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Evolution of Research Topic at ISPIM from 2009 to 2014

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Abstract: Previous research has proposed that conference proceedings can demonstrate an ability to innovate and propose new ideas. Therefore, ISPIM proceedings could be a store of novel research ideas and a platform to identify and evaluate emerging research trends in innovation management, which may later gain popularity in journal publications. The main aim of this study is to empirically evaluate how the keywords and keyword derived research topics in ISPIM full academic papers (N=1084) from 2009 to 2014 have evolved over time by using popularity-based scientometric methods. This study can also be considered to complement a study by Santonen and Conn (2015), who recently defined the list of the TOP50 research topics at ISPIM. As a result we describe the contemporary body of knowledge of innovation management research and validate that there is indeed subtle incremental change.

Keywords: ISPIM, research topic, trend analysis, scientometrics, popularity-based, keyword analysis, variant keyword search

1 Introduction

Science by definition builds on previous knowledge, which evolves over time, refines and develops knowledge and serves as a foundation for further research. Thus, in-depth understanding of the evolution of scientific knowledge in any research domain, including innovation management, is vital. ISPIM is among the leading research communities (Bourdieu, 2004) focusing on the “innovation management” research topic (Baregheh et al. 2009). Scientific conference proceedings, as a relevant and important knowledge source, have been recognized but also criticized by many authors (Lisée, et al. 2008; Drott 1995). Importantly Montesi and Mackenzie (2008) suggested that conference proceedings can demonstrate an ability to innovate and propose new ideas. As a result, we argue that ISPIM proceedings could be a store of novel research ideas and a good platform to identify and evaluate emerging trends in innovation management research.

Santonen and Ritala (2014) recently analysed the co-authorships relations within the ISPIM community and we now have a good understanding about the underlying structure of the author collaboration network within the ISPIM community. Moreover, Santonen and Conn (2015) identified TOP50 innovation management research topics by applying popularity-based scientometrics analysis (Choi et al, 2011) to ISPIM full academic papers. As a result, the TOP50 list was populated by research topics, where keywords can be derived from the mainstream innovation classifications such as product, process, market, organizational keywords based on Schumpeter's (1934) typology or Chesbrough's open innovation (Chesbrough and Bogers, 2014) as an example. Most of the ISPIM papers seemed to follow traditional innovation management research themes and portray a kind of "incremental innovation" research approach.

However, the Santonen and Conn (2015) study has clear limitations. First, it provided only very limited information about the temporal evolution of research topics at ISPIM and only briefly argued that "the most popular keywords mainly increased linearly". Temporal trend information about the derived TOP50 research topics was not provided at all and internal correlations between research topics were not measured to validate that the different research topics are genuinely unidimensional. Secondly, the remaining set of keywords not included into TOP50 research topic list represents about a third of ISPIM keywords. These keywords can contain plenty of possible emerging research topics, which have gained less interest, but might have an increasing trend. Therefore, more in-depth temporal analysis on the keywords and research topics could reveal more fledgling research topics, which may later gain more or less popularity in innovation management. As a result in this study, we are empirically evaluating how the keywords and keyword derived research topics covered by the ISPIM community have evolved over time.

This paper is organised as follows. Following this introduction we discuss the theoretical foundations of our study. In third section, we present our research methodology including data collection and data harmonization process. Fourth, we present our results and then finally, we conclude with our findings and discussion of theoretical and practical implications.

2 Theoretical background

2.1 Scientometrics as a research method

Most typically the literature reviews in management research including innovation management research domain have been based on narrative reviews (McLean, 2005) instead of more rigorous research methods such as a systematic literature review (Tranfield et al. 2003; Becheikh et al., 2006), meta-analysis (Tornatzky and Klein, 1982) or scientometrics (Larivière et al. 2012). In this study we follow scientometrics approach, which is closely related to bibliometrics (Pritchard, 1969) and informetrics (Nacke, 1979). Each of these overlapping terms – scientometrics, bibliometrics and informetrics – have well documented history and are utilizing similar methodologies under different name (Hood and Wilson, 2001). Basically, scientometrics can be defined as the quantitative study of science and technology (Van Raan, 1998). Santonen and Conn (2015) study illustrated a comprehensive framework for classifying various types and

combinations of scientometrics studies (Figure 1) and there has been also other similar attempts by other management scholars (Zupic and Čater, 2014).

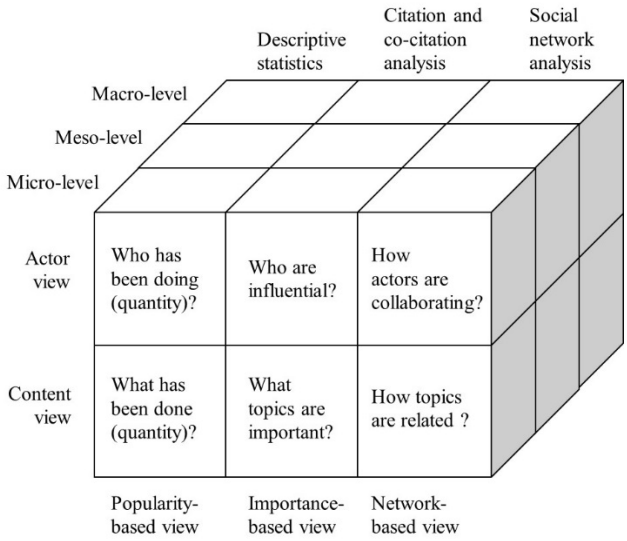

Figure 1: A comprehensive framework for classifying scientometrics studies (Santonen, 2015)

Scientometrics studies have typically been classified as "popularity-based" and social "network-based" studies (later also SNA) (Choi et al, 2011). Popularity-based studies are typically analysing frequency of actors (e.g. authors and organizations) or content (e.g. keywords). SNA-studies are instead focusing on the collaboration relationships, which most typically are based on co-authorship (e.g. Su and Lee, 2012), citation/co-citation networks (Pilkington and Meredith, 2009) or keywords (Yi and Choi, 2011). Citation and co-citation studies, which are illustrated in the middle of the Figure 1 cube, are focusing on the importance or impact (Pilkington and Meredith, 2009). Recently the usefulness of keywords and keyword networks as a fundamental carrier of knowledge has been recognized (Su and Lee, 2010) and related methodologies have been developed (Yi and Choi, 2011). By following Santonen and Conn (2015) classification, this study is focusing on the content view with the help of popularity-based research methods by using ISPIM full academic paper keywords as data source.

2.2 Prior studies evaluating research trends

Overall, scientometrics studies and especially SNA studies have been successfully used to study various types of scientific communities (e.g. Newman 2001, Morlacchi et. al. 2005, Vidgen et. al. 2007) also including innovation communities such as global open innovation research (Su and Lee 2012), crowdsourcing (Santonen et al .2012) and co-authorships relations in ISPIM community (Santonen and Ritala, 2014). There are some studies evaluating the content view based research trends in other research domains such

as 1) Mao et al. (2010) study on evaluating risk assessment research trends, 2) Tsai & Yang (2010) and Lee & Chen (2012) analysis of knowledge management trends, 3) Muñoz-Leiva et al. (2013) study to detect salient research topics in financial marketing research and 4) Wu et al. (2012) and Ruhanen et al. (2015) studies in tourisms research. Examples in innovation management includes 1) Balzat and Hanusch (2004) study focusing on the trends in the research on national innovation systems utilizing narrative review approach, 2) Crossan and Apaydin (2010) utilizing systemic review of the literature in order to define a multi-dimensional framework of organizational innovation, 3) Becheikh et al. (2006) study in the manufacturing sector and 4) Kim et al. (2013) study on patterns of innovation in SaaS networks.

3 Research methodology

3.1 Objectives of the study

The main aim of this study is to empirically evaluate how the keywords and research topics at ISPIM events have evolved over time by using popularity-based scientometrics methods (Choi et al, 2011; Larivière et al. 2012) and a selection of standard Social Network Analysis methods (Borgatti et al., 1992). Importantly, Santonen and Conn (2015) did not test the internal correlations between TOP50 research topics. Therefore, the robustness of the TOP50 research topics needs to be verified by analysing internal correlation between TOP50 research topics. In all, this study can be considered as complement to a study by Santonen and Conn (2015), who's list of the TOP50 innovation management research topics we analysing more in-depth.

3.2 Data collection and unit of analysis

The unit of analysis in this study is an ISPIM conference (and symposium) full academic paper publication, which by definition are "accomplished, substantial and complete academic research results of an empirical or theoretical nature" (ISPIM, 2015, p. 3). We limit our time span to publications from 2009 to 2014 due more robust data. In all, our dataset included a total of 1084 full academic papers, which profile is more in-depth described by Santonen and Conn (2015), thus omitted from this paper.

3.3 Construction of research topics

The format and definition of keyword is not unambiguous and there are multiple variations how to write keywords with similar meanings. Therefore, "Variant keyword search" – process (VKS) (Santonen and Conn, 2015) was utilized to tackle synonyms and the separation of multiple terms problem during the keyword harmonization process and to derive more generic research topics from individual keywords (Choi et al. 2011; Yi and Choi, 2011). *Variant keyword search* – process includes following phases:

- PHASE 1: All author given keywords were separated into individual words. For example "business model innovation" is treated as three separate words

"business", "model" and "innovation". This phase detects which individual words are dominant keywords.

- PHASE 2 Using individual words (from PHASE 1) as search terms when searching original keyword list. This phase detects and links all keyword variants for search terms including possible spelling errors, spelling differences and combined terms such as "new product development" and "product development" are linked to "product" research topic.
- PHASE 3: As an iterative process 1) removing irrelevant and illogical keyword variant links such as "pr**open**sity to innovate" link from "open" search term and 2) identifying possible wildcard search terms in order eliminate additional spelling differences such as "technology" and "technological" combined as *techno** wildcard search term.
- PHASE 4: Creating research topic ranking list by calculating 1) the sum of all linked research terms, 2) the number of variant terms and 3) identifying the most frequent individual keywords within a research topic.

The outcome of *Variant keyword search* – process PHASES 1 to 4 have been presented in prior study by Santonen and Conn (2015) and ranking list of the TOP50 research topics have been presented. However, to validate the unidimensionality of the research topics, in the additional PHASE 5, the internal correlations between research topics were measured. A matrix of Pearson's r correlation coefficients for all possible pairs of research topics columns of a matrix were computed (Harrell, 2015). In sensitivity analysis the threshold value for correlation was varied between 0.3, 0.5 to 0.7 to indicate weak, moderate or strong correlation. When threshold value for correlation was set at level of 0.7 indicating strong correlation, only following two research topic pairs had internal correlation:

1) "study" (original topic rank 29/50.) and "case" (rank 33.) correlation 0.965
2) "product" (rank 8.) and "new" (rank 20.) correlation 0.843

When threshold value for correlation was diminished to the level of 0.5 indicating moderate correlation, following additional research topic pairs were detected:

1) "inno" (rank 1.) and "open" (rank 4.) correlation 0.500
2) "development" (rank 3.) and "research" (rank 7.) correlation 0.532
3) "development" (rank 3.) and "product" (rank 8.) correlation 0.685
4) "model" (rank 9.) and "business" (rank 11.) correlation 0.546
5) "development" (rank 3.) and "new" (rank 20.) correlation 0.672

Finally, when threshold value for correlation was diminished to the level of 0.3 indicating weak correlation, only few additional research topic pairs were detected:

1) "techno" (rank 5.) and "transfer" (rank 36.) correlation 0.356
2) "system" (rank 17.) and "dynamic" (rank 43.) correlation 0.326
3) "industry" (rank 19.) and "university" (rank 45.) correlation 0.304

As result we argue that the TOP50 list division is fairly robust, but one might could consider combing the following research topic as one: 1) "case" and "study" to "case

study", 2) "new", "product" and "development" to "new product development", which are well-known and unambiguous terms in innovation management research. We argue that combing other research topics is less straightforward, since correlation levels are clearly lesser varying between weak and moderate. However, in this study we decided to keep the original TOP50 list in order to keep the full comparability to Santonen and Conn (2015) original TOP50 research topics list.

4 Results

4.1 Descriptive statistics

In order to get an idea of how the innovation management research have developed from 2009 to 2014, research topics relative share in each year was calculated. In Appendix Table 1 we have presented the descriptive statistics for annual distribution of each TOP50 research topics. Furthermore, in Table 2 we have summarised the TOP50 research topics annual distribution result and also compared how large share each year is covering in relation to other years.

Table 2 Summary and comparison of TOP50 research topics relative shares in each year.

	2009 %	*2010 %*	*2011 %*	*2012 %*	*2013 %*	*2014 %*	*Avg %*	*Std.Dev. %*
A) TOP50 research topics relative share from all available keywords								
	61.07	61.27	64.72	61.85	58.20	62.30	61.57	2.11
B) TOP50 research topics relative share when years are compared with each other								
	14.38	14.35	16.74	14.64	22.01	17.88	16.7	2.99

As a result on the average the TOP50 research topics are covering about 61.6 percent of all keyword, but the comparison of the different years indicate that there are subtle annual differences (std. dev. 2.11 percent). In year 2013 TOP50 research topics were least dominant (58.20 percent share) while in 2011 TOP50 topics covered maximum 64.72 percent of all keywords. Interestingly, year 2013 resulted also the highest research topic hits (22.01 percent) when compared to other years, but there wasn't any correlation between measures "A" and "B". However, since our dataset was grounded on annual instead of event level data (i.e. each year included two events), in further studies one should also evaluate the event level data to understand more in-depth the relationship between number of keywords and keyword derived research topics.

4.2 Research topic trends

The individual research topic analysis revealed that only following three research topics from TOP50 list had clear decaling trend: Inno* (-0.814*), development (-0.939**) and analysis (-0.919**). Also the following two research topics had almost to decaling trend: research (-0.790, sig. 0.061) and theory (0.796, sig. 0.058). Since there was moderate internal correlation between research and development research topics, an

additional “research development” research topic was also constructed to verify if those two keywords together would result decaling trend. However, correlation in that case remained non-significant (-0.777, sig. 0.069).

In order to evaluate how similar or different the years were in terms of research topic frequency distribution, a matrix of Pearson’s r correlation coefficients for all possible pairs of year columns of a matrix were computed (Harrell, 2015). The correlations for research topic frequencies between years 2009 to 2014 are presented in Table 3.

Table 3 TOP50 research topic frequency correlations between 2009 to 2014, N=3147

	2009	*2010*	*2011*	*2012*	*2013*
2010	0.870**				
2011	0.820**	0.840**			
2012	0.480**	0.510**	0.580**		
2013	0.850**	0.870**	0.820**	0.550**	
2014	0.720**	0.740**	0.740**	0.630**	0.800**

**. Correlation is significant at the 0.01 level (2-tailed).

As a result, the correlations ranged from minimum 0.480** to maximum 0.870** indicating moderate to strong correlation between the various years. Basically we can argue that the research topic frequency distribution is somewhat similar in different years, excluding the year 2012 which correlations to the other years are only moderate (ranging from 0.480** to 0.630**), whereas correlations between all the other years are strong (ranging from 0.720** to 0.870**). Moreover, we could not detect any additional relationship when correlations were analysed in terms of time difference between the years.

On the average, standard deviation values for TOP50 research topics was 0.45 percent and ranged from minimum 0.08 percent to maximum 1.22 percent. These results indicate that besides the previously identified declaining trends, there might be other underlying factors which might explain the division between research trends. First, the standard deviation and average share value correlated with each other (0.603**) indicating that those research topic which are the most popular, are also facing more annual variety. Interestingly, the correlation increased a bit (0.632**) when the most popular “Inno*” research topic was excluded from the dataset to carry out sensitivity analysis.

Another possible error source is a conference theme. Like in many other scientific conferences, also in each ISPIM event the organizer defines a specific conference theme for each event, which is highlighted in call of papers announcement. In our opinion a successful and well defined conference theme, should stimulate authors to post papers on this specific theme. Prior conference themes from ISPIM website were identified (http://ispim.org/events/past-ispim-events/). “Sustain*” research theme which dominant keyword is “Sustainability” represent 41.5 percent of this research them was clearly influenced by conference theme. In Figure 2 we have presented evolution of “sustain*” research trend, which highest peak is in 2011, the very same year when conference themes were “2011 XXII ISPIM Conference - Sustainability in Innovation: Innovation Management Challenges “ and “2011 The 4th ISPIM Innovation Symposium - Managing Innovation for Sustained Productivity: Creating Advantage and Resilience”. This partially validates that conference organizer at IPSIM can influence on the research focus

areas, but most in most researchers are following their own interest regardless of the predefined themes.

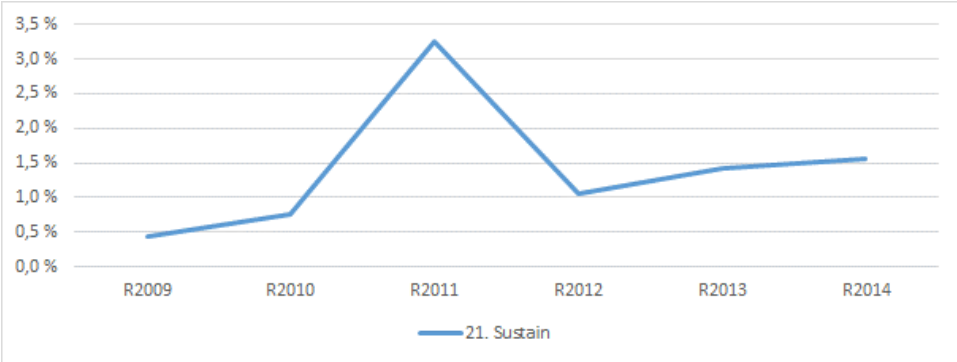

Figure 2: Evolution of sustain* research trend.

4.3 Keyword trends

Since research topic related analysis did not reveal any substantial trends, we also conducted similar analysis at the keyword level. In order to evaluate how similar or different the years were in terms of keyword frequency distribution, a matrix of Pearson's r correlation coefficients for all possible pairs of year columns of a matrix were computed (Harrell, 2015). The correlations for keyword frequencies between years 2009 to 2014 are presented in Table 4.

Table 4 Keyword frequency correlations between 2009 to 2014, N=3147

	2009	*2010*	*2011*	*2012*	*2013*
2010	0.804**				
2011	0.712**	0.784**			
2012	0.728**	0.742**	0.726**		
2013	0.770**	0.808**	0.784**	0.762**	
2014	0.646**	0.684**	0.687**	0.693**	0.731**

**. Correlation is significant at the 0.01 level (2-tailed).

As a result, the correlations ranged from minimum 0.646** to maximum 0.808** indicating moderate to strong correlation between the various years. Visual examination of the Table 4, suggests that years which have less time difference were more similar than the years which had longer time difference. The correlation tests between "time difference" and "correlations measures" resulted almost significant negative correlation (-0.491, sig. 0.063, N=15) indicating that there is a faint tendency that the keyword frequency distribution at ISPIM is evolving slowly and incrementally. Although each next year is covering somewhat similar topics as the year before, eventually keywords are slowly changing to new directions. To verify this, a longer time period is needed.

Nevertheless, ISPIM events are following incremental evolution in which changes to research contents are minor.

Finally when annual distribution of individual keywords were evaluated more in-depth, it appeared that 78.9 percent of all keywords (N=2482) occurred only in one year and only 42 keywords (1.3 percent) occurred in each year, 47 keywords (1.5 percent) in five years, 77 keywords (2.4 percent) in four years, 132 in three years (4.2 percent) and 367 in two years (11.7 percent).

In order to analyse keyword popularity trends, the relative share of all keywords which had occurred in three or more years was calculated. Keyword occurrence below this threshold was considered more or less random. As a result following keywords had upward trend: co-creation (0.967** correlation to year), product innovation (0.939**), new service development (0.918**), strategic foresight (0.912*), process industry (0.813*).

The following keywords had downward trend: innovation (-0.843*), knowledge management (-0.908*), patent (-0.869*), innovation culture (-0.857*), intellectual property (-0.926**), organizational capability (-0.831*) and culture (-0.842*).

5 Conclusions

This study empirically verified the evolution of ISPIM research topics during the period 2009 to 2014. We found that the TOP50 research topic list identified by Santonen and Conn (2015) is robust. Moreover, our results also verify that there is subtle incremental change in what kind of content is covered at ISPIM events. ISPIM, as a conference organizer, only has limited influence on research focus areas by introducing attractive themes and in most cases researchers typically following their own interest regardless of the predefined conference themes. Therefore, it is suggested that conference themes could be considered as a tool to draw attention outside of innovation management research scholar circles in order to diversify conference participants. As a result, we have described the contemporary body of knowledge of innovation management research more in-depth than prior studies. This temporal analysis helps understanding and verifying how (little) innovation research priorities have changed over time, but validates that there is some change.

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Appendix: Table 1: TOP50 ISPIM research topics relative share between 2009 to 2014

	2009 %	*2010 %*	*2011 %*	*2012 %*	*2013 %*	*2014 %*	*AVG. %*	*STD.DEV %*
1. Inno*	22.16	22.10	22.47	20.70	21.40	19.22	21.34	1.22
2. *MGMT.*.	4.97	6.28	4.74	3.50	4.17	3.74	4.57	1.01
3. Develop.	4.97	5.09	4.09	4.25	3.81	3.30	4.25	0.68
4. Open	3.89	3.68	3.99	4.88	3.88	4.17	4.08	0.42
5. Techno*	4.43	4.12	4.18	3.93	4.38	2.96	4.00	0.54
6. Co*	3.46	2.28	2.60	4.88	3.53	3.30	3.34	0.91
7. Research	3.14	3.36	3.06	3.08	2.97	2.26	2.98	0.37
8. Product	3.14	2.49	2.51	2.02	3.32	3.39	2.81	0.55
9. Model	2.16	2.28	2.32	2.23	2.26	4.35	2.60	0.86
10. *KNOWLl.*	2.92	1.41	2.97	2.65	3.18	2.26	2.57	0.65
11. Business	1.73	2.28	2.51	2.02	1.77	4.52	2.47	1.05
12. Strateg*	2.59	2.38	2.60	2.55	1.62	2.70	2.41	0.40
13. Service	1.95	1.84	2.04	1.59	2.54	2.43	2.07	0.36
14. Process	2.16	2.06	2.51	2.12	1.91	1.65	2.07	0.28
15. Organi*	2.92	1.52	1.76	3.40	1.77	1.57	2.15	0.80
16. Creat*	1.62	1.52	1.02	1.91	2.26	2.70	1.84	0.59
17. System	2.16	1.84	1.02	1.49	1.98	2.61	1.85	0.55
18. Network	2.92	1.73	1.39	1.70	1.91	1.48	1.85	0.55
19. Industry	1.51	1.63	1.86	1.91	2.19	1.22	1.72	0.34
20. New	1.51	1.08	1.95	2.23	2.40	1.57	1.79	0.49
21. Sustain*	0.43	0.76	3.25	1.06	1.41	1.57	1.41	0.99
22. *FIRM.*	1.30	0.87	1.67	1.80	1.55	1.39	1.43	0.33
23. *PERF.*	1.19	1.52	1.30	1.91	1.27	1.48	1.44	0.26
24. Enterp*	1.19	1.73	2.04	0.96	1.48	1.04	1.41	0.42
25. Value	1.62	1.63	0.74	0.74	1.06	2.35	1.36	0.63
26. Capability	1.51	1.41	1.39	1.17	0.99	1.57	1.34	0.22
27. User	1.08	1.19	1.11	0.96	1.13	1.04	1.09	0.08
28. Analysis	1.62	1.41	0.93	0.96	0.85	0.78	1.09	0.34
29. Study	1.19	1.19	0.65	1.27	0.78	1.30	1.06	0.28
30. Design	0.76	0.87	1.67	0.96	0.71	1.22	1.03	0.36

**. Correlation is significant at the 0.01 level (2-tailed).
Abbreviation: MGMT.. = Management, KNOWL. = Knowledge, PERF. = Performance, FIRM. = Firm, Company, Corpo*

	2009 %	2010 %	2011 %	2012 %	2013 %	2014 %	AVG. %	STD.DEV %
31. Market	0.32	0.76	1.02	1.70	1.69	0.96	1.08	0.54
32. Social	0.65	1.08	0.84	0.85	0.85	1.30	0.93	0.23
33. Case	1.08	0.76	0.46	1.27	0.71	1.13	0.90	0.31
34. National	0.97	0.87	0.65	0.42	1.06	0.96	0.82	0.24
35. Method	0.65	1.08	0.65	0.64	0.99	0.87	0.81	0.20
36. Transfer	0.86	0.87	0.65	0.96	0.92	0.52	0.80	0.17
37. Based	0.32	0.65	1.11	1.27	0.64	0.70	0.78	0.35
38. Learning	1.19	0.43	1.02	0.53	0.64	0.70	0.75	0.29
39. Customer	0.32	1.52	1.11	0.32	0.71	0.52	0.75	0.48
40. Resource	0.76	1.30	0.37	0.32	0.99	0.43	0.70	0.39
41. Foresight	0.22	0.76	0.28	0.64	1.13	0.87	0.65	0.35
42. Project	0.32	1.30	0.28	1.17	0.49	0.70	0.71	0.43
43. Dynamic	0.32	1.19	0.74	0.64	0.56	0.61	0.68	0.29
44. *ENTR.*	0.86	0.22	0.37	0.74	0.85	0.78	0.64	0.27
45. University	0.65	0.87	0.65	0.53	0.85	0.17	0.62	0.25
46. Change	0.54	0.54	0.84	0.42	0.49	0.87	0.62	0.19
47. Capacity	0.65	0.87	0.56	0.53	0.49	0.61	0.62	0.13
48. Action	0.22	0.43	0.84	0.96	0.56	0.52	0.59	0.27
49. Theory	0.32	0.22	0.65	0.74	0.49	0.96	0.56	0.27
50. *INFO.*	0.54	0.76	0.56	0.53	0.42	0.70	0.58	0.12

Abbreviation: *ENTR.* = Entrepreneurship, *INFO.* = Information