DOI: 10.47899/ijss.1328084

Collaboration Patterns and Topic Trends in Business Process Management Conferences*

İş Süreçleri Yönetimi Konferanslarının İşbirliği Örüntüleri ve Konu Eğilimleri

Muhammet DAMAR[1], Güzin ÖZDAĞOĞLU[2], Onur ÖZVERİ[3]

Abstract

One of the most important scientific activities in which business process management (BPM) research attempts have been presented is the BPM Conferences that have been organized since 2003. These conferences guide the future of the field concerning different aspects of the subject. This study focuses on the accumulated literature that BPM conferences have constituted. In this regard, it aims to investigate the portfolio of BPM conferences to pinpoint the trends that have been followed over the years. A bibliometric dataset of the proceedings between 2005 and 2020 was extracted. The methods of scientometrics and bibliometrics are adopted to reveal the collaborations and clusters regarding citations, co-authorships, co-occurrences of keywords, and topic structures, the trends, and summary statistics. Clusters have emerged around certain authors and these authors are pioneering researchers who direct international studies on BPM and have created many research and development opportunities with their research laboratories. The situation in author relations is also reflected in the statistics of institutions and countries. With the keyword and abstract analyses at different depths and dimensions, inferences were made about the topics discussed at the BPM Conferences. Co-authorship analyses regarding authors and countries revealed the clusters around the authors and their countries such as Van der Aalst (Netherlands), Mendling (Austria), Weske (Germany), Dumas (Estonia), La Rossa (Australia), and Reijers (Netherlands). It has been observed that the keywords that have been recorded intensively in the last five years are concentrated around the topics of industry 4.0, big data, internet of things, blockchain, cloud computing, and artificial intelligence. In general terms, it has been observed that especially the topics such as process mining, semantic structures of processes, business process execution language, and related projects have come to the fore. Findings emphasize that these topics have been affected by the business and technology dynamics of the relevant period.

Keywords: Scientometrics, Bibliometrics, Business Process Management Conferences, Collaborations, Topic Modelling

Öz

İş süreçleri yönetimi (İSY) araştırma girişimlerinin sunulduğu en önemli bilimsel etkinliklerden biri, 2003 yılından bu yana düzenlenen İSY Konferanslarıdır. Bu konferanslar, konunun farklı yönleri ile ilgili olarak alanın geleceğine rehberlik etmektedir. Bu çalışma, İSY konferanslarının oluşturduğu birikimli literatüre odaklanmaktadır ve bu bağlamda, yıllar boyunca takip edilen eğilimleri belirlemek için İSY konferans bildirileri portföyünü incelemeyi amaçlamaktadır. 2005 ile 2020 yılları arasındaki yayınların bibliyometrik veri seti çıkarılmış, alın-

* In this article, the principles of scientific research and publication ethics were followed. / Bu makalede bilimsel araştırma ve yayın etiği ilkelerine uyulmuştur.

[1] Muhammet DAMAR
ORCID: 0000-0002-3985-3073
Assoc. Prof. Dr., Dokuz Eylül University, İzmir, Türkiye. muhammet.damar@deu.edu.tr
Doç. Dr., Dokuz Eylül Üniversitesi, İzmir, Türkiye. muhammet.damar@deu.edu.tr

[2] Güzin ÖZDAĞOĞLU
ORCID: 0000-0003-3055-3055
Prof. Dr., Dokuz Eylül University, Faculty of Business, Business Administration Department, İzmir, Türkiye. guzin.kavrukkoca@deu.edu.tr
Prof. Dr., Dokuz Eylül Üniversitesi, İşletme Fakültesi, İşletme Bölümü, İzmir, Türkiye. guzin.kavrukkoca@deu.edu.tr

[3] Onur ÖZVERİ
ORCID: 0000-0001-9203-917X
Prof. Dr., Dokuz Eylül University, Faculty of Economics and Administrative Sciences, Business Administration Department, İzmir, Türkiye. onur.ozveri@deu.edu.tr
Prof. Dr., Dokuz Eylül Üniversitesi, İktisadi ve İdari Bilimler Fakültesi, İşletme Bölümü, İzmir, Türkiye. onur.ozveri @deu.edu.tr

Geliş Tarihi/*Received* : 15.07.2023
Kabul Tarihi/*Accepted* : 10.10.2023
Çevrimiçi Yayın/*Published* : 18.10.2023

Makale Atıf Önerisi /Citation (APA):
Damar, M., Özdağoğlu, G., Özveri, O. (2023). Collaboration Patterns and Topic Trends in Business Process Management Conferences. *İzmir Sosyal Bilimler Dergisi*, 5(2), 88-107. DOI:10.47899/ijss.1328084

tılar, ortak yazarlıklar, anahtar kelimelerin birlikte oluşumları ve konu yapılarının yanı sıra eğilimler ve özet istatistikleri ile ilgili işbirliklerini ve kümeleri ortaya çıkarmak için bilimetri ve bibliometri yöntemleri benimsenmiştir. Bu alanda belirli yazarlar etrafında kümelenmeler ortaya çıkmıştır. Bu yazarlar, BPM konusunda uluslararası çalışmalara yön veren, araştırma laboratuvarlarıyla pek çok araştırma ve geliştirme olanağı yaratmış öncü araştırmacılardır. Yazar ilişkilerinde var olan durum kurum ve ülke istatistiklerine de yansımaktadır. Farklı derinliklerde ve boyutlarda gerçekleştirilen anahtar kelime ve özet analizleri ile BPM Konferanslarında ele alınan konular hakkında çıkarımlar yapılmıştır. Yazar ve Ülkeler ile ilgili ortak yazarlık analizleri Van der Aalst (Hollanda), Mendling (Avusturya), Weske (Almanya), Dumas (Estonya), La Rossa (Avustralya), and Reijers (Hollanda) gibi araştırmacıların etrafında kümelenmelerin olduğunu ortaya çıkarmıştır. Son beş yılda yoğun bir şekilde kaydedilen anahtar kelimelerin endüstri 4.0, büyük veri, nesnelerin interneti, blok zinciri, bulut bilişim ve yapay zeka konuları etrafında yoğunlaştığı görülmüştür. Genel çerçevesiyle, son yıllarda özellikle, süreç madenciliği , süreçlerin semantik yapıları, süreç uygulaması geliştirme dilleri ve ilgili projeler gibi konuların ön plana çıktığı ve bu konuların ilgili dönemin iş ve teknoloji dinamiklerinden doğrudan etkilendiği gözlenmektedir.

Anahtar Kelimeler: Bilimetri, Bibliometri, İş Süreçleri Yönetimi Konferansları, İşbirlikleri, Konu Modelleme

1. INTRODUCTION

Business processes are considered as an organization's main components since they have a significant effect on products and services, customer experiences, and income (Dumas et al., 2018). A business process is basically a structured, measurable set of activities designed to produce specifically defined outputs for a particular customer or market, with a flow that consists of a start, finish, and order of these activities by time and place, with clearly defined inputs and outputs (Davenport, 1993; Weske, 2003). Another definition by Hammer and Champy (1993) states that a business process is a set of actions that takes one or more types of input and transforms it into a useful output for the customers and it is a mechanism that has a goal and interactions with environmental factors and other processes. Ko (2009) emphasized the term "value-added" in the definition along with the necessity of collaborations to achieve a common business goal. Various researchers have different statements on what a business process is. Burattin (2015) collected definitions created for various intents and viewpoints in this broad field and identified common elements.

Accordingly, business process management is a concept that creates value in terms of the creation, redesign, and management of processes in enterprises as well as ensuring sustainability. The sustainability of enterprises in the future can be ensured along with the efficient and effective management that BPM would provide (Sun, Su, & Yang, 2016; Muellerleile, Ritter, Englisch, Nissen, & Joenssen, 2015).

Different articles in international conference proceedings and books deal with BPM issues (van der Aalst, La Rosa & Santoro, 2016). The high number of citations for term business process management (BPM) seems to prove that BPM is an important field of recent research activities. The BPM issue is the point of research focused on technological or methodological solutions for the problems related to implementation (Jeston & Nelis, 2008).

One of the most important scientific activities, in which BPM research attempts have been presented, is the BPM Conferences that have been organized since 2003. These conferences guide the future of the field concerning different dimensions of the subject in various tracks in relation to BPM. Officially BPM (2021) describes the importance of these scientific events as

> "*The BPM conference series embraces the diversity and richness of the BPM field and serves as a melting pot for experts from a mix of disciplines including Computer Science, Information Systems Engineering, and Management*"

In this regard, the purpose of this study is to present bibliometric research including the basic statistics, network relationships and topic structures of the portfolio of articles in the relevant literature on BPM enhanced with advanced visuals. In this context, related approaches are used along with bibliometrics and scientometrics methodologies. The dataset consists of the papers presented in these conferences and published in the proceedings between the years 2005-2020. Scopus was preferred since the data obtained from Scopus is better organized and consistent for proceedings. The dimensions of the dataset comprise the title, year, authors, keywords, citation counts, references, and abstracts. In the scope of scientometrics, basic statistics, text, and network analytics are adopted to highlight the trends and relationships. In this regard, co-citation, co-authorship, and co-occurrence analyses are conducted to reveal collaborations and relationships. Furthermore, topic structures are examined via Latent Dirichlet Allocation, a commonly used algorithm for topic modeling in text analytics.

This study investigates the literature in BPM Conferences from different perspectives, e.g. authors, topics, countries, to pinpoint the trends that have been followed over the years. Since business processes and BPM are directly affected by the way organizations do business, the topic structures of the research and the distribution of the topics by years reflect the dynamics of the relevant period, as well as the technological and methodological developments in

process design, modeling, and analysis. Industry 4.0 and related issues, which have left their mark in recent years, both increase the importance of BPM and provide data and analysis infrastructures that will facilitate initiatives in this direction. Accordingly, the technologies based on Cyber-Physical Systems (CPS), Internet of Things (IoT), Digital Factory, etc. help to improve processes based on effective process measurement, simulation, and application of predictive models (Steiner, 2019). With this transformation, BPM research has come to an even more important point in the literature as highlighted in the findings. From this perspective, this study presents findings that guide researchers in this field by drawing the big picture of network and topic patterns at BPM Conferences where leading and responsive BPM research is presented and discussed.

The paper's organization is as follows: the second section describes the theoretical framework and the position of the study in the literature; the third section describes the methodology of bibliometrics and scientometrics; the fourth section presents the findings and discussions. The fifth section concludes the paper.

2. THEORETICAL FRAMEWORK

Business Process Management (BPM) is a growing field of interest since the 1990s. It can be stated that the first seeds of BPM were taken with Fordism and then started to develop with the statistical approaches developed about quality control. In the assembly line, Henry Ford, undertook low-cost mass production by applying Taylor's principles and the moving assembly line and achieved great success. In the 1920s, Taylor's motion and time study were followed by Walter A. Shewhart's statistical approaches in the 1930s. Then the methods were applied regarding statistical control under the leadership of W. Edwards Deming in the 1940s. The quality movements started in Japan in the 1960s and continued with the total quality management practices surrounding the whole world in the 1980s (Johanson & Carr,1995).

With the widespread use of machines in the first industrial revolution, the mode of production changed. In the second industrial revolution, mass production became possible with the use of assembly lines. In the third industrial revolution, the digitalization age has started with the help of computers and automation and the production processes have begun to be conducted via automation. The fourth industrial revolution formally started in 2011 when it was declared in Hannover Fair as Industry 4.0. With Industry 4.0, cyber-physical system applications have started in industrial production, making smart factories possible. The innovations brought by Industry 4.0 and future technological developments have brought short and long-term sustainability perturbations to the agenda of enterprises (Ghobakhloo, 2018).

Process management, as well as developing and improving business processes, integrates technologies and innovations for these developments into processes. With the help of this integration, they ensure a competitive advantage by keeping the process performances at the highest level (Wamba & Mishra, 2017). Due to reasons such as the growth of the size of the organizations, the increase in global competition and the developments in web-based business applications such as e-commerce and e-business, process management should be supported with software technologies. To be able to serve the developing and accelerating markets, companies can reduce their costs, increase efficiency, and reduce the processing time by using the relevant computer and software technologies in process management applications (Rahimi, Møller C, & Hvam, 2016).

This story has still been handled in the recent studies to align the new developments and the revolutions with the improvements in the BPM research. Nowadays, the fourth industrial revolution is a hot topic in any field as if it is in BPM research because the business practices and the related technologies have a crucial impact on BPM.

BPM proposes various methodologies and techniques for organizations in accordance with the above-mentioned purposes to model their businesses and monitor the performance levels. The improvements in both social and technological issues have a critical impact on this field. In this respect, various studies have been conducted for BPM research such as workflows, data and information flows, resources and roles, performance monitoring, and techniques and approaches to shed light on relevant business practices.

It is possible to come across many review studies or literature analyses based on bibliometric data in the field of BPM. For example, Turra, Juliani, and Salla (2018) investigated the articles handling BPM research in Brazilian journals. Erdogan and Tarhan (2018) applied a systematic mapping approach for publications about process mining studies in healthcare to reveal the concept map of the related area. Although health data and associated techniques are challenging, they have concluded that these practices follow an increasing trend. Chaves, Ensslin, Andrade de Lima, and Ensslin (2017) conducted a bibliometric analysis on the publications related to organizational performance evaluation and process management to reveal the article, journal, and author statistics as well as keyword patterns.

Wamba and Mishra (2017) evaluated articles from 2006 to 2016 that dealt with the integration of big data and BPM in order to get a better knowledge of how BPM, business process reengineering (BPR), and business process innovation (BPI) can be integrated with bigdata.

Veit, Lacerda, Camargo, Kipper, and Dresch (2017) put forth the bibliometrics of the Business Process Management Journal and recommended a structure for BPM research knowledge creation. In their analysis, they identified eight linked categories to reflect the range of research concerns and functional domains in BPM articles, i.e. Marketing and customer relationship management, performance measurement, knowledge management and innovation, complete quality control, auditing, electronic commerce, human resources, and supply chain management.

Ensslin, Ensslin, Dutra, Nunes, and Reis (2017) presented the findings of the literature analysis in business process governance and stated the bibliometric parameters regarding the performance evaluation. Houy, Fettke, and Loos (2010) investigated the scientometrics of empirical research in BPM to reveal the subject trends and applied approaches to highlight the current state and opportunities for future works. The themes of business process management, six sigma, and the application of business processes in organizations have been placed at the forefront of related studies by researchers.

BPM has gained traction in the literature, particularly in light of current challenges like Industry 4.0, Cyber-Physical Systems (CPS), Digital Twin, and the Internet of Things (IoT). The reason for this is thought that it is a field developed via the integration and tight interaction of many distinct disciplines such as Computer Science, Information Systems Engineering, and Management. As previously noted, numerous scholars in the area have conducted systematic reviews or bibliometric studies on a variety of topics linked to BPM and assessed various aspects of the field. Accordingly, the BPM Conferences are one of the field's most significant scientific gatherings, where the field's most knowledgeable and expert individuals hold groundbreaking conversations and analyze the field's present and future.

In this regard, this research focuses on the body of knowledge created by BPM Conferences.This study is not the first attempt at analyzing the research patterns of the BPM Conferences. At the tenth instance of the BPM Conference in 2012, van der Aalst (2012) provided an extensive analysis of research use cases as evident in BPM Conference papers between 2003 and 2011. Recker and Mendling (2016) extended van der Aalst's analysis by widening the scope of the review structure to scientific, methodological, research and impact components. However, thus far, the reviews of BPM Conferences have only shown limited results in terms of dimension richness.

Different from the previous papers regarding BPM Conference proceedings, in this study, the analyses are conducted through and integrated approach over the related bibliometric data. In addition to technological developments, the widespread effects of the results of these studies, which examine the topic from many different perspectives, are revealed by the publications they present to the literature. This study applies the methodologies of bibliometrics and scientometrics through bibliometric data retrieved from Scopus. The results are presented with summary statistics, tables, and graphs, as well as time and cluster-based network visualizations. Thus, both the leading studies and the academic social network formed by the authors in the conferences are discussed via analytical findings. The study provides a holistic view of the academic accumulation in the relevant field. It is complementary to the previous studies that were conducted with different methodologies in the past years. From the perspective of research in bibliometrics and scientometrics, it would contribute to the previous studies with its approach to extract the details about the topics and topic trends of the conference papers. This framework including several analyses can also be adopted by well-established conferences to monitor the trends and collaborations.

3. METHODOLOGY

3.1 Scope of the Research

The study focuses on investigating the characteristics of the literature accumulated in "the International Conference on Business Process Management" with the help of scientometrics. Therefore, examines the related proceedings that were published in several sources since 2005. Through the analyses and visualizations conducted with the bibliometric dataset, this study aims at revealing the followings:

- The number of proceedings over the years,
- Academics with high ranking regarding the number of publications and number of citations,
- Demographics related to the countries, institutions, and research areas,
- Network representations that were built regarding co-authorships, or other bibliographic relationships,
- Keyword changes over time, topic structure and trends in the abstracts.

3.2 Data Source and Dataset Extraction

This study analyses a bibliometric dataset consisting of BPM Conference proceedings that can be found in the Scopus database between 2005 and 2020. The date of collection of the relevant data from Scopus is 25.08.2021. Two consecutive queries were executed to find the data on the target.

The first query finds all proceedings presented in BPM Conferences and published in several resources through the following statement:

- confname('international and conference and on and business and process and management') or confname('international and conference and on and business and process and management') or confname ('business and process and management and 2005').

This query returned with 1353 papers. However, some of these papers were published as conference reviews or editorials rather than a conference paper. Then, the document type was limited to "conference paper' in the second query as follows:

- confname('international and conference and on and business and process and management') or confname('international and conference and on and business and process and management') or confname ('business and process and management and 2005') AND (LIMIT-TO (DOCTYPE, "cp") OR LIMIT-TO (DOCTYPE, "cr"))

The second query returned 1550 papers subjected to the analyses.

3.3 The Use of Scientometrics and Bibliometrics

Investigating the demographic and content patterns with various characteristics has become possible with the help of methodologies such as bibliometrics and scientometrics to reveal the academic performance and the social networks of a research area. In this context, the scientific dynamics are investigated and visualized over multiple dimensions simultaneously. These methodologies analyze bibliometric datasets to perform co-occurrence, co-authorship, and co-citation analyses and visualize the patterns through network visualizations to obtain the research topics, to reveal the collaborations, and to understand the patterns of citations (Boyack, 2004). Furthermore, they propose metrics to compare or evaluate the performance of journals, authors, or other parties (Patience, Blais, & Bertrand, 2017). They have many distinct characteristics, as indicated in (Garfield, 2009), as well as many common ones.

In the scope of scientometrics and bibliometrics, several summary tables were obtained in addition to H-index of the conferences. Collaborations and research patterns were visualized via networks constructed based on the analyses regarding co-authorships, citations, and co-occurrences of keywords. Spreadsheets, VOSviewer (Van Eck & Waltman, 2013; VOSviewer, 2018), and Bibliometrix (Aria & Cuccurullo, 2017) platforms were used to perform the related analyses.

3.4 Topic Modeling

The topic structures were examined via Latent Dirichlet Allocation (LDA) (Blei, Andrew, & Jordan, 2003; Blei & Lafferty, 2009), a commonly used algorithm for topic modeling in text analytics. A topic is a distribution over a set of words, and topic modeling techniques evaluate each document as a combination of topics.

In this sense, topics constitute the semantic structure in the text. This structure was used to highlight the basic concepts in the abstracts as well as the topic categories by considering the common topic structures in the dataset. The LDA was executed to estimate clear concepts in RapidMiner 9.10 where the dataset was also cleansed. The time dimension is also used to aggregate the topic estimations by years via a pivot table to visualize the topic trends.

4. RESULTS AND DISCUSSION

4.1 Author, Countries, and Institutions

BPM papers in the dataset (f:1652) can be categorized into three titles that are conference papers (f:1550), editorials (f:101), conference reviews (f:57), and articles (f:1). All findings were obtained from the conference papers including 1550 papers. These papers have been cited 18369 times so far, and these citations resulted in an H-index of 58, indicating that the conference has had an important impact on the related literature. Table 1 lists the conferences decomposed into the year, locations, the number of papers and citations. The papers in the dataset were produced by 2592 authors where 150 of the authors have contributed with at least five papers, and 51 of them contributed with at least 10 papers.

When looking at the venues of BPM Conferences since 2005, it can be observed that they took place in a variety of countries, including Australia, Spain, Brazil, China, the United States, and Germany. This may be seen as an indication that the conference had a worldwide influence on BPM and drew the attention of the field's greatest academics, as well as researchers from all around the world. Furthermore, the presence of leading researchers in the field might explain why these conferences were held three times in Austria and twice in Germany, Spain, and Australia.

This intuitive understanding corresponds to the conclusions of the author's analysis.

Table 1. Paper and citation distributions in BPM conferences

Year	Conferences Name	Location	Papers	Citations
2020	BPM 2020	Seville, Spain	83	76
2019	BPM 2019	Vienna, Austria	186	546
2018	BPM 2018	Sydney, Australia	126	580
2017	BPM 2017	Barcelona, Spain	173	698
2016	BPM 2016	Rio de Janeiro, Brazil	70	839
2015	BPM 2015	Innsbruck, Austria	168	1127
2014	BPM 2014	Eindhoven, The Netherlands (relocated from Israel)	129	1041
2013	BPM 2013	Beijing, China	57	1014
2012	BPM 2012	Tallinn, Estonia	130	2235
2011	BPM 2011	Clermont-Ferrand, France	81	1182
2010	BPM 2010	Hoboken (NJ), USA	25	553
2009	BPM 2009	Ulm, Germany	100	1955
2008	BPM 2008	Milan, Italy	81	1847
2007	BPM 2007	Brisbane, Australia	37	2345
2006	BPM 2006	Vienna, Austria	50	1304
2005	BPM 2005	Nancy, France	53	1027

The authors contributing to the BPM Conferences with higher number of papers are as follows: Van Der Aalst, W.M.P. (f:76, c:2957), Mendling, J. (f:56, c:2121), Weske, M. (f:52, c:1211), Dumas, M. (f:44, c:2260), Reijers, H.A. (f:38, c:834), Reichert, M. (f:29, c: 481), Fahland, D. (f:25, c:1458), Maggi, F.M. (f:24, c:702), La Rosa, M. (f:23, c:967), Carmona, J. (f:23, c:998), Weidlich, M. (f:20, c:1132), Montali M. (f:20, c:1070), Garcia-Banuelos L. (f:20, c:805), Van Dongen B.F. (f:19, c:963), Weber I. (f:19, c:610), respectively. Van der Aalst, W.M.P., Mendling, J., Dumas, M., Weske, M., Reijers, H.A., Reichert, M., La Rossa, M. are the leading authors in both general and the related clusters (Figure 1).

When the time dimension is considered, these leading authors have been on the scene for several years, they have studied with new researchers for new developments in the field. Collaborations among the authors can also be a result of the co-authorship analysis. Figure 1 highlights the collaborations in many dimensions, such as author clusters and their collaborations by years (pictures at the top with co-authorship network analysis), heat maps to emphasize the author groups and leading authors in each group according to years (pictures at the top with co-authorship overlay analysis).

Co-authorship occurs when two or more authors publish a publication together (Melin & Persson, 1996). If two or more authors are listed as co-authors for the same publication, it is highly likely that they collaborated in some way (Ponomariov & Boardman, 2016). As can be seen in the co-authorship network analysis in Figure 1, it can be seen that some researchers work together more intensively. In the analysis performed according to minimum six documents in the co-authorship network analysis, 15 different clusters were reached. It is seen that clusters occur mostly around researchers with high productivity. E.g; Van Der Aalst, W.M.P. (cluster 1 with 16 members), Fleischman, A. and Kurz, M. (cluster 2 with 14 members), Dumas, M. (cluster 3 with 13 members), Reijers, H.A. (cluster 4 with 8 members), Mendling, J. (cluster 5 with 8 members), Weske, M. (cluster 6 with 7 members), Fahland, D. (cluster 9 with 6 members), Reichert, M. (cluster) 14 with 4 members). The significance of the existence of pioneer scholars in the area, as well as the weight of the clusters established around them, is a striking finding. Another element of the growing trend is that specialists from many different disciplines (Computer Science, Information Systems Engineering, and Management).join together to build research laboratories (Mendling Lab, 2021; PAIS Lab, 2021; Dumas Lab, 2021) and conduct their research in these environments due to the nature of the field. The papers produced in this way can be categorized with respect to the Scopus database Subject Area category as computer science (f: 1550), mathematics (f: 1311), business, management, and accounting (f:591), decision sciences (f:591), engineering (f:591). can also be seen when the document distribution is evaluated.

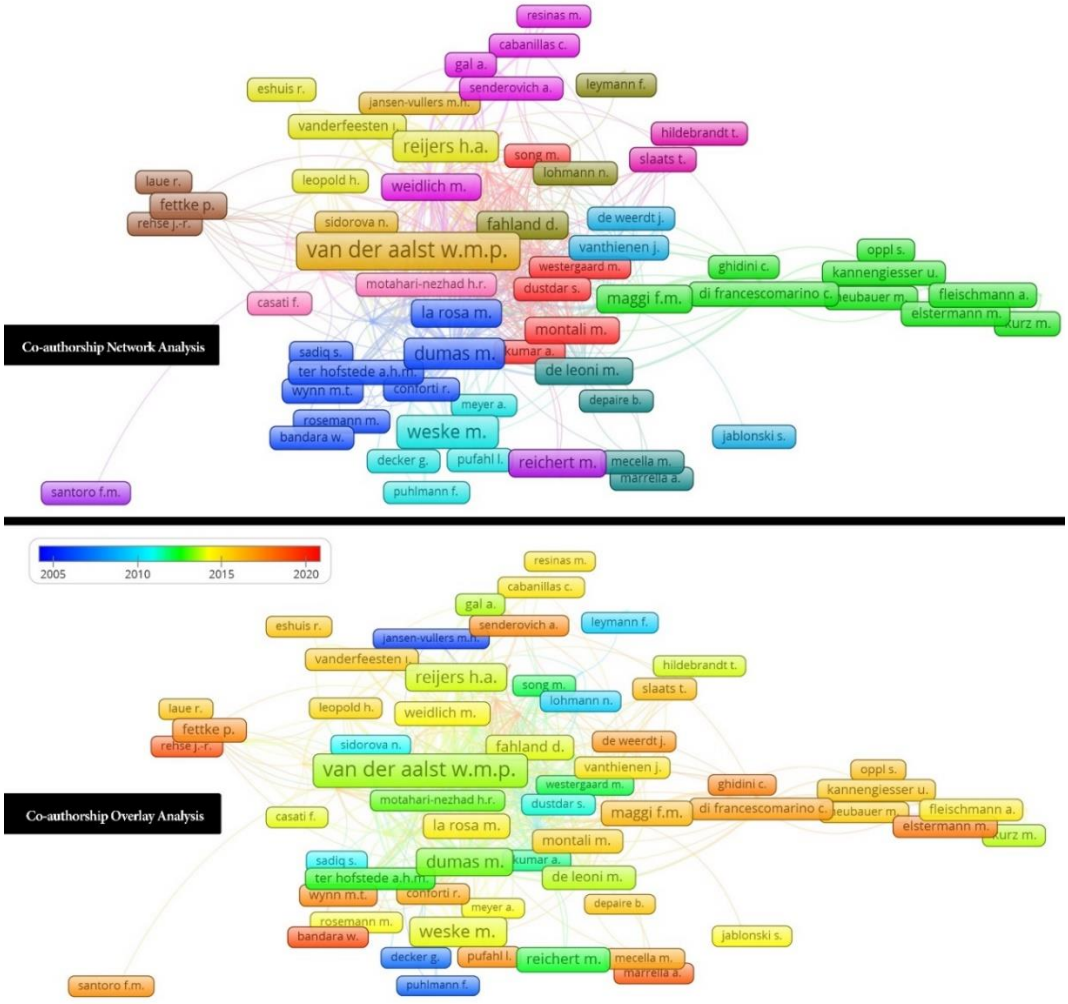


Figure 1. Co-authorship Network and Overlay Visualization (Authors with min 6 papers)

Researchers who presented at least six studies were included in the analysis that formed the foundation of the visual in order to prevent this issue and to focus better on researchers who are important in the field and to focus the reader's attention on researchers with high efficiency in the field. Otherwise, even independent nodes can appear in the network for the papers where the authors conduct individual research in the field.

The countries and the regions can be effective for the constitution of the author clusters. To extract this information, country statistics were given in terms of paper counts and citations in addition to the co-authorship network based on countries (Figure 2). In the given time range, 70 countries were represented in the conferences where 36 of them contributed with a minimum five and 27 of them with minimum 10 studies. The corresponding countries, citation distributions, most productive authors, and institutes in BPM conferences (Top 15) are presented in Table 2.

The top three collaborating countries are also depicted in this table. In this table, it is important for researchers to list competent researchers and institutions in the field of Business Process Management, especially in their post-doctoral research. The top five countries contributing the BPM Conferences are Germany (f:505; c:6350), Netherlands (f:221, c:6297), Austria (f:166, c:2643), Australia (f:158, c: 3545), and Italy (f:126, c:2192), respectively.

According to Table 2, Germany, Austria, Spain, Australia, Netherlands come to the fore among the countries regarding collaborations in the field of BPM. Figure 2 highlights these findings by visualizing country networks regarding their collaboration levels. Another striking finding is that, in some cases, the most prolific researchers are not from the listed country, i.e. Weber, I.

Figure 2 exhibits the clusters as well as the connections. In this sense, South Korea, Chile, India, New Zealand, United States are in the same cluster, while Saudi Arabia, Luxemburg, United Kingdom, Argentina, Japan are in a different cluster; Germany, Austria, and Liechtenstein have grouped in yet another cluster. Furthermore, the collaborations among the countries can also be monitored by adding the time layer or dimension to see the changes by

years, overlay visualization in Figure 2 reflects this situation. The colors changes from blue to red, and the colors close to red such as orange and somehow yellow tones emphasize the recency of the collaborations.

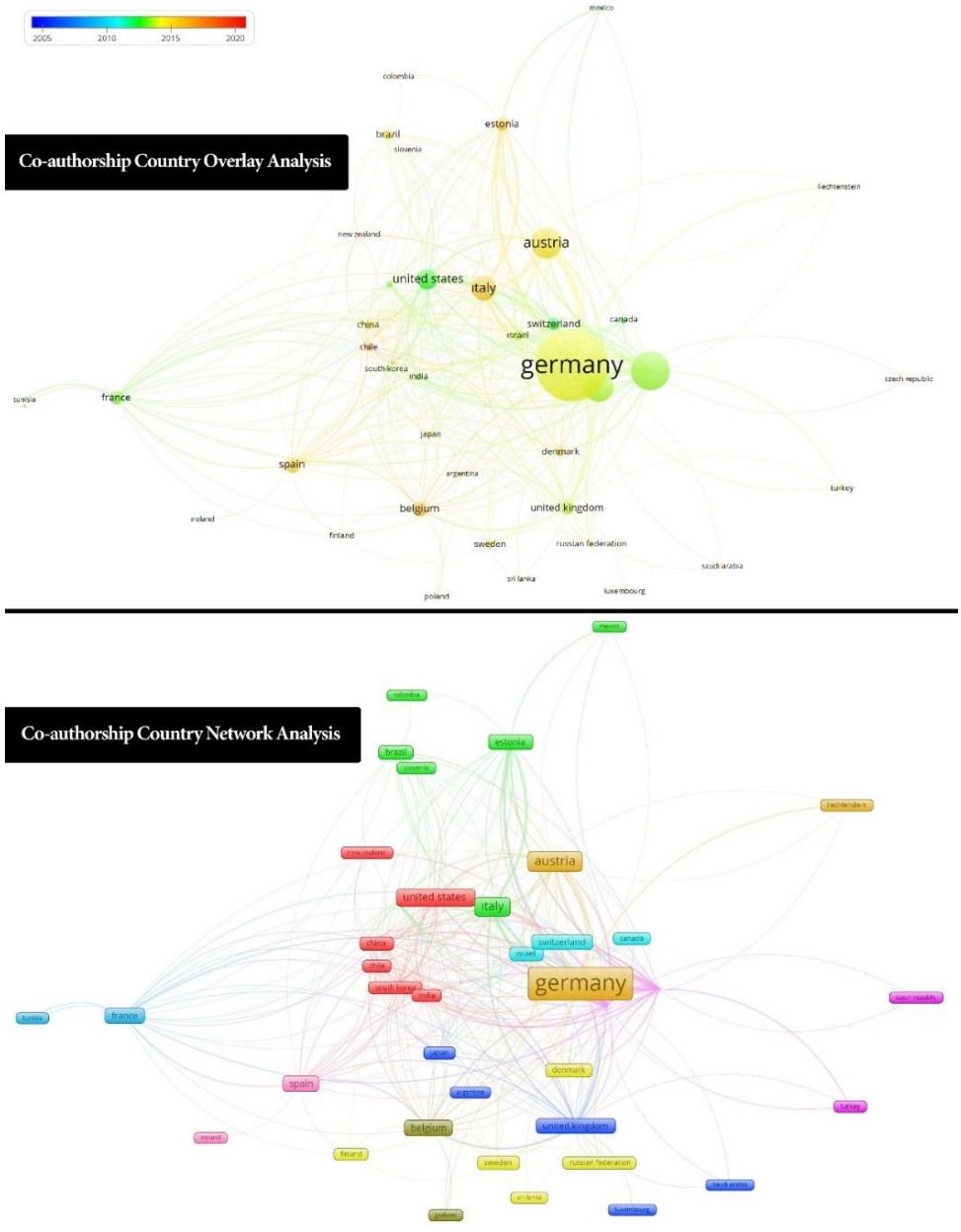


Figure 2. Countries and collaborations among the countries (clusters, years)

Turkey is in 25th place in the ranking with 13 studies and 85 citations. Researchers who contributed to BPM conferences with two or more studies are as follows: Demirors, O. (f:8), Ertugrul, A.M. (f:2), Turetken, O. (f:2). The most influential institution in BPM conferences is Middle East Technical University (METU) having eight studies. METU is followed by ASELSAN A.Ş. These instiutions have collaborated with the Technische Universiteit Eindhoven (f:3). The countries with which Turkey has the most intensive collaboration in the participation of the BPM conferences are Netherlands (f:4); Germany (f:1); Astraia (f:1), United Kingdom (f:1) (Figure 2). Participation by year indicates that the highest participation was achieved with four studies in 2014, followed by two studies in 2016 and 2005, and one study each in 2019, 2018, 2017, 2015 and 2013. When the relationship and future of studies in the field of BPM are evaluated, the picture does not look very good for Turkey. It can also be stated that the number of citations received and the participation in the congress over the years are quite low. Among the researches in Turkey, Prof. Dr. Onur Demirors' contribution to the BPM conference draws attention with eight studies.

Table 2. Countries' paper, citation distributions and most productive authors and instutions in BPM Conferences (Top 15)

Rank	Country	Papers	Citations	Most Productive Authors (Top 3)	The Most Productive Instutions (Top 2)	Best Partner (Top 3)
1	Germany	505	6350	Weske, M. (52); Reichert, M. (29); Mendling, J. (24)	Hasso-Plattner-Institut für Softwaresystemtechnik GmbH (69);Universität Potsdam (62)	Austria (48); Netherlands (41); Australia (27)
2	Netherlands	221	6297	Van Der Aalst, W.M.P. (47); Reijers, H.A. (38); Fahland, D. (23)	Technische Universiteit Eindhoven (172); Vrije Universiteit Amsterdam (15)	Germany (41); Australia (23); Austria (20)
3	Austria	166	2643	Mendling, J. (51); Rinderle-Ma, S. (13); Di Ciccio, C. (13)	Wirtschaftsuniversität Wien (60); Johannes Kepler University Linz (34)	Germany (48); Netherlands (20); Australia (12)
4	Australia	158	3545	Dumas, M. (29); La Rosa, M. (23); Weber, I. (14)	Queensland University of Technology (76); UNSW Sydney (20)	Germany (27); Netherlands (23); Estonia (22)
5	Italy	126	2192	Montali, M. (20); Maggi, F.M. (16); Di Francescomarino, C. (15)	Free University of Bozen-Bolzano (23); Sapienza Università di Roma (18)	Estonia (19); Netherlands (15); Australia (13)
6	United States	96	2179	Kumar, A. (8); Hull, R. (7); Motahari-Nezhad, H.R. (7); Su, J. (5)	IBM Thomas J. Watson Research Center (24), Pennsylvania State University (10)	Germany (12); Australia (10); Austria (8)
7	Spain	69	1289	Carmona, J. (23); Resinas, M. (6); Ruiz-Cortés, A. (6); Munoz-Gama, J. (5); Gómez-López, M.T. (5)	Universitat Politècnica de Catalunya (26); Universidad de Sevilla (16)	France (7); Netherlands (6); Belgium (6); Chile (5); United Kingdom (5); Italy (5)
8	Belgium	64	1047	Vanthienen, J. (16); De Weerdt, J. (9); Van Looy, A. (8)	KU Leuven (30); Universiteit Gent (18)	United Kingdom (9); Netherlands (6); Spain (6); Austria (4); Germany (4)
9	United Kingdom	58	1063	Vanthienen, J. (7); Baesens, B.(4); Norton, B. (4); De Smedt, J. (3); Domingue, J. (3); Gilani, W. (3); Mouratidis, H. (3); vanden Broucke, S.K.L.M. (3)	The Open University (8); KU Leuven (8); The University of Manchester (4); City, University of London (4); University of Southampton (4)	Germany (10); Belgium (9); Italy (6)
10	Estonia	56	2026	Dumas, M. (36); Maggi, F.M. (21); García-Bañuelos, L. (19)	Tartu Ülikool (55); Queensland University of Technology (14)	Australia (22); Italy (19); Netherlands (9)
11	France	55	1081	Godart, C.(5); Tata, S. (5); Carmona, J. (5); Gaaloul, W. (4); Barkaoui, K. (3); Cortes-Cornax, M. (3); Perrin, O. (3)	Centre National de la Recherche Scientifique (10); Laboratoire Lorrain de Recherche en Informatique et ses Applications (8)	Spain (7); Netherlands (5); Australia (5); Germany (4); Tunisia (4)
12	Switzerland	49	874	Völzer, H. (9); Pautasso, C. (7); Koehler, J. (6); Ivanchikj, A. (6)	IBM Research - Zurich (17); Università della Svizzera italiana (6)	Germany (13); Austria (3); Italy (3); Canada (2); Netherlands (2); United Kingdom (2)
13	Brazil	38	210	Santoro, F.M. (9); Baião, F.A. (6); Thom, L.H. (5)	Uni. Fed. do Estado do Rio de Janeiro (13); Uni. Fed. do Rio Grande do Sul (6)	Germany (4); Austria (4); United States (3); Italy (2); Netherlands (2); Portugal (2)
14	Israel	35	1219	Gal, A.(13); Weidlich, M.(11); Soffer,P.(11); Mendling, J. (8); Senderovich, A. (8)	Technion - Israel Institute of Technology (18); University of Haifa (14)	Austria (9); Germany (9); Netherlands (6); United States (4)
15	Denmark	35	368	Slaats, T. (14); Burattin, A. (11); Debois, S. (7); Hildebrandt, T. (7)	IT-Universitetet i København (16); Danmarks Tekniske Universitet (13)	Netherlands (9); Austria (7); Spain (3)

The most productive institutions in terms of the research they presented to BPM conferences and the top 20 most pioneering researchers in these institutions are shown in Table 3. In addition to the country dynamics of the BPM Conferences, distribution of the institutions ranked to top five are Technische Universiteit Eindhoven (f:172), Queensland University of Technology (f:76), Hasso-Plattner-Institut für Softwaresystemtechnik GmbH (f: 69), Universität Potsdam (f:62), Wirtschaftsuniversitat Wien (f:60), respectively.

Table 3. The Most productive 20 Instutions and BPM Pioneer

Rank	Instutions	Papers	Country	Authors
1	Technische Universiteit Eindhoven	172	Netherlands	Van Der Aalst, W.M.P. (47)
2	Queensland University of Technology	76	Australia	Dumas, M. (22) & La Rosa, M. (19)
3	Hasso-Plattner-Institut für Softwaresystemtechnik GmbH	69	Germany	Weske, M. (52)
4	Universität Potsdam	62	Germany	Weske, M. (48)
5	Wirtschaftsuniversität Wien	60	Austria	Mendling, J. (48)
6	Tartu Ülikoo	55	Estonia	Dumas, M. (36)
7	Johannes Kepler University Linz	34	Austria	Stary, C. (10)
8	Universität Ulm	31	Germany	Reichert, M. (27)
9	KU Leuven	30	Belgium	Vanthienen, J. (16)
10	Karlsruhe Institute of Technology	30	Germany	Elstermann, M. (13)
11	Humboldt-Universität zu Berlin	27	Germany	Mendling, J. (14) & Weidlich, M. (14)
12	Universität Rostock	27	Germany	Lohmann, N. (8)
13	Universitat Politècnica de Catalunya	26	Spain	Carmona, J. (23)
14	IBM Thomas J. Watson Research Center	25	United States	Hull, R. (7)
15	Universität Bayreuth	25	Germany	Jablonski, S. (9)
16	Friedrich-Alexander-Universität Erlangen-Nürnberg	23	Germany	Kurz, M. (11)
17	Free University of Bozen-Bolzano	23	Italy	Montali, M. (18)
18	Metasonic AG	22	Germany	Fleischmann, A. (8)
19	Technische Universität Darmstadt	21	Germany	Mühlhäuser, M. (13)
20	Technische Universität Wien	20	Austria	Dustdar, S. (10)

Table 4. Most Cited 10 References

Rank	Author	Year	Citations	Title
1	Van Der Aalst, W.M.P.	2011	40	Process mining: discovery, conformance, and enhancement of business processes
2	Rozinat, A., Van Der Aalst, W.M.P.	2008	32	Conformance checking of processes based on monitoring real behavior
3	Van Der Aalst, W.M.P.,…, Barros, A.P.	2003	28	Workflow patterns
4	Van Der Aalst, W.M.P.	2016	28	Process Mining Data Science in Action
5	Van Der Aalst, W.M.P.,…, Maruster, L.	2004	27	Workflow mining: discovering process models from event logs
6	Nigam, A., Caswell, N.S.	2003	24	Business artifacts: an approach to operational specification
7	Fleischmann, A.,…, Borger, E.	2012	21	Subject-oriented business process management
8	Dumas, M.,…, Reijers, H.A.	2013	21	Fundamentals of business process management
9	Van Der Aalst, W.M.P., Ter Hofstede, A.H.M.	2005	15	Yawl: yet another workflow language
10	Rojas, E., …, Capurro, D.		14	Process mining in healthcare: A literature review

One of the interesting findings of the study is that researchers write their institutions differently in the conference data obtained for bibliometric analyzes. In fact, this situation creates a disadvantage for the institutions where researchers work in ranking systems such as THE, QS, ARWU, or URAP (Damar, Özdağoğlu, & Özveri,

2020). For example, for Technische Universiteit Eindhoven; "department of mathematics and computer science, eindhoven university of technology, eindhoven, netherlands", "eindhoven university of technology, eindhoven, netherlands", "eindhoven university of technology, netherlands", "department of mathematics and computer science, eindhoven university of technology , eindhoven, netherlands". If Vienna is for the university of economics and business; Although there is a situation similar to eindhoven university of technology as "vienna university of economics and business, vienna, austria". It is another finding that should be highlighted that institutions operating in the Netherlands and Germany are in the first place in the distribution of institutions.

4.2 Citations

The research impact of the conferences in the literature can be measured through the citations as well as the number of papers. In this regard, Table 4 highlights the most cited studies in the Scopus.

The data in Table 4, the co-citation analysis of the 1550 conference papers obtained, and the studies utilized as common references were analyzed. Although the reference types are used in the same document, it has been seen that they have different display styles, and the citation values for which approximately common references are given have been reached through the cited reference data obtained from the program. In fact, it can be stated that this is an issur that would create limitations for future researchers and studies. In the range of 2005-2020, 27096 references and 14914 distinct sources were used by 1550 papers, and these papers cited the papers of 23717 authors. The conference papers consist of five co-citations that were used five times.

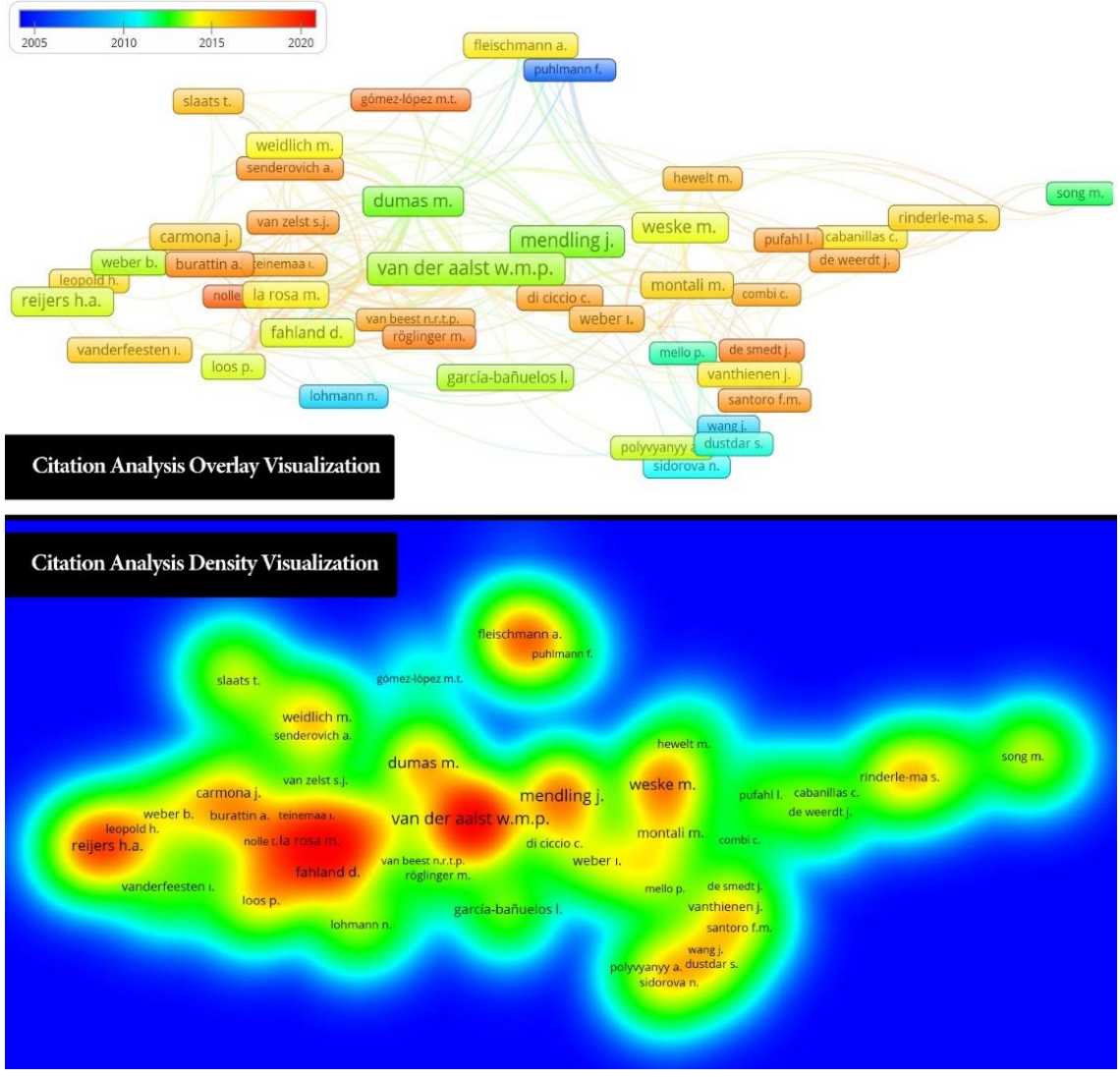


Figure 3. Citation network-overlay visualization and the related densities

Table 5. The most-cited 20 Proceedings in Scopus database.

Rank	Title	Sources	Year	Author	Citations
1	Process mining manifesto	Lecture Notes in Business Information Processing, 99 LNBIP (PART 1), pp. 169-194	2012	Van Der Aalst, W., Adriansyah, A., De Medeiros, A.K.A., (...), Westergaard, M., Wynn, M.	645
2	Fuzzy mining - Adaptive process simplification based on multi-perspective metrics	LNCS (including subseries LNAILNB)4714 LNCS, pp. 328-343	2007	Günther, C.W., Van Der Aalst, W.M.P.	543
3	Graph matching algorithms for business process model similarity search	LNCS 5701 LNCS, pp. 48-63	2009	Dijkman, R., Dumas, M., García-Bañuelos, L.	308
4	Modeling control objectives for business process compliance	LNCS 4714 LNCS, pp. 149-164	2007	Sadiq, S., Governatori, G., Namiri, K.	288
5	Untrusted business process monitoring and execution using blockchain	LNCS) 9850 LNCS, pp. 329-347	2016	Weber I.,Xu X., Riveret R.,Governatori G.,Ponomarev A.,Mendling J.	255
6	What makes process models understandable?	LNCS 4714 LNCS, pp. 48-63	2007	Mendling, J., Reijers, H.A., Cardoso, J.	206
7	On the suitability of BPMN for business process modeling	LNCS 4102 LNCS, pp. 161-176	2006	Wohed, P., Van Der Aalst, W.M.P., Dumas, M., Ter Hofstede, A.H.M., Russell, N.	202
8	Towards a formal analysis of artifact-centric business process models	LNCS 4714 LNCS, pp. 288-304	2007	Bhattacharya, K., Gerede, C., Hull, R., Liu, R., Su, J.	202
9	Trace clustering in process mining	Lecture Notes in Business Information Processing 17 LNBIP, pp. 109-120	2009	Song, M., Günther, C.W., Van Der Aalst, W.M.P.	201
10	Efficient compliance checking using BPMN-Q and temporal logic	LNCS 5240 LNCS, pp. 326-341	2008	Awad, A., Decker, G., Weske, M.	187
11	Service interaction patterns	Lecture Notes in Computer Science 3649, pp. 302-318	2005	Barros, A., Dumas, M., Ter Hofstede, A.H.M.	185
12	Discovering block-structured process models from event logs containing infrequent behavior	Lecture Notes in Business Information Processing 171 171 LNBIP, pp. 66-78	2014	Leemans, S.J.J., Fahland, D., van der Aalst, W.M.P.	180
13	Decision mining in ProM	LNCS 4102 LNCS, pp. 420-425	2006	Rozinat, A., Van Der Aalst, W.M.P.	177
14	Supporting flexible processes through recommendations based on history	LNCS 5240 LNCS, pp. 51-66	2008	Schonenberg, H., Weber, B., Van Dongen, B., Van Der Aalst, W.	137
15	Monitoring business constraints with linear temporal logic: An approach based on colored automata	LNCS 6896 LNCS, pp. 132-147	2011	Maggi, F.M., Montali, M., Westergaard, M., Van Der Aalst, W.M.P.	134
16	Process mining based on regions of languages	LNCS 4714 LNCS, pp. 375-383	2007	Bergenthum, R., Desel, J., Lorenz, R., Mauser, S.	131
17	Process equivalence: Comparing two process models based on observed behavior	LNCS 4102 LNCS, pp. 129-144	2006	Van Der Aalst, W.M.P., De Alves Medeiros, A.K., Weijters, A.J.M.M.	129
18	Introducing the guard-stage-milestone approach for specifying business entity lifecycles	LNCS 6551 LNCS, pp. 1-24	2011	Hull R., Damaggio E., Fournier F., Gupta M.,Heath III F., Hobson S., Linehan M. (...) Vaculin R.	121
19	Generation of business process models for object life cycle compliance	LNCS 4714 LNCS, pp. 165-181	2007	Küster, J.M., Ryndina, K., Gall, H.	118
20	Behavioral similarity - A proper metric	LNCS 6896 LNCS, pp. 166-181	2011	Kunze, M., Weidlich, M., Weske, M.	110

The number of publications in the reference list with 10 or more citations is 291; with 20 or more citations is 118; with 50 or more citations is 29. Lecture Notes in Computer Science (LNCS) publications seem to be cited by researchers relatively more (nearly 1200) than the others. It should also be noted that the studies presented in previous conferences were intensively cited. However, journals such as Information Systems, MIS Quarterly, Business Process Management, Decision Support Systems, IBM Systems Journal, Data & Knowledge Engineering are other sources that researchers frequently refer to in their work at the BPM conference. This finding actually highlights the important journal list for researchers in this field.

Table 4 presents the references presented in that the conference papers are mostly cited to show the related dynamics, whereas Table 5 shows the citation frequencies in the Scopus database. The citation-based connections among the authors can be visualized with the help of citation networks. When Table 4 and Table 5 are evaluated, it is seen that the leading contributors of the field stand out again (Figure 1). Moreover, Figure 3 exhibits another network and density heatmap where citing relationships and intensities among the conference papers were analyzed, The authors like Van der Aalst, Mendling, Dumas, Weske, and Reijers are in the center of presents the relevant structure.

their clusters. Overlay visualization in Figure 3 has also time dimension showing the changes and trends in citation connections by years.

4.3 Subject Areas, Keywords and Topics

Online databases categorize each paper under at least one subject area. The papers of BPM Conferences were categorized under six subject areas. All papers were assigned to “Computer Science”, 1311 papers were also assigned to “Mathematics”, 591 papers to “Business, Management and Accounting”, “Decision Sciences”, and “Engineering”, respectively.

Different types of analysis have been adopted in order to reveal the focus of the studies included in the database and to explain the changes in these subjects over time. First, by using the keywords defined by the authors as input, co-occurrences were analyzed and a network was obtained that visualizes the use of words together (Figure 4). In this sense, co-word analysis constructs the conceptual structure of a field by analyzing the patterns of co-occurrence of word pairs in the relevant publication (Zupic & Čater, 2015). The hierarchical structure of the keywords is also developed by using factor analysis and visualization with the help of a dendrogram, in this context Figure 5 presents the relevant structure.

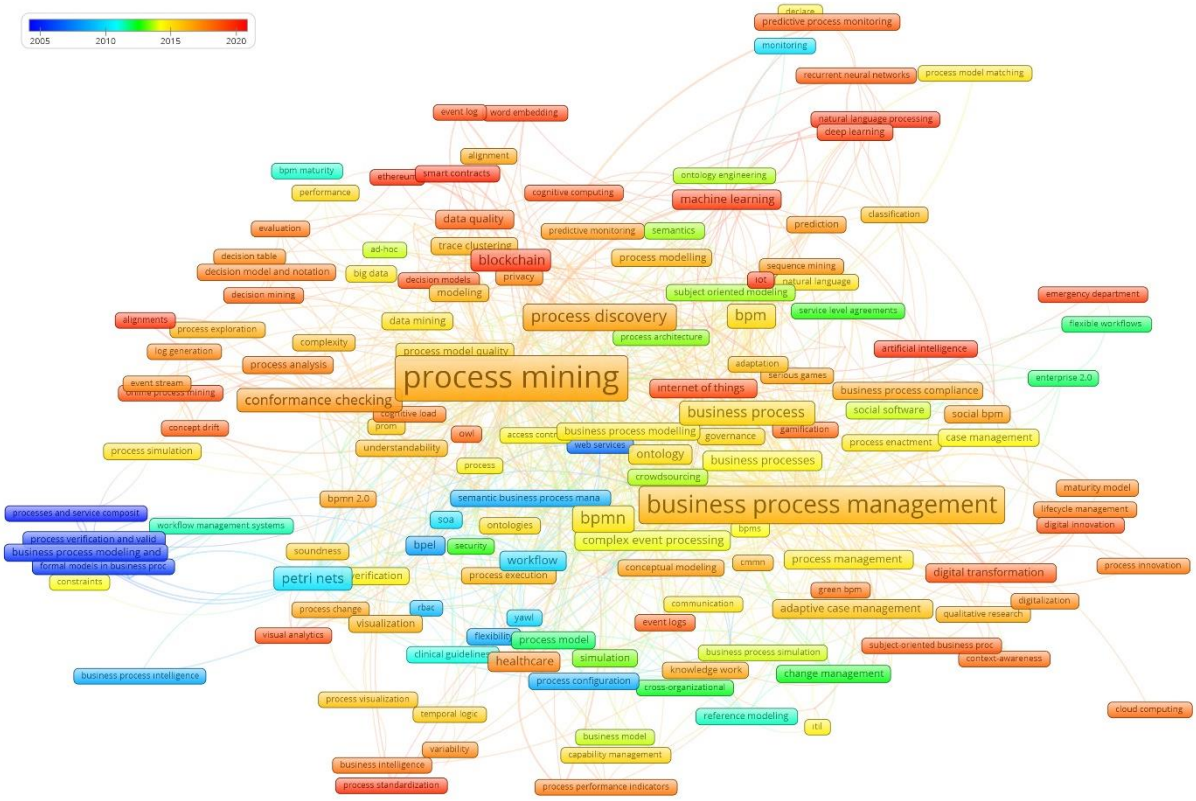


Figure 4. Co-occurrences overlay visualization (minimum 3)

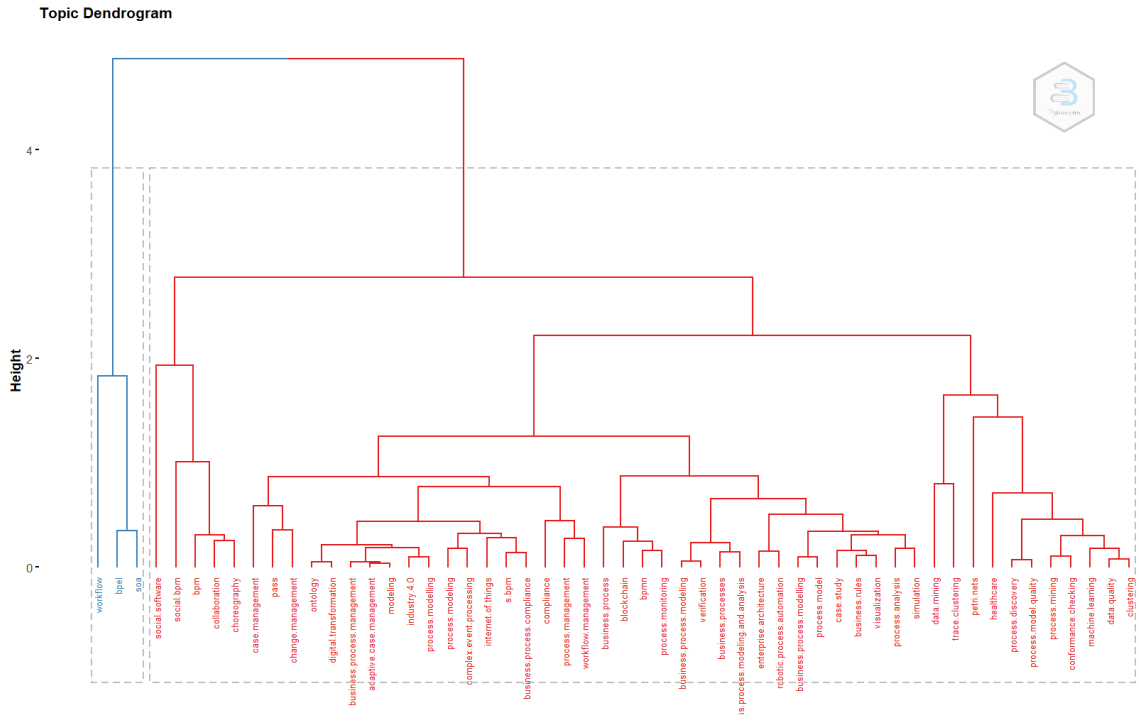


Figure 5. Topic dendogram retrieved from factorial analysis (Bibliometrix)

When both Figures 4 and 5 present the most intensively researched topics at BPM conferences which are important for researchers working in this field to see the topics discussed most intensely by leading researchers in the international platform and to perceive the pattern in the field. Utilizing the overlay analysis, the change in the author keywords used in the studies of the researchers over time can be seen. The trend, which turns from dark blue to blue, green, and yellow in the time flow between 2005 and 2015, turns from yellow to orange and red after 2015. Artificial intelligence, robotic process automation, process standardization, etherium, blockchain, smart contracts, machine learning, deep learning, natural language processing, artificial intelligence, industry 4.0, big data, internet of things are the concepts and themes in recent studies that were presented in BPM Conferences.

The fact that BPM is one of the basic approaches for all institutions, and its shape and transformation with developing technology and global trends, and concepts such as industry 4.0, big data, internet of things, blockchain, cloud computing, and artificial intelligence are among the keywords that have been recorded intensively in the last five years centered around it. These concepts are critical for today's businesses to be at the forefront of global competition. Tupa and Steiner (2019) supported these findings by stating that the new technologies based on Internet of Things and Services, SMART solutions, and the concept Industry 4.0 are potential concepts in BPM implementation. Weber et al. (2016) stated that the integration of business processes between organizations is generally beneficial for all relevant parties, but the lack of trust hinders this issue and stated that blockchain technology can be integrated for process monitoring as a solution to this issue.

Özdağoğlu, Damar, and Özdağoğlu (2020a) state that blockchain is relatively a new technology that takes its roots from adistributed data structure shared on a decentralized network. Although the first attempts of the blockchain technology started in developing cryptocurrencies, this technology has provided opportunities for other fields related to the management of security issues and shared resources. This partially explains the fact that BPM has been a subject that has been studied extensively in recent years. Additionally; In his studies, in which he examined the articles on blockchain produced between 2013-2018, he stated that in recent years, topics such as cloud computing, security, internet of things have been discussed intensively with blockchain technology. Özdağoğlu, Özdağoğlu, Topoyan, and Damar (2020b) states that, industry 4.0 and related articles, it has been revealed that the concept of industry 4.0 and concepts such as cloud computing, data privacy, big data, intelligent manufacturing systems have been a trend in recent years.

It is also revealed with Özdağoğlu, Damar and Özdağoğlu (2020a) and Özdağoğlu, Özdağoğlu, Topoyan, and Damar (2020b) that related technologies such as industry 4.0, blockchain, cloud computing, big data, which are also prominent in BPM studies in the literature, actually transform the integrated and global production sector or businesses together. In fact, all the available information in

Figure 4 and Figure 5 show that BPM is an umbrella concept, has a direct or indirect relationship with many technologies, is shaped and transformed by these technologies.

To reveal the main subjects handled at the conferences, the keywords statistics were first summarized regarding the frequencies. When the 2005-2020 time range is considered, the most frequent keywords used at least 30 times are as follows: Some nodes of the network in Figure 5 are larger than others. This situation is shaped by the distribution of research keywords that are used most intensively in the BPM conferences in the 2005-2020 period. In this regard, featured keywords are, Enterprise resource management (f:1303), administrative data processing (f:604), business process (f:342), business process management (f:238), process mining (f:206), data mining (f:201), business process model (148), semantics (f:141), process modeling (f:133), process model (f:127), information management (104), systems engineering (f:104), information systems (f:85), petri nets (f:81), process control (f:74), mathematical models (f:71), management science (f:69), web services (f:69), artificial intelligence (68), process discovery (f:68), process engineering (f:68), computer science (f:65), design (f:65), technical presentations (f:62), computer circuits (f:60), management information systems (f:56), enterprise resource planning (f:55), process monitoring (f:54), business process modeling (f:51), ontology (f:51), computers (f:50), process execution (f:50), blockchain (f:49), conformance checking (f:49), cognitive systems (f:48), modeling languages (f:46), computer simulation (f:45), algorithms (f:42), process design (f:42), s-bpm (42), big data (f:41), bpmn (f:40), health care (f:39), process instances (f:39), subject-oriented (f:39), life cycle (37), data processing (f:35), decision making (f:34), problem solving (f:34), competitive intelligence (f:33), case management (f:32), process management (f:32), user interfaces (f:31), bpm (f:30), model checking (f:30), work simplification (30), respectively.

In addition to private sector organizations, it is inevitable to keep up with these developments within public institutions. Today, in a world where competition is concentrated in every field, one of the methods of ensuring customer satisfaction is process management practices. In this context, BPM consists of identifying the processes and owners of organizations; identifying the needs of their suppliers; determining the needs of their customers; making measurements in the necessary steps; monitoring their performance and making the required improvements are all activities. That is, BPM covers not only the analysis and modeling of business processes but also corporate applications, leadership, and performance audits (Rohloff, 2009). It also offers an umbrella that incorporates a wide range of process management approaches to integrate with Enterprise Resource Planning (ERP), other performance enhancement initiatives, globalization, and e-business platforms to obtain agility and flexibility for adapting to change. Under the common umbrella of process management, various tools are used to connect and manage the company's development efforts, and the right problem is solved with the right tools (Hammer, 2015).

BPM software platforms act as a performance monitoring tool for processes. Process owners can obtain statistics about the performance of processes (Chang, 2016). Each process creates a value in which one can measure customer performance to design and implement a customer-oriented process. Hence, customers define the performance metrics that determine how the process performance is measured. Since the process performance is demonstrated by changing customer demands, processes can react quickly to the market (Kirchmer, 2011; Khoshafian, 2014). With BPM, businesses achieve advanced visibility, transparency, and control, which offer new products, new inventions, and optimized customer experiences. To do so, special tools, notations, and frameworks have been developed and some of them took place in keyword co- occurrences network, e.g. Business Process Modeling Notation (BPMN), Petri Nets, YAWL, Business Process Execution Language (BPEL), Event-logs.

Many clues about research topics can be obtained through keywords and the word clusters they create. In order to deepen the analysis of the topics covered, the text data created by the abstracts were taken as input and a topic modeling approach was applied to these data. In this regard, the abstracts were first cleansed using operations, tokenization, filtering stopwords, filtering only verbs and nouns, and stemming. Afterward, LDA was executed on the cleansed data to obtain topic-word and document-topic matrices. LDA gives only clues about which words and documents can be factored under the same title based on the user parameter "number of topics". The best parameter value can be selected by considering the perplexity measure. For this study, ten topics resulted in a better value than 5, 15, 20, and higher values. Therefore, possible word and document groupings were obtained for ten topics from zero to nine. The topic distributions over words and document distributions over topics were interpreted and summarized regarding the most frequent application areas as follows:

- T0: process logic, agents, and robotic process automation, and related applications,

- T1: service oriented architectures, web services, bpel, enterprise applications. business process management tools, software, and software development projects.
- T2: data management, decision making in business processes and related technologies such as cloud computing, internet of things,
- T3: business process modeling, bpmn, process behaviors and ontologies,
- T4: workflow management, process modeling, resource allocation, the frequent applications are in healthcare services,
- T5: process execution, errors, problem verification; rules, constraints, and applications in different modeling languages,
- T6: process quality; performance measurement evaluation,
- T7: process mining
- T8: compliance, privacy, regulations, risk, data management.
- T9: change management and adaptation; process-oriented management approach; monitoring, simulation, and scenarios; documentation and standardization,

Table 6. Topic distributions over years

Row Labels	T0	T1	T2	T3	T4	T5	T6	T7	T8	T9	Grand Total
2005	6	3	13	15	4	7	2	2	1	0	53
2006	5	2	15	15	1	6	5	1	0	0	50
2007	3	4	4	14	2	4	3	3	0	0	37
2008	7	11	11	26	4	6	6	6	4	0	81
2009	11	9	11	41	5	5	9	7	2	0	100
2010	2	4	2	10	1	3	0	2	1	0	25
2011	5	27	7	20	0	12	4	4	1	1	81
2012	16	13	9	32	13	7	11	21	8	0	130
2013	5	14	0	12	4	5	6	10	1	0	57
2014	10	21	3	37	8	7	13	27	3	0	129
2015	18	31	1	46	16	7	12	23	12	2	168
2016	10	8	1	16	5	5	3	21	2	0	71
2017	13	15	4	44	7	1	6	28	2	53	173
2018	9	26	5	30	10	2	9	29	6	0	126
2019	13	31	9	30	33	8	6	45	10	1	186
2020	9	29	3	9	7	3	1	20	2	0	83
Grand Total	142	248	98	397	120	88	96	249	55	57	1550

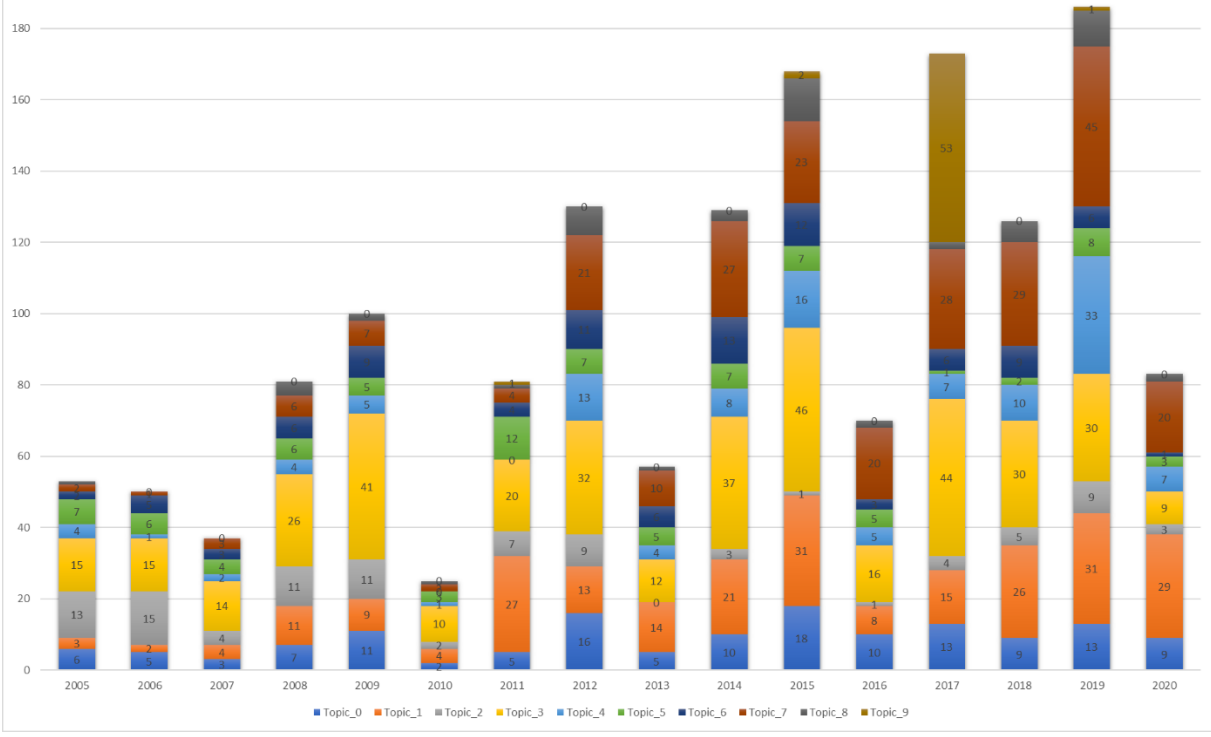


Figure 6. Topic distributions over years

Topic probabilities for the abstracts as documents were calculated within LDA, and the abstracts were assigned to the topic with the highest probability. The abstracts with the years and topics are aggregated in a summary table (Table 6) and visualized (Figure 6), where the distribution of the topics by year can be seen (Table 6). Table 6 and Figure 6 highlight that the dominant topic for most of the years is topic 3 including the concepts of business process modeling, BPMN, process behaviors, and ontologies. This is not surprising that the recent developments within the scope of Industry 4.0 necessitate the semantic and behavioral structure of the entities and processes in order to integrate with the internet of things. Process mining (topic 7) comes just after topic 3, and topic1 closely follows it by taking third place in the ranking. Topic 1 combines the research related to the studies where process models are converted into executable models at the implementation phase of the BPM lifecycle.

As exhibited in Figure 6, the frequencies of the topics by year do not follow a stable or consistent distribution. Starting from 2014 topic 3 and topic 7 dominates the other topics, however, in 2017 topic 9 has the highest relative frequency just for that period and topic 4 appears in 2019 near to the top. In the last conference organized in 2020, topic 1 and topic 7 hold the leading position in the list. Besides, topic one had stable trend in the last three years related to creating executable and process-aware information systems with the help of BPEL, web services, service-oriented architectures, and related software projects. The findings infer that the current dynamics of BPM applications and technological developments have a direct impact on BPM efforts and related research attempts.

5. CONCLUSION

International BPM Conferences, which have been organized since 2003, have made significant contributions to the literature of this field with the research and discussions conducted by the participants from many different locations and academic levels. The accumulation of the studies over the years has been reported with studies such as reviews or bibliometrics from time to time. This paper presented such a study as scientometric research to reveal not only the statistics but also collaborations among the authors and countries; citation patterns of the related papers; and the main subjects and the potential topics by using text mining and network analytics.

Due to data quality problems, the research environment included the conference papers that were presented in the International BPM Conferences between 2005 and 2020 published by the sources within the Scopus database. Scopus database was selected as a data source regarding the data quality it provides for proceedings. Co-authorship analyses regarding authors and countries revealed the clusters around the authors and their countries such as Van der Aalst (Netherlands), Mendling (Austria), Weske (Germany), Dumas (Estonia), La Rossa (Australia), and Reijers (Netherlands). These are also the authors of the literature that have provided the fundamental sources globally used in this field on a global scale, e.g. (Van Der Aalst, 2011; Weske, 2012; Dumas, La Rosa, Mendling, & Reijers, 2018). Author clusters are also reflected in the citation network. The citation network indicating the years in colors especially highlighted the use of the resources by time. The researchers in the field of BPM can use both co-authorship and citation networks to follow the relevant literature.

When the keywords were analyzed to emphasize the main content of the papers, it was seen that the keywords related to information management, data analytics, and process intelligence were the most selected ones. In addition to the keyword statistics, a topic model was developed through the papers' abstracts in the dataset by utilizing the LDA approach. Word distributions of the abstracts over topics and the topic distributions over the abstract were estimated using the topic model. This model assigned each paper to a topic; thus, all papers were classified under a topic. Then the topics were tried to be interpreted. By using the publication years along with the topics, the topic trends were obtained and visualized for the selected time range. The results indicated that there were new topics in BPM research recently related to the technological and methodological developments as well as permanent topics regarding new attempts and applications of process design and evaluation.

The main contribution of the paper is such that it revealed the collaborations and clusters regarding citations, co-authorships, co-occurrences of keywords, and topic structures as well as the trends and summary statistics. So, it used advanced analytics and related tools, including text clustering, network models, and topic modeling. All findings were combined to present a kite view of the contributions that BPM Conferences have brought to the literature. It is thought that the findings would provide many insights and research opportunities for researchers and executives who are interested in the outputs of the BPM Conferences. The study provided a holistic view of the academic accumulation in the relevant field. It is complementary to the previous studies that were conducted with different methodologies in the past years.

REFERENCES

Aria, M., & Cuccurullo, C. (2017). Bibliometrix: An R-tool for comprehensive science mapping analysis, Journal of Informetrics, 11(4), 959-975.

Blei, D.M., & Lafferty, J.D. (2009). Topic models. Text Mining: Classification, Clustering, and Applications. Ashok Srivastava, Mehran Sahami (Eds.), 101-124. CRC Press. Taylor & Francis Group: Boca Raton. ISBN 978-1-4200-5940-3.

Blei, D.M., Andrew, Y.N., & Jordan, M.I. (2003). Latent Dirichlet Allocation. Journal of Machine Learning Research, 3, 993-1022.

Boyack, K.W. (2004). Mapping knowledge domains: characterizing PNAS. Proceedings of the National Academy of Sciences, 101(suppl 1), 5192-5199. doi: 10.1073/pnas.0307509100.

Burattin, A. (2015). Process mining techniques in business environments. In volume 207 of Lecture Notes in Business Information Processing. Springer International Publishing.

Chang, J.F. (2016). Business process management systems: strategy and implementation. Auerbach Publications. Taylor & Francis Group, ISBN 10: 0-8493-2310, USA.

Chaves, L.C., Ensslin, L., Andrade de Lima, M.V., & Ensslin S.R. (2017). Organizational performance evaluation and process management: mapping of the field. Revista Electronica De Estrategia E Negocios-Reen, 10(1), 100-141. doi: 10.19177/reen.v10e12017101-139.

Damar, M., Özdağoğlu, G., & Özveri, O. (2020). Bilimsel üretkenlik bağlamında dünya sıralama sistemleri ve Türkiye'deki üniversitelerin mevcut durumu. Üniversite Araştırmaları Dergisi, 3(3), 107-123.

Davenport, T. H. (1993). Process innovation: reengineering work through information technology. Harvard Business Press: Cambridge.

Dumas Lab (2021). Business Process Management Research Group, University of Tartu. Erişim adresi: https://www.researchgate.net/lab/Business-Process-Management-Research-Group-University-of-Tartu-Marlon-Dumas

Dumas, M., La Rosa, M., Mendling, J., & Reijers, H.A. (2018). Fundamentals of business process management. Heidelberg: Springer. ISBN 978-3-662-56508-7.

Ensslin, L., Ensslin, S.R., Dutra, A., Nunes, N.A., & Reis, C. (2017). BPM governance: a literature analysis of performance evaluation. Business Process Management Journal, 23(1), 71-86. doi: 10.1108/BPMJ-11-2015-0159.

Erdogan, T.G., & Tarhan, A. (2018). Systematic Mapping of Process Mining Studies in Healthcare. IEEE Access, 6, 24543-24567. doi: 10.1109/access.2018.2831244.

Garfield, E. (2009). From the science of science to scientometrics visualizing the history of science with HistCite software. Journal of Informetrics, 3(3), 173-179. doi:10.1016/j.joi.2009.03.009.

Ghobakhloo, M. (2018). The future of manufacturing industry: A strategic roadmap toward Industry 4.0. Journal of Manufacturing Technology Management, 29(6), 910-936. doi:10.1108/jmtm-02-2018-0057.

Hammer, M. (2015). What is business process management?. In Handbook on business process management 1, 3-16. Springer, Berlin, Heidelberg. ISBN 978-3-642-00415-5, doi: 10.1007/978-3-642-00416-2.

Hammer, M., & Champy, J. (1993). Reengineering the Corporation: A Manifesto for Business Revolution. Paperback edition, HarperBusiness, New York.

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. doi: 10.1108/14637151011065946.

Jeston, J., & Nelis, J. (2008). Business process management. Oxford: Butterworth-Heinemann. https://doi.org/10.4324/9780080492520

Johanson, H.J., & Carr D.K. (1995). Best practices in reengineering. New York: Mc Graw Hill.

Khoshafian, S. (2014). Intelligent BPM: the next wave for customer-centric business applications. ISBN 978-0-615-51512-0. Pegasystems Inc. One Rogers St. Cambridge.

Kirchmer, M. (2011). High performance through process excellence: from strategy to execution with business process management. Springer Science & Business Media. ISBN 978-3-642-21164-5, e-ISBN 978-3-642-21165-2, doi: 10.1007/978-3-642-21165-2, Springer, Heidelberg Dordrecht London New York.

Ko, R.K.(2009). A computer scientist's introductory guide to business process management (BPM). XRDS: Crossroads, The ACM Magazine for Students, 15(4), 11-18.

Melin, G., & Persson, O. (1996). Studying Research Collaboration Using Co-authorships. Scientometrics, 36(6), 363-377.

Mendling Lab (2021). Process Management and Information Systems, Humboldt-Universität zu Berlin. Erişim adresi: https://www.informatik.hu-berlin.de/en/forschung-en/gebiete/promis-en

Muellerleile, T., Ritter, S., Englisch, L., Nissen, V., & Joenssen, D.W. (2015, July). The influence of process acceptance on BPM: an empirical investigation. In 2015 IEEE 17th Conference on business informatics, 1, 125-132. IEEE.doi: 10.1109/CBI.2015.11.

Özdağoğlu, G., Damar, M., & Özdağoğlu, A. (2020a). The State of the art in blockchain research (2013–2018): scientometrics of the related papers in web of science and scopus. In Digital Business Strategies in Blockchain Ecosystems (pp. 569-599). Springer, Cham.

Özdağoğlu, A., Özdağoğlu, G., Topoyan, M., & Damar, M. (2020b). A predictive filtering approach for clarifying bibliometric datasets: an example on the research articles related to industry 4.0. Technology Analysis & Strategic Management, 32(2), 158-174.

PAIS Lab (2021). Laboratory of Process-Aware Information Systems (PAIS Lab). Erişim adresi: https://pais.hse.ru/en/lab/staff/aalst

Patience, C.A., Blais, B., & Bertrand, F. (2017). Citation analysis of scientific categories. Information Science Heliyon, 3(5), e00300. doi: 10.1016/j.heliyon.2017, e00300.

Ponomariov, B., & Boardman, C. (2016). What is Co-authorship?. Scientometrics, 109(3), 1939-1963.

Rahimi, F., Møller, C., & Hvam L. (2016). Business process management and IT management: The missing integration. International Journal of Information Management, 36(1), 142-154. doi: 10.1016/j.ijinfomgt.2015.10.004.

Recker, J., & Mendling, J. (2016). The state of the art of business process management research as published in the BPM conference. Business & Information Systems Engineering, 58(1), 55-72. doi: 10.1007/s12599-015-0411-3.

Rohloff, M. (2009). Case study and maturity model for business process management implementation. In International Conference on Business Process Management, 128-142. Springer, Berlin, Heidelberg. doi: 10.1007/978-3-642-03848-8_10.

Sun, Y., Su, J., & Yang, J. (2016). Universal artifacts: a new approach to business process management (BPM) systems. ACM Transactions on Management Information Systems (TMIS), 7(1), 1-3. doi: 10.1145/2886104.

Tupa, J., & Steiner, F. (2019). Industry 4.0 and business process management. Tehnički glasnik, 13(4), 349-355. https://doi.org/10.31803/tg-20181008155243

Turra, M.E.D., Juliani, L.I., & Salla N.M.D.C. (2018). Business Process Management - BPM: A Bibliometric Study on National Scientific Production. Revista Administracao Em Dialogo, 20(3), 46-68. doi: 10.23925/2178-0080.2017v20i3.36961.

Van der Aalst, W.M.P. (2012) A decade of business process management conferences: personal reflections on a developing discipline. In: Barros AP, Gal A, Kindler E (eds) Business process management BPM2012. Lecture Notes in Computer Science, 7481,1-16. Springer, Heidelberg. doi: 10.1007/978-3-642-32885-5_1.

van der Aalst, W. M. P., La Rosa, M., & Santoro, F. M. (2016). Business process management. Business & Information Systems Engineering, 58(1), 1-6. https://doi.org/10.1007/s12599-015-0409-x

Van Der Aalst, W.M.P. (2011). Process mining: discovery, conformance and enhancement of business processes. Heidelberg: Springer. ISBN 978-3-642-19345-3.

van der Aalst, W.M.P., ter Hofstede, A.H.M., & Weske, M. (2003). Business process management: a survey. In: van der Aalst, W.M.P., ter Hofstede, A.H.M., Weske, M. (eds.) BPM 2003. LNCS, vol. 2678, pp. 1-12. Springer: Heidelberg.

Van Eck, N., & Waltman, L. (2013). Software survey: VOSviewer, a computer program for bibliometric mapping. Scientometrics, 84(2), 523-538. doi:10.1007/s11192-009-0146.

Veit, D.R., Lacerda, D.P., Camargo, L.F.R., Kipper, L.M., & Dresch, A. (2017). Towards Mode 2 knowledge production: Analysis and proposal of a framework for research in business processes. Business Process Management Journal, 23(2), 293-328. doi: 10.1108/BPMJ-03-2016-0045

VOSviewer (2021). Visualizing scientific landscapes. Erişim adresi: http://www.vosviewer.com .

Wamba, S. F., & Mishra, D. (2017). Big data integration with business processes: a literature review. Business Process Management Journal, 23(3), 477-492. doi: 10.1108/BPMJ-02-2017-0047.

Weber, I., Xu, X., Riveret, R., Governatori, G., Ponomarev, A., & Mendling, J. (2016). Untrusted business process monitoring and execution using blockchain. In International Conference on Business Process Management (pp. 329-347). Springer, Cham.

Weske, M. (2012). Business Process Management. Springer, Berlin, Heidelberg. ISBN 978-3-642-28615-5.

Zupic, I., & Čater, T. (2015). BibliometricMethods in Management and Organization. Organizational Research Methods, 18(3), 429-472.

© 2019 & 2023 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY NC) license. (https://creativecommons.org/licenses/by-nc/4.0/).