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Science Mapping the Research of Business Process Management: Patterns and Implications for Comparable Information Technology Fields

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ABSTRACT

Business ethics, as a content of formal higher education, occupies This paper maps the research and maturity of the Business Process Management (BPM) scientific field by using existing literature reviews and bibliographic methods to formulate generalizable patterns and implications, which could be proposed for comparable, multidisciplinary Information Technology (IT) fields. By applying text mining to the corpus of BPM conference and journal papers, systematically selected from Scopus, generalizable drivers of BPM evolution and maturity are determined, including the proposal of implications for comparable IT fields. Results showed four literature clusters, which relate reasonably well with the BPM lifecycle and PDCA/PDSA cycle concepts. BPM and comparable research fields seem to be driven by the maturing of technological capabilities and organizational acceptance in the sectors in which they are heavily applied. This study comprehensively analyzes BPM journal articles and conference proceedings using bibliometric analysis to provide new research directions.

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1. Introduction

This study looks at the drivers of literature development and maturity of the Business Process Management (BPM) field and the opportunities to generalize the empirical results obtained by the science mapping of BPM literature. The research discipline of BPM has progressed by growing within the disciplines of Computer science, Management Science, and Information systems science (Recker & Mendling, 2016; van der Aalst, 2013). Consequently, BPM is a field involving multi-disciplinary science concepts, methods, and tools (Glykas, 2013), making its evolution pattern an ideal case for potential generalization across comparable fields at the intersection of Computer and Information science(s).

A robust bibliometric approach of text mining has been applied as a method of choice for science mapping of the BPM literature, including international journals and conference proceedings, to explore the corpus of core BPM papers believed to belong to a newly emerging multi-disciplinary field. As a result, some important papers from the related (sub)fields, primarily from workflow management (e.g. (Rinderle et al., 2003; Sadiq et al., 2007)), have not been selected for analysis. This is both a limitation and a feature of the paper, which aims to analyze the bibliometric patterns of the core BPM corpus and identify those, which might be applicable to a range of emerging multi-disciplinary IT fields of study.

An attempt to generalize the research findings across the comparable multi-disciplinary fields located at the intersection of Computer and Information science(s), follows up on the recent empirical findings on the co-evolution of 28 research fields (Iwami et al., 2020). Their conclusions of field co-evolutions (op. cit., p. 14) suggest a historical pattern of literature development based on the linkages with underlying technologies and methodological tools. We use the results of science mapping the BPM field to develop generalizable formal propositions of drivers relevant for theorizing and literature maturity across a range of comparable multi-disciplinary fields.

The objective of the paper is to analyze the bibliometric patterns of the BPM corpus and its trends by focusing on the following research questions:

- Which journals and authors influenced the Business Process Management literature the most?
- Which themes attracted the greatest attention from BPM scholars, are there any trends to be recognized?
- What is the potential application of identified BPM patterns in multi-disciplinary IT fields?

The paper is organized as follows. After the introduction, the second section describes the BPM field using the available literature reviews. The third section identifies the data retrieval strategy, methods, and software used. The fourth section presents the empirical results of science mapping the

BPM literature, while the fifth section contains text mining results. Discussion (the sixth section) generalizable propositions of development and maturity of BPM and comparable multi-disciplinary fields are developed. The seventh section outlines the study's limitations and recommendations for the future research agenda, including a preliminary conclusion of the study.

2. Literature review

After three decades, the BPM discipline reached a certain level of maturity (Houy et al., 2010; van der Aalst, 2013), which can be assessed from an overview of BPM literature presented in Table 1. Those have been identified based on a systematic search for BPM literature reviews performed in the last ten years, confirming the relevant corpus of literature, which can be analyzed using bibliometric methods. Nevertheless, except for using citation and co-citation analyses (Klun & Trkman, 2016), the contemporary bibliometric methods, such as the recent developments in text mining and citation analysis tools (van Eck & Waltman, 2017), have been applied only partially to this corpus (see Table 1).

Table 1

BPM literature reviews and application of bibliometric methods

Authors	Scope of review	Focus of review	Methods used
Sidorova and Isik, 2010	Abstracts of journal articles in EBSCO database between 1927-2008	Broad: Themes in Business Process research	Latent semantic analysis (LSA.)
Houy et al., 2010	Journal articles between 1991-2008 in databases WOS SCI and EBSCO	Specific: Empirical BPM research	Not named
vom Brocke and Sinnl, 2011	Journal articles and conference papers until 2009	Specific: Research on culture in BPM.	Not named
Niehaves and Plattfaut, 2011	Journal articles and conference papers until 2009	Specific: Research on Collaborative BPM.	Not named
van der Aalst, 2013	Paper published in the BPM conference proceedings, 2003-2012	General: BPM research use cases	Not named
Anand et al., 2013	Articles from AIS top journals and articles from the Science Direct database, 2005-2011	Broad: Multiple characteristics of articles	Not named
Recker and Mendling, 2016	Papers published in the BPM conference proceedings, 2003-2014	Multiple characteristics of BPM conference papers	Citation analysis
Klun and Trkman, 2018	Papers published in peer-reviewed journals in SCI and SSCI of the Core collection of WoS	Broad: Current state of the field	Citation, co-citation and cluster analysis
Danilova, 2018	Academic journals in the citation databases Emerald, EBSCO Business Source Complete, ScienceDirect and Taylor & Francis	Specific: Process owners in BPM.	Not named

Notes. Adapted and extended from Recker & Mendling, 2016.

Sidorova & Isik (2010) provide a cross-disciplinary perspective on business process (BP) research and identify the key research themes within the BP field (design, IT, organizational implementation, and management & control), along with the research associated with TQM, supply chain management, and e-commerce.

Niehaves & Plattfaut (2011) contains reviewed state of the collaborative BPM and contributed to identifying five clusters of literature relevant for future research: (1) certification and auditing, (2) simulation, (3) collaboration through non-contractual agreements, (4) collaborative BPM and (5) research towards the theoretical understanding of collaborative BPM Additional specialized reviews have been performed by (vom Brocke & Sinnl, 2011) on the role of culture in BPM and process ownership in BPM practicing organizations (Danilova, 2018).

Paper, written by van der Aalst (2013), provides an overview of the state-of-the-art topics in BPM and discusses the following key concerns: (1) process modeling languages, (2) infrastructure for process enactment, (3) process model analysis, (4) process mining, (5) process flexibility, and (6) process reuse.

In their review, Recker & Mendling (2016) aimed to cover the research approach, methods, and impact of papers presented at BPM conferences. The authors included 347 conference papers, which were classified and used to develop a set of recommendations to increase the maturity of future BPM research.

Klun & Trkman (2016) identified six clusters of BPM topics in scientific journals, which include: (1) practice-oriented BPR, (2) workflow management, (3) BPM concepts, (4) methods in business process modeling, (5) information technology and (6) BPM success factors. They describe the evolution of BPM, since its Business Process Reengineering (BPR)-related roots, in terms of the constant need for re-invention: firstly, from the radical BPR agenda to a more realistic workflow approach and, currently, from a state of fragmentation into multiple specialized subtopics, toward a more holistic discussion of the role of processes in digital transformation, social networks, and other relevant IT constructs.

The issues raised by Klun & Trkman (2016) question the generalizability of the constructs, such as the process orientation, and introduce a limit to theorizing, which questions the very definition of BPM as a holistic management approach (Rosemann & Brocke, 2010). This would certainly, limit the opportunities for epistemologically oriented research, looking to develop and test generalizable theories from the analysis of the BPM literature corpus. Nevertheless, a previous theory review of BPM empirical studies, published in the same journal (Houy et al., 2010), made a strict difference between those belonging to the epistemological 'school of thought' versus those using the applied approach, looking to develop new IT tools and models. Houy et al. (2010) labeled the two types of BPM empirical studies as 'behavioral' and 'design' science, constituting 55% vs. 45% of papers, as analyzed by their systematic literature review. The very amount of 'behavioral' studies indicates a potential for epistemological BPM research.

On the other hand, Anand et al. (2013) found that most of the top Association for Information Systems Research (AIS) journals did not, historically, devote much attention to business-process-related research. This is supported by a study, that found the amount of papers, developing the applied ('Mode 2') BPM knowledge, to be equal to 64.1% of papers, published in the Business Process Management Journal, as a principal publication outlet in the BPM field (Veit et al., 2017). Since the 'Mode 2' knowledge production is inter-disciplinary and driven by application and partnerships, as opposed to the traditional 'Mode 1' knowledge production, based on epistemologically oriented, traditional academic disciplines (Gibbons et al., 2010), those concepts could approximate the 'behavioral' vs. 'design' science notions.

Although the epistemological orientation of the BPM core literature corpus is not in the focus of this study, *results hinting at the applied nature of the majority of BPM literature could have significant implications for the analysis of the BPM field development and maturity, as well as its generalizability.*

3. Methodology

Bibliometric literature reviews can process a considerably higher volume of studies, published over a longer timespan, with a lower investment of time and resources while providing a comprehensive picture of the research topic (Hernández-Torrano & Ibrayeva, 2020). Bibliometric analyses use bibliographic information from scholarly databases (e.g., Web of Science, Scopus, PsycINFO, ERIC) (Andres, 2009). Bibliometric mapping is considered an important subject matter (Morris & Van der Veer Martens, 2008), as it reveals the structure and dynamics of a particular line of research (Zupic & Čater, 2015). The advances in bibliometric software enable the researchers to perform text mining techniques, which present an additional input to bibliometric studies and science mapping as a specific approach to systematic literature review (Sinoara et al., 2017).

To understand the drivers of development, relevant to fields on the intersection of computer and information science(s), this study uses the BPM discipline as a potentially generalizable case, which is analyzed by applying text mining and science mapping, considered to be useful when the research goal is to provide an overview of trends in a field, based on a broad corpus of research items and application of specialized software (Bu et al., 2020; Chen et al., 2014). Systematic mapping represents a specific type of systematic literature review (Sinoara et al., 2017).

We used text mining and clustering to synthesize the characteristics of the BPM core corpus. Text mining applies data mining to text files (Kotu & Deshpande, 2015) and supports knowledge discovery (Kaur & Chopra, 2016; Sinoara et al., 2017). In addition, it makes it possible to locate similar studies within bibliographic data (Justicia De La Torre et al., 2018).

3.1. Data retrieval and procedure

The Scopus database is chosen for the bibliometric analysis since it has broader coverage than the Web of Science (WoS) database (Hallinger &

Kovačević, 2019). The first step of a literature review study is to locate the relevant literature (Creswell & Creswell, 2018), so an advanced Scopus search was performed in April 2020. Three inclusion criteria were applied:

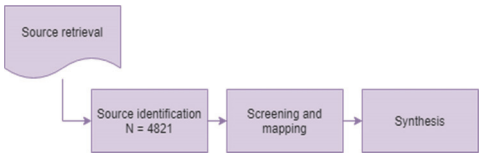
- Document type: journal
- Document type: conference paper
- Language: English

We aimed to include articles and conference papers whose title, abstract, or keywords contained the "business process management" phrase. The resulting keyword string, used for the identification of bibliographic items was as follows: TITLE-ABS-KEY ("business process management") AND (LIMIT-TO (DOCTYPE, "cp") OR LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (LANGUAGE, "English")). We wanted to provide insight into the current state of BPM research and did not restrict the bibliographic search in terms of research topics or the field.

The process conducted is shown in Figure 1, which follows the generic methods and process of bibliometric research, regardless of the science field being mapped (Andres, 2009). Such a methodology has been applied in various fields ranging from business management and organization (Zupic & Čater, 2015) to education leadership (Hallinger & Kovačević, 2019).

Figure 1

The generic bibliometric research process

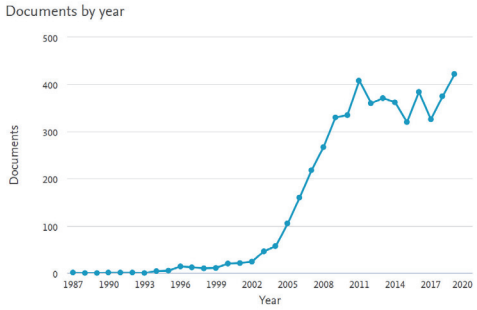


Notes. Authors' presentation of the research process.

The search resulted in 4821 documents published between 1987 and April 2020. Only 31.2 % of listed documents are journal articles, which demonstrated the knowledge gap in the existing studies, which avoided mapping of the conference proceedings in the field of BPM. Although the field of BPM is a new one (starting in the late 1980s), its growing popularity is evident, with the majority of research items being published from 2001 onwards, with exponential growth from 2002 to 2011 (see Figure 2).

Figure 2

Distribution of BPM-related documents in the Scopus database



Notes. Results of empirical research (authors' calculation).

The authors downloaded documents' bibliographic data and imported them to Excel from the Scopus database website. The Scopus data included the authors' names, article titles, year, source title, volume, issue, citation data, abstracts, keywords, and references. Various software tools were used for bibliographic analyses, as described in the following section of the paper.

3.2. Software tools used

Bibliographic data, derived from 4,821 documents indexed in Scopus, was analyzed using MS Excel and the specialized VOSviewer software, version 1.6.15.

Excel has been used for pre-processing and filtering data to obtain the number of citations and link strength and to sort full names of authors, sources, and documents for preparing the thesaurus files. Those are used to reduce unwanted redundancy, i.e. merge different variants of authors' names

(e.g. "van der aalst, w.", "van der aalst, w.m.p.", "van der-aalst, w." and "van der aalst, w.m." - belonging to a single author).

VOSviewer is a free software for creating and visualizing bibliometric maps (Jan & Ludo, 2010) and text mining, used to create term maps based on a corpus of documents (Eck & Waltman, 2011; Jan & Ludo, 2010), showing the relatedness of concepts in a science field. The text mining procedure starts with the identification of noun phrases. Word sequences that end with a noun are selected, and plural phrases are transformed into singular ones.

The second step relates to selecting the most relevant noun phrases (also referred to as terms), followed by mapping, clustering, and visualizing the obtained results. The terms' relatedness in this paper is determined based on co-occurrences in paper abstracts.

3.3. Fundamental bibliometric characteristics of the core Business Process Management (BPM) literature

To complement the analysis of the existing literature reviews (see Section 2), in this section, the BPM core literature is briefly described by using the standard bibliometric indicators obtained by using the citation and co-citation analyses. Since a similar study (Klun & Trkman, 2016) provides a similar coverage of Web of Science-based coverage of journal papers, we provide a limited amount of fundamental bibliometric information by using the traditional citation analysis (Eugene, 1972) and the two standard weight attributes - the links and the total link strength (Eck & Waltman, 2011).

The citation analysis of authors has resulted in the identification of 7,976 authors, with the twenty most-cited authors of the core BPM literature identified in Table 2, along with the number of documents, number of citations, and citations per document. According to the link strength, the top authors are ranked as calculated by the VOSviewer software (with the minimum threshold for the number of documents per author and citations per author set to two).

Table 2

Top twenty BPM authors published in the Scopus database

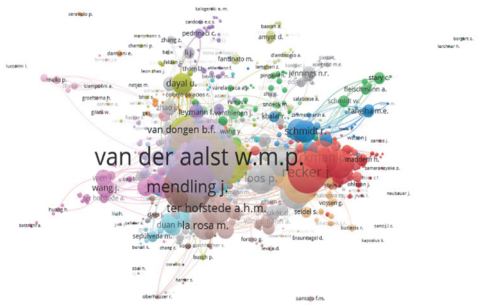
Rank	Author	Number of documents	Number of citations	Citations per document	Total link strength
1	van der Aalst, WMP.	79	5415	68.54	1323
2	Mendling J.	69	1532	22.20	708
3	Reijers H.A.	34	1408	41.41	592
4	Recker J.	31	1158	37.35	540
5	Rosemann M.	42	1359	32.36	470
6	Weske M.	58	1533	26.43	445
7	Trkman P.	10	910	91	413
8	Song M.	14	1584	113.14	410
9	Becker J.	42	367	8.74	362
10	Ter Hofstede A.H.M.	26	840	32.31	353
11	Loos P.	50	543	10.86	337
12	Verbeek H.M.W.	7	809	115.57	329
13	Roglinger, M.	20	266	13.3	325
14	La Rosa, M.	20	642	32.1	303
15	Schmiedel, T.	13	383	29.46	302
16	Indulska M.	19	786	41.37	275
17	Fettke, P.	33	437	13.24	270
18	Van Dogen B.F.	8	1179	147.38	256
19	Janiesch, C.	23	191	8.3	241
20	Vom Brocke, J.	19	439	23.1	239

Notes. Authors' presentation.

Out of the citation map, including 2,010 authors who met the thresholds, 985 authors with the greatest total link strength were selected to obtain a more accessible map (see Figure 3). According to the Scopus search criteria, author Wil van der Aalst proved to be the most productive and most cited author in the BPM core literature corpus, with 79 items and 5,415 citations. The result is consistent with his H-index of 147, demonstrating over 100,000 citations the author received in the broad field of Information Technology. Mendling (69 items) and Weske (58 items) follow, each receiving over 1,500 citations. A slightly larger number of citations is attributed to Song, for whom 14 items have been identified, therefore receiving one of the largest ratios of citations per document.

Figure 3

Citation map of the BPM core literature, ased on the total link strength



Notes. Authors' presentation.

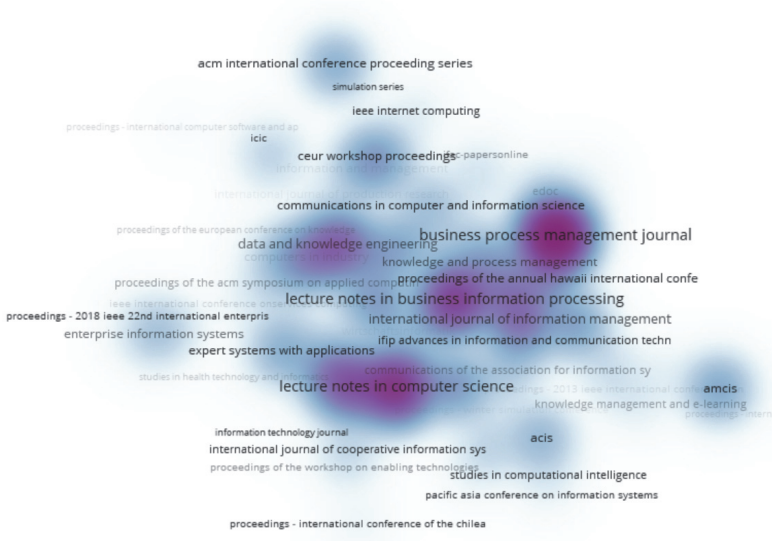
To visualize the most cited sources with the most significant impact in the BPM field, as well as to obtain an overview of the general structure of the BPM body of knowledge and the publication outlets (Jan & Ludo, 2010), the density visualization is used (see Figure 4).

The map is created using the total link strength metric and the map colors, depending on the number and the importance of the neighboring items. A thesaurus file has been made to eliminate redundancy among sources. The threshold has been set to at least five documents per source, which generated 98 highly cited Scopus sources out of 1,599 BPM-related sources.

A source with the highest total link strength is the *Business Process Management Journal,* while the Lecture Notes publish the highest number of items in Computer Science (N=479). When this source is excluded from analysis, the highest number of Scopus items belongs to the CEUR Workshop Proceedings (N=196), followed by the Business Process Management Journal (N=168). Of the top twenty sources, 30% belong to conferences (N=6), while the majority fit the academic journals (N=12), which could have been expected. Table 3 shows the calculated total strength, number of documents, and number of citations for each source

Figure 4

The map of most cited Scopus sources in the BPM field



Notes. Authors' presentation.

Table 3

Top twenty highly cited BPM sources in the Scopus database

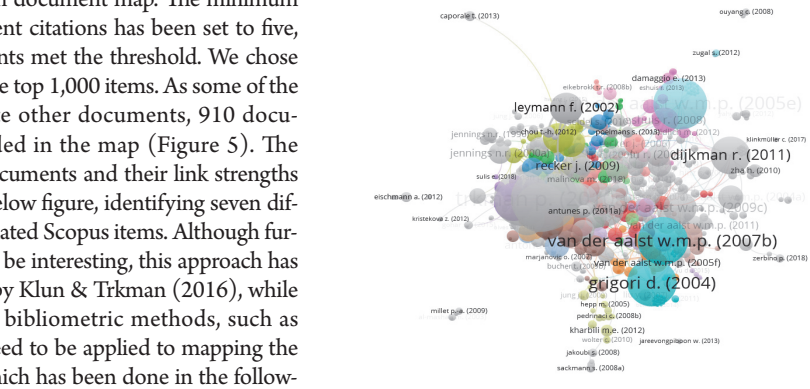
Rank	Source title	Number of documents	Number of citations	Total link strength
1	Business Process Management Journal	168	4105	629
2	Lecture Notes in Business Information Processing	404	2083	317
3	Lecture Notes in Computer Science	479	6319	315
4	Information Systems Journal	29	1729	209
5	Data and Knowledge Engineering Journal	18	1496	208
6	International Journal of Information Management	10	853	150
7	Business and Information Systems Engineering Journal	21	403	104
8	ECIS - European Conference on Information Systems	70	705	100
9	Computers in Industry Journal	18	894	99
10	Decision Support Systems Journal	25	990	98
11	AMCIS - Americas Conference on Information Systems	89	333	88
12	Total Quality Management and Business Excellence Journal	11	304	88
13	CEUR workshop proceedings	196	627	85
14	Proceedings of the Annual Hawaii International Conference on System Sciences	49	629	84
15	Information and Software Technology Journal	18	665	78
16	ACM international conference proceeding series	94	257	73
17	Knowledge and Process Management Journal	18	290	72
18	Expert Systems with Applications Journal	27	503	71
19	ACIS - Australasian Conference on Information Systems	40	765	59
20	Information Systems Frontiers Journal	14	211	58

Notes. Authors' presentation.

The citation analysis aimed to identify highly cited documents, and more importantly focus was to present a citation document map. The minimum number of document citations has been set to five, and 1,733 documents met the threshold. We chose to select links for the top 1,000 items. As some of the documents did cite other documents, 910 documents were included in the map (Figure 5). The most important documents and their link strengths are shown in the below figure, identifying seven different clusters of related Scopus items. Although further analysis would be interesting, this approach has already been used by Klun & Trkman (2016), while the contemporary bibliometric methods, such as text mining, still need to be applied to mapping the BPM literature (which has been done in the following section).

Figure 5

Citation analysis of the BPM field



Notes. Authors' presentation.

The top-cited documents from our limited search (see Table 4) are sorted by link strength, with the highest number of Scopus citations belonging to a study on the critical BPM success factors by Trkman, followed by a study of BPM competitive strength by Zairi and van der Aalst et al., related to handling the BPM use cases.

Table 4

Top twenty most cited BPM studies from the core literature corpus, indexed by the Scopus database.

Rank	Scopus document	Scopus citations	Links
1	Trkman, P. (2010). The critical success factors of business process management. *International Journal of Information Management, 30*(2), 125-134.	440	68
2	Zairi, M. (1997). Business process management: A boundaryless approach to modern competitiveness. *Business Process Management Journal*, 3(1), 64-80.	243	54
3	Van Der Aalst, W. M. P., Weske, M., & Grünbauer, D. (2005). Case handling: A new paradigm for business process support. *Data and Knowledge Engineering, 53*(2), 129-162.	505	49
4	Hung, R.Y.-Y. (2006). Business Process Management as a competitive advantage: A review and empirical study. *Total Quality Management and Business Excellence, 17*(1), 21-40.	158	46
5	van der Aalst W. M. P., Reijers, H. A., Weijters A. J. M. M., van Dongen B.F., Alves de Medeiros, A. K., Song M., & and Verbeek, H. M. W. (2007). Business process mining: An industrial application. *Information Systems, 32*(5), 713-732.	494	45
6	Grigori, D., Casati, F., Castellanos M., Dayal U., Sayal M., & Shan M. -C. (2004). Business Process Intelligence. *Computers in Industry*, *53*(3), 321-343.	343	44
7	Houy C., Fettke P., & Loos, P. (2010). Empirical research in business process management - analysis of an emerging field of research. *Business Process Management Journal, 16*(4), 619-661.	120	34
8	Dijkman R., Dumas M., Van Dongen B., Krik, R., & Mendling, J. (2011). Similarity of business process models: Metrics and evaluation. *Information Systems, 36*(2), 498-516.	412	32
9	Pritchard, J.-P., & Armistead, C. (1999). Business process management – lessons from European business. *Business Process Management Journal*, *5*(1), 10-35.	92	32
10	Weske, M., Van Der Aalst, W. M. P., & Verbeek, H. M. W. (2004). Advances in business process management. *Data and Knowledge Engineering, 50*(1), 1-8.	156	29
11	Rosemann, M., & De Bruin T. (2005). Towards a business process management maturity model, in *Proceedings of the 13th European Conference on Information Systems, Information Systems in a Rapidly Changing Economy (ECIS)*. (pp. 1-12).	197	27
12	Armistead C., Pritchard J.-P., & Machin, S. (1999). Strategic business process management for organizational effectiveness. *Long Range Planning, 32*(1), 96-106.	101	26
13	Van Der Aalst W. M. P., Pesic, M., & Schonenberg, H. (2009). Declarative workflows: Balancing between flexibility and support. *Computer Science - Research and Development*, *23*(2).	346	25
14	Leymann, F., Roller, D., & Schmidt M. T. (2002). Web services and business process management. *IBM Systems Journal*, *41*(2), 198-211.	376	23
15	Ko, R. K. L., & Lee, S. S. G., & Lee E. W. (2009). Business process management (BPM) standards: A survey. *Business Process Management Journal, 15*(5), 744-791.	240	23
16	Erol, S., Granitzer, M., Happ, S., Jantunen, S., Jennings, B., Johannesson, P., Koschmider, A., Nurcan, S., Rossi, D., & Schmidt, R. (2010). Combining BPM and social software: Contradiction or chance? *Journal of Software Maintenance and Evolution*, 22, 449-476.	104	22
17	Smart, P. A., Maddern, H., & Maull R. S. (2009). Understanding business process management: Implications for theory and practice. *British Journal of Management, 20*(4), 491-507.	68	22

18	Recker, J., Rosemann, M., Indulska M., & Green, P. (2009). Business process modeling - A comparative analysis. *Journal of the Association for Information Systems, 10*(4).	240	20
19	Bruno, G., Dengler, F., Jennings, B., Khalaf, R., Nurcan, S., Prilla, M., Sarini, M., Schmidt, R., & Silva, R. (2011). Key challenges for enabling agile BPM with social software. *Journal of Software Maintenance and Evolution, 23*(4),	109	20
20	Eshuis, R., & Grefen, P. (2008)." Constructing customized process views. *Data and Knowledge Engineering, 64*(2), 419-438.	121	18

Notes. Authors' presentation.

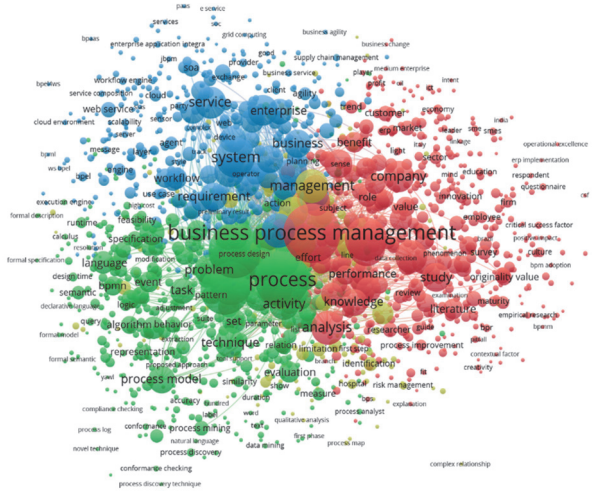
3.4. Mapping the BPM core literature: In search of generalizable patterns

In the science mapping of the BPM core literature corpus, the bibliometric data were analyzed using text mining and similarity visualizations. Text mining helps avoid manual screening of more than 4,800 titles and abstracts (Ananiadou et al., 2009), with the abstract field used to identify noun phrases, which is useful for analyzing co-occurrences (see Section 3.2.).

From the total number of 52,192 noun phrases occurring in at least ten publications in the corpus, the term map contains 1,694 most relevant, weighted by the total link strength. The term "paper" was excluded from the analysis, and the minimum number of items per cluster was set to 88. These were technical preconditions for visualizing the relatedness of the analyzed terms based on their co-occurrences in the core BPM corpus. Text mining resulted in four clusters (see Figure 6), numbered according to their size (Cluster 1 is the largest, and Cluster 4 is the smallest).

Since visualization helps with interpreting the text mining (Justicia De La Torre et al., 2018), it was easy to use the resulting map to point out the most frequent terms in each cluster (see Table 5), whose frequencies in the core BPM corpus help to describe and interpret the literature patterns, based on BPM terms' co-occurrence.

Figure 6
Visualization of the key themes (clusters) in the BPM field.



Notes. Authors' presentation.

Table 5

Scopus clusters of BPM literature and the key cluster terms (with noted frequencies for each term)

Cluster number	Cluster 1 (red)	Cluster 2 (green)	Cluster 3 (blue)	Cluster 4 (yellow)
Number of items	572	536	394	192
The most frequent phrases	business process management (2551), bpm (1398), analysis (852), intent (14), initiative (171), benefit (307), knowledge (540), performance (392), indicator (60), research (782), study (620), development (620), role (288), first step (58), understanding (230), impact (284), need (583), organization (1100), company (726)	business process (2099), approach (1820), tool (734), process (2264), user (327), feature (214), modelling (104), technique (679), data (699), activity (711), event (306), problem (667), model (1385), evaluation (340), information (605), documentation (65), task (487), input (81), time (617), runtime (90), experiment (146), domain (336), context (628), process mining (165), feasibility (134), rule (253), simulation (153), measure (125), process analysis (38), order (834)	System (1188), application (743), service (769), platform (299), technology (659), infrastructure (186), business process execution (54), integration (446), workflow (361), requirement (583), architecture (473), implementation (603), resource (419), attribute (35), application integration (16), framework (871)	Improvement (361), effectiveness (212), limitation (156), quality (382), efficiency (344), synthesis (25), management (841)

Notes. Authors' presentation.

The obtained results in the form of four clusters are similar to the BPM lifecycle stage concept used to classify the BPM literature in a review by Santos Rocha & Fantinato (2013). Although there is no overall agreement on the number or names of the BPM lifecycle phases, they are usually conceptualized in terms of the definition, execution, follow-up, control, and analysis of business processes, in addition to their improvement (Hernández González et al., 2019). This framework can be further simplified into four general stages related to van der Aalst (2013): (1) business process modeling, (2) an enactment (process implementation involving the configuration of the information systems); (3) analysis (diagnosing problems by using the process model/maps) and (4) management (involving all other BPM activities, including additional adjustments of the process).

Another classification, following the notion of analyzing, planning, implementing, and evaluating management plans, is provided by Santos Rocha & Fantinato (2013), who recognizes the following BPM lifecycle stages: (1) design & analysis; (2) configuration; (3) enactment and (4) evaluation. Those would fit the obtained mapping rather well, with Cluster 1 easily identified as corresponding to the design & analysis, Cluster 2 to the configuration (implementation), Cluster 3 to enactment, and Cluster 4 to the evaluation stages.

Based on the year publication, the key terms in the BPM literature have also been analyzed to describe the trends and dynamics of the BPM core literature corpus. Mapping historical developments is easier for bibliometric studies in more established fields, such as organization and management (Zupic & Čater, 2015), or even specialized ones, such as education management and leadership (Hallinger & Kovačević, 2019). As BPM rapidly evolves for twenty years, the obtained research results can be used as an indication of its development.

The initial literature belongs to Cluster 3, which could be interpreted in terms of the Enactment stage in the BPM lifecycle, which is fairly logical due to the emphasis on the actual cases of implementing the BPM concept and the supporting technologies/information systems. More recent concepts include: "digitalization", "agility", "contextual factor", "process mining technique", "process discovery", "novel technique", "cloud" and "cloud computing". Except for the technological development of cloud computing, those terms are 'scat-

tered' around different stages of the BPM lifecycle, making it somewhat inaccurate to describe the historical development of the BPM core literature.

Nevertheless, our results resonate with the empirical findings of Recker and Mendling (2016), who notice that as much as 56% of BPM conference papers cover process discovery, while only 6% and 2% discuss process re-design and evaluation. This is consistent with the analysis of the BPM research conducted by van der Alst (2013), who notices an (over)emphasis on process modeling and modeling languages in the BPM literature in general, with the topics of process mining and enactment infrastructures (usually based on cloud software) gain prominence in recent literature.

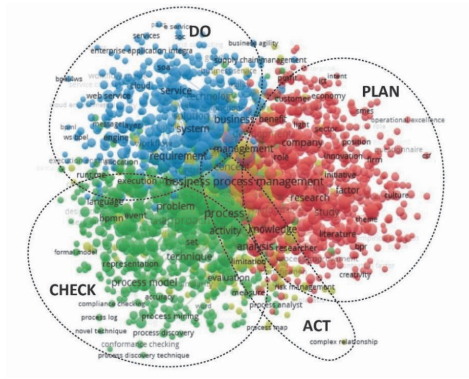
Overall evaluation of the BPM literature mapping, based on the lifecycle stage, seems to *support its connections to the technological developments and their implementation in the earlier stages of the BPM lifecycle, which involve the initial design of the process models and supporting IT infrastructure. This puts into question a supposedly high level of the BPM literature maturity, which could be further supported by a descriptive approach to research in BPM conference papers.* This has been established by Recker and Mendling (2016), who found only a handful of papers using hypotheses testing, with only 2% of papers using surveys for data collection and 4.3% applying the experimental evaluation of data.

Another conceptual framework, the PDCA cycle, can also be used for the science mapping of the BPM field. It is an interactive four-step strategy for solving problems and improving business processes (Arveson, 2020; Moen & Norman, 2009). It is also referred to as the PDSA (Plan, Do, Study, Act) cycle (Moen & Norman, 2009; Sokovic et al., 2010) to emphasize the importance of organizational learning, which makes it a good choice for the analysis of historical literature development and its drivers. Another benefit of the PDCA/PDSA cycle, when used as a conceptual tool for science mapping, is that its steps are typical, clearly demarcated stages, implying that an organization moving through them achieves a higher level of learning and continuous development. This is clearly shown by the conceptual identification of the multiple cycles of implementing the PDCA/PDSA methodology with the Japanese continuous improvement philosophy of 'kaizen', leading to a higher level of organizational quality and performance (Huda & Preston, 1992). In addition, this framework has already been used as one of the dimensions in the classification of the Green BPM literature (Opitz et al., 2014), as well as a classifying framework in the recent review of literature in the field of Smart Cities (Ninčević Pašalić et al., 2021) and in field of simulation modeling (Jadric et al., 2020), which supports its usage in the context of evaluating the core BPM literature corpus.

Figure 7 shows the obtained visualization of the BPM field mapping based on the PDCA/PDSA cycle, resulting in three large and one underdeveloped literature cluster. Cluster 1 and the associated terms (identifying and analyzing problems, determining goals, objectives, and defining targets) are linked to the Plan stage; Cluster 3 (related to BPM implementation) to the Do stage; Cluster 2 (related to measuring of BPM results and their evaluation) to the Check stage; Cluster 4 (related to organizational learning and change/improvement) to the Act stage. Once again, the lack of BPM literature in the Act stage resonates with the findings, which were evaluating the BPM conference papers only. This *suggests a lower level of the BPM field maturity, compared to the arguments of the increasing maturity, based on the growth of the literature items, dealing with BPM topics.*

Figure 7

Mapping of the BPM core literature to the PDCA conceptual framework



Notes. Authors' presentation.

It is very important to compare the obtained results of the BPM science mapping to a similar study of the Smart Cities literature, which is developing on the intersection of IT, information science, urban, and social studies. The PDCA-based evaluation of this literature tends to concentrate on the Plan stage (Ninčević Pašalić et al., 2021), which could serve as an indication that the positioning of literature is linked to the stage of the development, related to the underlying technologies and (business) practices in the sectors, in which the concept is heavily applied. This finding will be further discussed in the following section of this study.

4. Discussion

BPM could be located on a map of IT fields, located at the intersection of Computer and Information science(s), which has been developed by (Iwami et al., 2020), in their study of scientific field(s) co-evolution, based on the bibliometric indicators and time series analysis. Those fields could be described in terms of the Applied Science, IT Systems and Networks section of the IT fields research map created by these authors (Iwami et al., 2020, p. 11), and refer to a potentially wide range of topics, such as Business Intelligence (BI) and Big Data (BD), Cloud Computing (CC), Knowledge Management (KM), Smart Cities (SC), etc.

There are several bibliometric studies of these fields, such as a paper by Liang & Liu (2018), providing a descriptive overview of the BI and BD literature. It includes the identification of four relevant literature clusters, although their historical mapping is not conducted. Another study uses a complex classification of the intelligence literature throughout four periods to describe the thematic evolution of the field (López-Robles et al., 2019). With a number of themes identified, they point to two major theoretical 'motor themes', driving the evolution of the literature. However, their conclusions might not be applicable to IT research, as the analyzed literature consists of all conceptual papers related to intelligence in various fields of study, from marketing to political science, disaster management, etc.

In a similar, cross-disciplinary field of KM, authors (Qiu & Lv, 2014) provide a descriptive commentary on the development of the KM core literature, finding an exponential growth of the literature and a well-established network of journals, researchers, and institutions. Additional evidence on the development of the KM field is provided by Gaviria-Marin et al. (2019), who draw on the conceptual work of Sadiq et al. (2007), to develop a map of KM literature development based on the increasing maturity of the knowledge concept.

The CC field, as a fairly new research topic, develops mainly by means of conference proceedings and seems to be dominated by computer science authors (Heilig & Voß, 2014). The analysis of CC literature keywords confirms the current orientation on technologies and their characteristics, with a shift toward socio-economic issues when future research trends are accounted for (Heilig & Voß, 2014).

Unfortunately, none of these studies provides a historical analysis of the field's literature and the recognition of its development drivers, which could be useful to further explore the drivers of the co-evolving IT fields, which were hinted by Iwami et al. (2020). Therefore, our results can be extremely helpful, not only in understanding the drivers of theorizing in the BPM field of research but also in proposing how the patterns of BPM theory development could help uncover the trends in the 'borderline' Computer/Information Science research fields.

Results obtained by the previous analysis of the epistemological vs. applied nature of BPM literature (Houy et al., 2010; Veit et al., 2017), as well as by science mapping of the BPM literature hint there could be a relationship between the historical development stage of the field and the positioning of its literature, according to the focus on underlying technologies and methodological tools. We propose that such a development pattern could be generalized across multiple multi-disciplinary fields, relation to Computer and Information sciences. If such a proposition is accepted, it will imply that theorizing in these fields is driven by the development of underlying technologies and (business) practices. This would not be a completely new phenomenon, as a comparable trend has been observed in Quality

Management literature (Fundin et al., 2018). However, there have not been any similar studies in the Computer/Information science literature.

Based on the results obtained by applying the PDCA/PDSA cycle to the BPM literature mapping, we believe it is possible to assess the literature maturity and link it to the maturity of underlying technologies. Namely, the notion of maturity is a well-defined term in IT theory and practice, describing the evolution of technology, an organization, or a specific intellectual construct, along the path from the less to a highly developed stage (Reis et al., 2017). Therefore, we also propose that, for the fields and topics on the intersection of Computer and Information sciences, the maturity of the literature/field is driven by the maturity of the underlying technological capabilities and their acceptance in major organizations in industry and other relevant sectors.

The research limitations and the future research agenda related to the testing of the two research propositions are described in the following section.

5. Conclusions and implications

The empirical results indicate that, although there is a certain level of maturity in the BPM literature, after reaching three decades of existence (Houy et al., 2010; van der Aalst, 2013), it is still a developing field, with the research topics currently tend to cluster outside of the Act stage of the PDCA cycle, when used as a classification device. Our results are similar to a previous study, categorizing the majority of specialized literature on 'Green BPM' into the Plan stage of the PDCA cycle (Hernández González et al., 2019) when considering its management activities dimension. In addition, the results we obtained for the BPM field are supported by the conclusions of similar recent bibliographic research (Jadric et al., 2020; Ninčević Pašalić et al., 2021) and the previous trends in other fields (Fundin et al., 2018).

5.1. Theoretical implications

The findings presented in this study carry several significant theoretical contributions for both the field of Business Process Management (BPM) research and the broader landscape of Computer/Information Science research. Based on the initial analysis of BPM literature, we propose that the patterns of the BPM literature development can be generalized to a number of fields on the intersection of Computer and Information science(s). We propose that their theorizing might be driven by the development of underlying technologies and (business) practices, which is applicable to the maturity of those fields, as well.

5.2. Policy and managerial implications

The findings described bring several implications for researchers and practitioners in the BPM field. The proposed linkage between the maturity of BPM literature/field and the maturity of underlying technological capabilities suggests that as technological innovations progress and become accepted within industry and other sectors, the BPM literature also matures in response. Managers and practitioners in BPM can utilize this insight to make informed decisions regarding technology adoption and its impact on their business processes. In addition, this insight has broader implications for researchers in various interdisciplinary domains, offering a framework for understanding the dynamics of theory development in relation to technological advancements.

5.3. Limitations and suggestions for future research

There are some limitations to the current study. Our analysis solely relied on the Scopus database as the source, which means that there is a possibility of relevant studies and instances that might have been excluded. This is a significant limitation as it restricts the scope of the research. Search strategy included only papers with the title, abstract, or keywords with the exact term "business process management". This resulted in some significant papers belonging to the adjacent (sub)fields, such as workflow management, being excluded by a narrower search strategy. However, we believe this is not a significant obstacle to identifying patterns of core BPM studies, which could be generalized as to describe some general trends in the development of specialized, multi-disciplinary IT fields.

The principal limitation is the screening of abstracts only (instead of the entire text) for text mining since the full-text analysis would require currently unavailable resources. In addition, the software used (VOSviewer) does not provide, in its current version, the functionality of filtering the visualizations and linking the results of the text mining to specific papers and authors. The analyzed corpus of documents included only Scopus items in English, with the books and book chapters excluded from the analysis.

These limitations of the bibliometric analysis should be addressed by future research, which should be replicated across a range of specialized, multi-disciplinary research fields on the intersection of Computer and Information science(s). Future work should also expand to other relevant scientific databases as well as to grey literature and comparison of the results should be made.

CRediT authorship contribution statement

I.N.P.: Conceptualization, Formal analysis, Writing – original draft, Writing – review

T.M.: Conceptualization, Methodology, Writing – original draft, Writing – review

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Научно мапирање истраживања менаџмента пословним процесима: обрасци и импликације за упоредна поља информационих технологија

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Кључне ријечи:
менаџмент пословним процесима, мапирање науке, рударење текста

САЖЕТАК

Овај рад мапира истраживање и зрелост научне области Менаџмент пословним процесима (БПМ) користећи постојеће прегледе литературе и библиографске методе да би се формулисали обрасци и импликације које се могу генерализовати и које би се могле предложити за упоредиве, мултидисциплинарне области информационих технологија (ИТ). Примјеном рударења текста на корпус БПМ конференција и радова из часописа, систематски одабраних из Scopus-а, утврђују се генерализовани покретачи еволуције и зрелости БПМ-а, укључујући приједлог импликација за упоредива ИТ поља. Резултати су показали четири кластера литературе, који су прилично добро повезани са концептима животног циклуса БПМ-а и ПДЦА/ПДСА циклуса. Чини се да су БПМ и упоредива истраживачка поља вођени сазријевањем технолошких способности и организационим прихватањем у секторима у којима се у великој мјери примјењују. Ова студија свеобухватно анализира чланке из часописа БПМ и зборнике конференција користећи библиометријску анализу како би пружила нове правце истраживања.