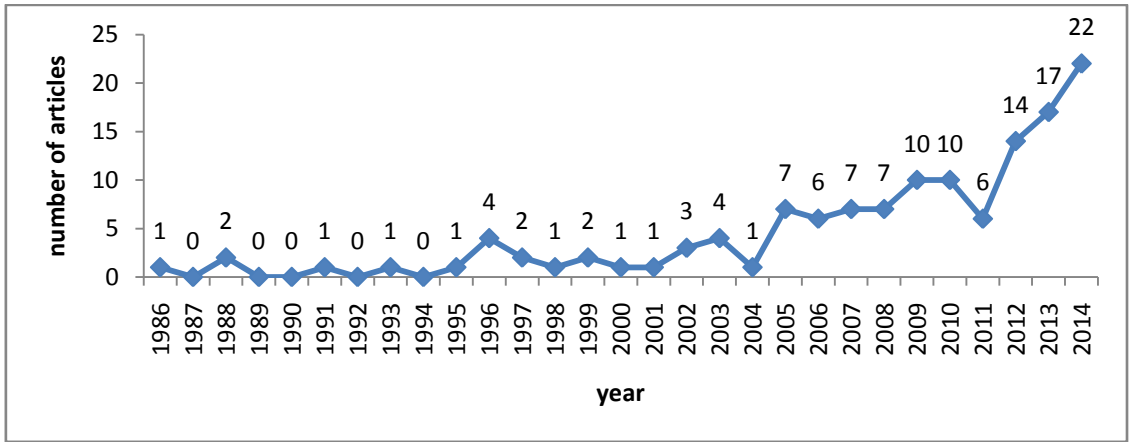

Figure 1. Research Results by the Years (Number)
Source: Based on Scopus, collection date: 05/08/2015.

Figure 1 shows that trend of the number of articles published annually in the time period 1986-2014 is growing. Since the first article was listed in Scopus database in year 1986 we observed that the numbers do not exceed the 10 articles per year up to the year 2008. Since 2009 year we can find the results of a two-digit (except year 2011). Finally, we can conclude that the number of articles of the thematic scope defined in individual years is rather small. Also, the increases of this number from year to year are not significant. We observe the higher result in 2014, and rising dynamics between 2006 and 2014. Nowadays we can observe the rapid progress in the volume and breadth of research into 'technology entrepreneurship' since that fact.

The search in Scopus let to identify 131 articles published in 77 journals, which technology entrepreneurship were classified and examined more closely, as described in Table 2.

Sexton and Smilor (1986) suggest criteria to identify a list of 'good' journals in technology innovation or entrepreneurship. Among all results from Scopus database we found 77 journals, included 65 journals that published only 1 or 2 articles connected to phrase technology entrepreneurship. The most articles have been published at such journals as Technovation, Research Policy and Journal of Technology Transfer. The total number of published articles with phrase "technology entrepreneurship" was 23, and 17% of all. Another finding suggests that there is specialization around a theme of technology entrepreneurship and researchers are interested to publish only in the three aforementioned journals. In the remaining journals scientific articles in this field appeared rather incidentally. Our key findings in relation to journal domains in this bibliometrics analysis are supported by previous studies. The majority of technology entrepreneurship articles are published in journals not considered contributors to technology innovation or entrepreneurship (Bailetti, 2012; Meyer, 2015). Among 77 journals that published the 131 articles reviewed here, only 17 (22%) were considered to be journals that contribute to technology innovation management or entrepreneurship. We identified 77 journals, but only 2 met the Sexton and Smilor's (1986) criteria to be at the list of "good" journals: Entrepreneurship Theory and Practice and Journal of Business Venturing. To include more journals in the list of good journals, we dropped the Sexton's requirement that the journal be included in the Financial Times' Top 45 Journals list. It let to find six journals included in the list: Technovation, Research Policy, Journal of Business Venturing, International Journal of Technology Management, IEEE Transactions on Engineering Management, Entrepreneurship Theory and Practice. We find that 27 percent of the 131 articles in Table 2 were published in six journals that met the relaxed Sexton's criteria for a 'good' journal.

Table 2. Research Results Due to Journals Publishing Scientific Articles Concerned on Technology Entrepreneurship (Number, %)

No	Journal Title	Articles /Records	Percentage*
1	Technovation	10	7.63
2	Research Policy	7	5.34
3	Journal of Technology Transfer	6	4.58
4	Entrepreneurship: Theory and Practice	5	3.82
5	International Journal of Technology Management	5	3.82
6	Journal of Business Venturing	5	3.82
7	Strategic Entrepreneurship Journal	5	3.82
8	International Journal of Entrepreneurship and Small Business	4	3.05
9	Academy of Management Learning and Education	3	2.29
10	IEEE Transactions on Engineering Management	3	2.29
11	International Journal of Continuing Engineering Education and Life-Long Learning	3	2.29
12	Journal of Small Business and Enterprise Development	3	2.29
13	Advances in the Study of Entrepreneurship, Innovation, and Economic Growth	2	1.53
14	Asia Pacific Journal of Management	2	1.53
15	International Journal of Innovation and Technology Management	2	1.53
16	Measuring Business Excellence	2	1.53
17	Middle East Journal of Scientific Research	2	1.53
18	Small Business Economics	2	1.53
19	Technological Forecasting and Social Change	2	1.53
20	Academy of Management Review	1	0.76
21	Advances in Strategic Management	1	0.76
22	Asia Pacific Business Review	1	0.76
23	Asian Academy of Management Journal	1	0.76
24	Asian Social Science	1	0.76
25	Chinese Management Studies	1	0.76
26	Computer	1	0.76
27	Doktorsavhandlingar vid Chalmers Tekniska Hogskola	1	0.76
28	EMJ - Engineering Management Journal	1	0.76
29	Entrepreneurship and Regional Development	1	0.76
30	Espacios	1	0.76
31	Etnograficeskoe Obozrenie	1	0.76
32	Frontiers of Business Research in China	1	0.76
33	Geographische Rundschau	1	0.76
34	IEEE Engineering Management Review	1	0.76
35	Industrial and Corporate Change	1	0.76
36	Industrial Marketing Management	1	0.76
37	Information Communication and Society	1	0.76
38	Innovation: Management, Policy and Practice	1	0.76
39	International Entrepreneurship and Management Journal	1	0.76
40	International Journal of Applied Engineering Research	1	0.76
41	International Journal of Economics and Business Research	1	0.76
42	International Journal of Engineering Education	1	0.76
43	International Journal of Entrepreneurial Behaviour and Research	1	0.76

44	International Journal of Entrepreneurship and Innovation Management	1	0.76
45	International Journal of Innovation Science	1	0.76
46	International Journal of Technology, Policy and Management	1	0.76
47	International Small Business Journal	1	0.76
48	ISIS	1	0.76
49	Journal of Business Ethics	1	0.76
50	Journal of Business Research	1	0.76
51	Journal of Economics and Management Strategy	1	0.76
52	Journal of Engineering Education	1	0.76
53	Journal of Entrepreneurship Education	1	0.76
54	Journal of High Technology Management Research	1	0.76
55	Journal of Technology Management and Innovation	1	0.76
56	Management Research Review	1	0.76
57	Management Science	1	0.76
58	Medical Device and Diagnostic Industry	1	0.76
59	Medical device technology	1	0.76
60	Medicine, health care, and philosophy	1	0.76
61	Natural Resources Forum	1	0.76
62	New Technology, Work and Employment	1	0.76
63	Pakistan Development Review	1	0.76
64	Production and Operations Management	1	0.76
65	Public Administration Review	1	0.76
66	Revista Europea de Direccion y Economia de la Empresa	1	0.76
67	Science and Public Policy	1	0.76
68	Seimitsu Kogaku Kaishi/Journal of the Japan Society for Precision Engineering	1	0.76
69	Strategic Management Journal	1	0.76
70	Technology Analysis and Strategic Management	1	0.76
71	Telcom Report (English Edition)	1	0.76
72	Turkish Online Journal of Distance Education	1	0.76
73	UPB Scientific Bulletin, Series D: Mechanical Engineering	1	0.76
74	Urban Studies	1	0.76
75	Venture Capital	1	0.76
76	World Applied Sciences Journal	1	0.76
77	World Economy	1	0.76

Notes: *the column 'percentage' the total number of articles 131 was taken as 100%.
Source: Based on Scopus, collection date: 05/08/2015.

Table 3. Cross Country Analysis (Number, %)

No	Country	Number of Articles/Records*	Percentage**
1	United States	59	45.04
2	United Kingdom	21	16.03
3	Canada	10	7.63
4	Malaysia	7	5.34
5	Netherlands	7	5.34
6	Italy	6	4.58
7	Australia	5	3.82
8	Germany	5	3.82
9	China	4	3.05
10	France	4	3.05
11	Portugal	4	3.05
12	Spain	4	3.05
13	India	3	2.29
14	Denmark	2	1.53
15	Finland	2	1.53
16	Israel	2	1.53
17	Norway	2	1.53
18	South Korea	2	1.53
19	Sweden	2	1.53
20	Belgium	1	0.76
21	Brazil	1	0.76
22	Greece	1	0.76
23	Hong Kong	1	0.76
24	Ireland	1	0.76
25	Pakistan	1	0.76
26	Romania	1	0.76
27	Russian Federation	1	0.76
28	Singapore	1	0.76
29	Slovenia	1	0.76
30	Switzerland	1	0.76
31	Thailand	1	0.76

Notes: *numbers are not mutually exclusive, one document can be written by several authors
**the column 'percentage' the total number of articles 131 was taken as 100%
Source: Based on data from Scopus, collection date: 05/08/2015.

Results of researches on technological entrepreneurship were published by researchers from 35 countries. Among them, researchers from USA, UK and Canada tend to dominate. Authors from USA, UK and Canada published in total 90 articles, what is more than 68% of total publication received from database. Results obtained from other countries were not higher than 10 articles. In 18 countries we found records as single articles (1 or 2) indicating incidental publications in these geographic regions.

One of several bibliometrics levels at which we can study the dynamics and the structure of journals, authors, research programs, and citations themselves, all form networks which can be analyzed with various statistical techniques such as factor (or vector) analysis, cluster analysis, graph analysis, or multidimensional scaling is citation and co-citation analysis. Our findings suggest that more than 30% of articles still have not been cited. These studies have not proved to be valuable; they were not spotted and used by the scientific community. Only 5 articles have been cited more than 100 times (Table 4). These articles were appreciated by the scientific community and still are an inspiration to take on new challenges with 'technology entrepreneurship' research.

Table 4. The Most Cited Articles (More than 100 Citations)

Lp.	Author	Article Title	Affiliation	Journal Title	Number of Citations
1	Raghu Garud, Peter Karnoe	Bricolage versus breakthrough: Distributed and embedded agency in 'technology entrepreneurship'	New York University, Copenhagen Business School	Research Policy	377
2	Shaker A. Zahra	Environment, corporate entrepreneurship, and financial performance: A taxonomic approach	Georgia State University	Journal of Business Venturing	295
3	Gary Duskhnitsky, Michael J. Lenox	When do incumbents learn from entrepreneurial ventures?: Corporate venture capital and investing firm innovation rates	University of Pennsylvania, Duke University	Research Policy	130
4	Sankaran Venkataraman	Regional transformation through technological entrepreneurship	University of Virginia	Journal of Business Venturing	121
5	Matrin F. Kenney, Urs Von Burg	Technology, entrepreneurship and path dependence: Industrial clustering in silicon valley and route 128	University of California-Davis, University of St. Gallen	Industrial and Corporate Change	121

Source: Based on Scopus, collection date: 05/08/2015.

Table 4 shows that the most cited publication (377 citations) was published in Research Policy journal by Garud and Karnoe (2003). Authors presented new perspective on technology entrepreneurship as involving agency that is distributed across different kinds of actors and explicate this perspective through a comparative study in Denmark and in United States.

4. Overview of Literature Search by Themes

Table 5 organizes all journal articles on technology entrepreneurship into eight themes and five time periods: 1986–1989, 1990–1999, 2000–2009, and 2010–2014. The duration of the first four periods is ten years, while that of the last period is only two years.

We find that over the first three time periods, the number of articles published in each period has generally more than doubled the number of articles published in the previous period. The number of articles published in the last 4 years is estimated about 53% of the number of articles published before. Our findings suggest that the 'technology entrepreneurship' literature is dominated by a theme that put attention on identifying the antecedents of technology firm formation. This result is supported by previous studies (Bailetti, 2012; Jaksic *et al.* 2014) which

concluded that external factors and technology firms formation is in the top of researchers' interests. As it was stated by Dahlstrand (2007), the technology-based entrepreneurship is very important for economic growth directly, by their own growth, and indirectly, for example, by providing specialized input to other firms. Another popular theme focuses on the consequences of technology entrepreneurship in the terms of: how, why, and when technology entrepreneurship affects the socio-economic development of a region. We also find that researchers' interest is connected by the themes to small firms engaged in technology entrepreneurship and they prefer investigate rather small technology firms than mid-sized and large firms. We also find that previous researches on technology entrepreneurship have contributed only to some fields of science, such as economics, entrepreneurship, or management.

Table 5. Breakdown of the Number of Journal Articles with Technology Entrepreneurship or Technological Entrepreneurship

No	Themes	Number of Journal Articles					
		1986-1989	1990-1999	2000-2009	2010-2014	Total	% of total
1.	External factors that influence formation of technology firms	0	4	23	42	69	52.67
2.	Explanations why and when technology entrepreneurship affects the socio-economic development of a region	1	2	8	7	18	13.74
3.	Approaches used by small technology firms to generate revenue and reduce costs	1	1	6	5	13	9.92
4.	Internal practices used to operate and transform small technology firms	0	3	4	2	9	6.87
5.	Interdependence between technology path and small technology firm formation and growth	1	1	1	4	7	5.34
6.	Overview of 'technology entrepreneurship'	0	0	2	6	8	6.11
7.	Corporate entrepreneurship function in mid-sized and large firms	0	1	2	2	5	3.82
8.	Contribution to other fields	0	0	1	1	2	1.53
	Total	3	12	47	69	131	100

Source: Own research based on Bailetti (2012).

5. Discussion and Conclusion

Our findings suggest that over the period 1986-2014 the importance of technology entrepreneurship still increase and encourage the researcher's interest. This global phenomenon is perceived as important for economic growth, differentiation, and competitiveness of firms, on both: regional and national level. Technology entrepreneurship usually is related to managers of small and medium firms who create, deliver, and capture value from new technology use. Technology entrepreneurship appeals also to managers of agencies and institutions that attract investments in new technologies.

The one of technology entrepreneurship functions is to set a mix of specialized individuals and heterogeneous assets in order to create and capture value for the firm through collaborative exploration and experimentation (Bailetti, 2012). This combination required the assets or its attributes to be unique and novel but this combination may change and evaluate in

time. In our article, we present the overview of general themes connected to technology entrepreneurship aiming to find the most recent trends in publishing in this area. We aimed to find the relevance of technology entrepreneurship in past and recent research.

As a main result of our research two aspects of technology entrepreneurship, to which scholars have paid particular attention, was identified. These aspects are: i) still growing interests about external factors influencing formation of technology firms; ii) growing trend of investigations to explain why and when technology entrepreneurship affects the socio-economic development of a region. The dominant theme (Theme 1) accounts for 52.67% of the number of articles on technology entrepreneurship published during the past four decades. It focuses on external factors that influence the formation of technology firms such as: government support, characteristics of technology entrepreneurs, external events that create technology opportunities for technology entrepreneurs, spin-off and technology transfer mechanisms, funding of new technology firms. Second popular theme focuses on influence of technology entrepreneurship on different economies in regional aspect. It concerns commercialization and technology transfer mechanisms in developed and developing countries or transition countries. The results also suggest that researchers put less attention on those aspects that allow technology entrepreneurship have significant contribution to other fields. Only 2 of the 93 articles focuses on a contribution made to another field. It confirms Busenitz and Barney's research on relationship between entrepreneurship and its environment (1997). The reason of that can be justified by the small number of researchers contributing to technology entrepreneurship field.

We find also some opportunities regarding the future trends created by research on technology entrepreneurship. There is small number of research in this field that allows identifying business opportunity means as new technology investments and R&D tools. New technologies are crucial technological innovations and give new ideas for technology businesses. The concept of technology entrepreneurship directs the efforts towards technologies that will let the economy and society to grow. We find that current research on technology entrepreneurship phenomenon is not only related strictly to small and medium enterprises and new ventures as previously stated by Petti (2012) and McIntyre *et al.* (2013). Bailetti (2012) find that technology entrepreneurship is quite well implemented in current literature about new and existing firms, in firms of different sizes: small, medium, large. This concept is based upon triple-helix and network relations. Technology entrepreneurship relies on strong systems of national economies' support on regional and global level. Finally, we find that technology entrepreneurship should be analyzed through different approaches, perspectives and capabilities. Another trend in research in this field is education. Lackeus and Middleton (2015) explored how university-linked entrepreneurship programs can bridge the gap between education and technology transfer within the business-university environment. They identified some bridging capabilities of venture creation programs.

The findings of our study have several limitations. One of those is that technology entrepreneurship can be perceived in different contexts. In wider, it expands over science and knowledge development and research and development where technology is necessary to enhance and plan those innovative technology projects and additional activities which gain the greatest potential to contribute to sustainable growth. Another limitation is that we base on analyze and results related only to one database Scopus. Our analysis and the results refer to the articles in the period 2014 (2015 has been disabled due to incomplete data). In addition, the analysis and results are related to scientific articles returned as search results in the database Scopus for phrase "technology entrepreneurship" or "technological entrepreneurship" in the field Article Title, Abstract, Keywords. In this context, the analysis based on another database, limited by other conditions, may give different results.

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