BIBLIOMETRIC ANALYSIS OF HR ANALYTICS LITERATURE

İK ANALİTİĞİ LİTERATÜRÜNÜN BİBLİYOMETRİK ANALİZİ

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Abstract

Human resource analytics (HR analytics) research has been popular in recent years and is a newly emerging research area. Examining the frame of the studies conducted in this field will shed light on new future studies in the field. This study examines how HR analytics work is built on the basis of the intellectual framework. This research aims to contribute to the literature by examining the references, authors, topics, citations and journals of the studies. For this purpose, 178 articles published between 2010 and 2021 in the Web of Science academic database were examined. The bibliometric analysis technique was used for the analysis. A wide variety of disciplines have been used in the journals that publish these articles to address the issues of HR analytics. Main themes gathered in the articles are around the concepts of big data, talent management and workforce analytics. The study results show that research interest in HR analytics has increased in recent years. While the competencies of HR professionals, data quality, technological developments, cooperation with the IT department are the main topics, the literature seems to neglect the issue of ethics.

Keywords: HR analytics, workforce analytics, people analytics, bibliometric analysis, co-citation analysis

Öz

İnsan kaynakları analitiği (İK analitiği) araştırması son yıllarda popüler olan ve yeni gelişen bir araştırma alanıdır. Bu alanda yapılan çalışmaların hangi çerçevede ilerlediğini görmek, ileride bu alanda araştırma yapacak akademisyenlere ve yeni çalışmalara ışık tutacaktır. Bu çalışma, İK analitiğinin entelektüel çerçeve temelinde nasıl çalıştığını ve ele alındığını incelemektedir. Bu araştırma ile, İK analitiği alanında yapılmış çalışmaların referansları, yazarları, konuları, atıfları ve dergileri incelenerek literatüre katkı sağlanması amaçlamaktadır. Bu amaçla, Web of Science akademik veritabanında yer alan 2010 ile 2021 yılları arasında yayımlanmış 178 makale incelenmiştir. İnceleme için bibliyometrik analiz tekniği kullanılmıştır. İK analitiği konularını ele alan ve bu makaleleri yayınlayan dergilerde çok çeşitli disiplinler kullanıldığı görülmektedir. Makalelerde kullanılan ana temalar; büyük veri, yetenek yönetimi ve işgücü analitiği kavramları etrafında toplanmaktadır. Çalışmanın sonuçları, İK analitiğine yönelik araştırma ilgisinin son yıllarda arttığını göstermektedir. İK profesyonellerinin yetkinlikleri, veri kalitesi, teknolojik gelişmeler, BT departmanı ile işbirliği ana konu başlıkları iken, literatürün İK analitiği kapsamında etik konusunu ihmal ettiği sonucuna varılmıştır.

Anahtar Kelime: İK analitiği, işgücü analitiği, insan analitiği, bibliyometrik analiz, ortak atıf analizi

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1. Introduction

Technological progress and dynamism have led many companies to redesign their strategies. Many studies indicate that intangible resources such as human resources and their behavior can provide sustainable competitive advantages (Hall, 1993; Valle et al., 2019). There is some consensus on considering intangible assets related to human resources, which are categorized as human capital, among the best explanatory elements for performance improvements (Villalonga, 2004; Liu, van Jaarsveld, Batt, and Frost, 2014). The planning, execution, effects and contributions of human capital and related issues are possible with HR analytics. There has been growing interest in HR analytics in the literature over the past five years. This growing interest will soon be evident in the number of articles attempting to explore different elements of other concepts associated with HR analytics.

HR analytics is the ultimate human resources field. HR has become more compatible with the changing business world and the effect of technology. Evidence-based HR and HR analytics have become increasingly important (Boudreau and Ramstad, 2007). HR decisions taken without following up-to-date studies, investments and results in the field of HR will be insufficient. HR is spread over a wide variety of areas within the business. HR professionals observe data with very different correlations to monitor the effects of their methods. The main function of HR analytics is to examine HR investments not only in one aspect but in their entirety. It is important to focus on HR analytics-related studies as it spreads throughout the business, affects customers, investors and other stakeholders outside the organization, and affects vital outputs such as competition analysis and performance. Marler and Boudreau (2017) states that they found little scientific evidence for HR analytics adoption in their literature review study. They stated that in the studies conducted, there were no theoretical predictions of the relationships and no data were collected to measure theoretical predictions. Studies on HR analytics are at the beginning and it is clear that more scientific studies are needed. HR analytics topics in the literature did not attract much attention, unlike the topics such as employee selection, employee turnover and performance-based awards, which the field of human resources focuses on. Bibliometric analysis provides serious contributions to researchers who will work in this field in terms of showing the current situation. It is necessary to know how comprehensive the studies on HR analytics can be, how much work has been done on which field and what remains untouched. Little is known about the factors associated with HR Analytics. Findings from past empirical and theoretical studies on innovation adoption will provide a suitable basis for building hypotheses on expected adoption models for HR Analytics and other current HR innovations. HR analytics is related to many issues such as data collection, statistical analysis, interpretation of the results, competence of the personnel who will make the analysis. It is also related to many complicated issues such as creating the hierarchy of employees and the company, and creating a network of stakeholders. With the use of information technologies and software, HR Analytics is a subject that needs to be researched in many ways. There are also abstract dimensions; such as performance, adoption, training and talent development (Marler and Boudreau, 2017).

It is important to examine the characteristics and the intellectual framework on which an emerging research is based, considering its importance. Therefore, the purpose of this study is to examine the researches related to HR analytics. By using a bibliometric analysis technique, HR analytics literature in Web of Science academic database is examined. In addition, the publications and co-citations that the researchers refer to in their studies are analyzed. It is aimed to determine the relationships and effects of the main articles contributing to the subject. The contribution of the research is to provide a new perspective for future research by examining the publications and authors most closely associated with HR analytics. The study also provides a basis for meta-analysis as it includes all sources related to the subject. It provides a quantitatively supported resource for a literature review that can be used in future studies. The results obtained from the study are explained,

reported and discussed in tables and figures. Finally, the conclusion section explains the implications and provides suggestions for future research.

2. HR Analytics

Big data has become an important asset for business. Making predictions and creating value for businesses by analyzing big data is a topic that HR literature has been closely interested in, in the last decade. This prediction process, called HR analytics, provides data such as assessment center results, psychometric tests or skill tests, personality inventories, employee satisfaction surveys, job entry and exit interviews, face to face interviews, and training outcomes. Defining the problems that can be solved with HR data in the organization, giving decision support to senior management with HR data, understanding specific problems and interpreting the analysis results correctly are the main elements of HR analytics.

There has been an increase in the importance of workforce analytics in recent years. This focus has brought HR professionals to a more strategic and effective decision-making point. HR professionals have realized the advantages of effective decision-making based on data in recent years. Data-driven technologies predict trends and make inferences by analyzing mass data, called big data.

It is seen that HR analytics have different definitions in the literature. HR analytics is defined as an analytical process (Huselid, 2018) and path, and is expressed as problem solving through technology to support systematic data analysis and corporate decision making (McIver et al., 2018). There are studies stating that it has a technical, analytical and data-centric role and requires analytical and technical knowledge, skills and competency (Andersen, 2017; van den Heuvel and Bondarouk, 2017; van der Togt and Rasmussen, 2017; Minbaeva, 2018). The goal of HR analytics is to collect and maintain data to forecast short and long-term trends in the supply and demand of workers in different industries and professions. In line with this goal, it helps organizations to make decisions regarding the best selection, development and retention of their human capital (Kapoor and Sherif, 2012).

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Big data, which has become an important element of data-oriented technologies, and gained attention at the World Economic Forum held in Davos in 2012. Big data was associated with metric related concepts such as data management, database, information management, and business intelligence around that time. Studies in the field of HR also show that big data is still in the development stage in terms of HR analytics (Aral et al., 2012). The major development contributing to HR analytics studies was Industry 4.0 which was announced for the first time at the Hannover Fair in 2011, and major initiatives started in 2015, supported by the European Commission. It can be noticed that HR analytics matured and its studies started to gain momentum in 2015 in parallel with all these technological developments. HR analytics collect data from business processes and make predictions about the workforce by making data-based analyzes. This supports HR to partner with business processes (van den Heuvel and Bondarouk, 2017). Multiple forms of technology are used to support data-based analysis and strategic decision making (van der Togt and Rasmussen, 2017; Minbaeva, 2018). While previous studies focused on the technical aspects of analytics such as collecting and analyzing data, recent studies emphasize on strategy and talent concepts. This shows that the perspective has shifted towards an HR-focused HR Analytics approach (Huselid, 2018). With the emphasis on strategy implementation and talent in the definition of HR Analytics after 2018, it seems that HR professionals' interest in the subject has increased. In the studies carried out in 2019, the concepts of talent management and competence development increase compared to 2018.

The efficiency of the HR function is particularly related to how well the HR function performs its core tasks. When it comes to HR efficiency, studies focus on two concepts, metrics and analytics. To evaluate efficiency, productivity and cost values for HR, metrics such as time to fill open positions,

HR staff ratio, and unit cost per employee were created. It is possible to produce a comprehensive set of metrics to evaluate the activities of HR (Lawler et al., 2004). Metrics made up of descriptive data sets. While popular, metrics are concepts that should not be confused with analytics. Metrics and analytics intersect in several points like numerical, statistical and mathematical competence. The metrics gives numerical values and percentages, which are useful for making a brief situation assessment instantly. Analytics, on the other hand, is insightfully composed of a combination of these metrics. Analytical process is the statistical forecasting process that includes metrics (Edwards and Edwards, 2019). HR analytics is a strategic and knowledge-based transformation from descriptive analysis to predictive analysis.

The purpose of HRM is to effectively manage the workforce that actually contributes to the organization's value creation process. In addition to this, HRM is responsible for procuring different employee groups (outsourced) when needed. According to the results of Deloitte 2020 Global Human Capital Trends research, the prevalence of alternative workforce usage is gradually increasing. 32% of the changes in workforce composition consists of alternative workforce (Deloitte, 2020). The number of self (outsource)-employed workforce is increasing and all this shows that human resources are becoming increasingly complex. According to the results of the Global Human Capital Trend research conducted by Deloitte in 2019, organizations have expressed that they are still not satisfied despite spending billions on HR analytics technologies. 26% of respondents believe that they use technology and analytics effectively, and only 6% believe that HR technologies are excellent (Deloitte, 2019). Despite the billions of dollars invested, the remaining percentage thinks that HR technologies are insufficient. Discussions continue about whether this technological dissatisfaction arise from technology and the systems used or the competencies of HR professionals, as it includes HR expertise, predictive and descriptive statistics and data mining.

3. Bibliometric Methodology

Bibliometric analysis is a tool that can be used to analyze published data. It is a research area that examines distribution of information among publication using mathematical and statistical techniques (Valle et al., 2019). Impact indicators, citation and co-citation analysis and mapping are performed with these techniques. Bibliometric analysis allows obtaining information such as citation analysis, co-citation analysis, determination of the country of origin, number of published journals and citations and keyword analysis. Citation analysis functions according to whether the authors cite documents that they reference in their research and that they consider important. How often these articles are cited can be related to the impact they have on the subject (Culnan, 1987). Co-citation analysis looks at articles that cite a particular set of references by collecting data from academic databases and using analytical techniques (McCain, 1990). In order to make such analyzes, it is necessary to search for resources on a particular subject and to collect relevant data on that subject.

4. Results

In the study, the relevant results were listed by searching the Web of Science academic database with the keyword "human resource analytics". Results were filtered according to their relevance to the researched subject and 178 sources were included in the study. The analysis was carried out in the scientific mapping program Vosviewer, designed for the visualization of bibliometric networks. The types of studies examined are shown in Figure 1. 50% of the studies are articles, 29% are proceedings papers, 7% are early access articles, 5% are editorial materials, 5% are book chapter articles, 4% are reviews, and 1% are books. It is seen that the majority of the studies are articles and proceeding publications. Editorial materials are the evaluations made by the journal editors for the journal issues published on a specific subject. They are important for the dissemination

of scientific knowledge. It is seen that there are special issues published on HR analytics and the editorial materials of these issues are among the most cited studies. There is a remarkable proportion of special issues on HR analytics. The special issues show that HR analytics topics diverge from traditional HR issues, that there is a high interest in the topic and that the editors care about this issue.
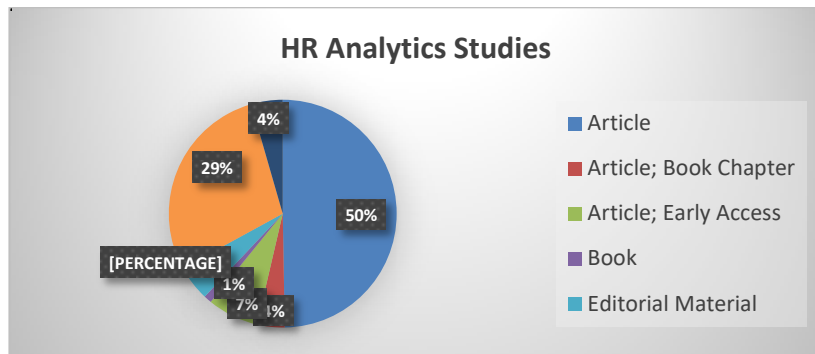

Figure 1. Types of publications

4.1. Publications per year

The articles reviewed were published between 2010 and 2021. In the figure below (Figure 2), the years of the studies and the number of publications made in that year are given to see when the works gained momentum. From 2010 to 2015, only a few articles appear to have been published. It is observed that there is an increasing interest in HR analytics after 2015. 2018 is the year when this interest was the most intense. It can be said that this interest continues and the development phase continues, although there are small decreases in the numbers afterwards. The number of studies published in early view (14) was included in the study as it is at a considerable level. The number of studies published in the last four years and published in early view is 112. The increase in the number of published articles indicates that the HR analytics topic has entered a stage of development. It may be useful to discover new research topics, to identify areas that have been less studied so far, and to explore international collaborations.
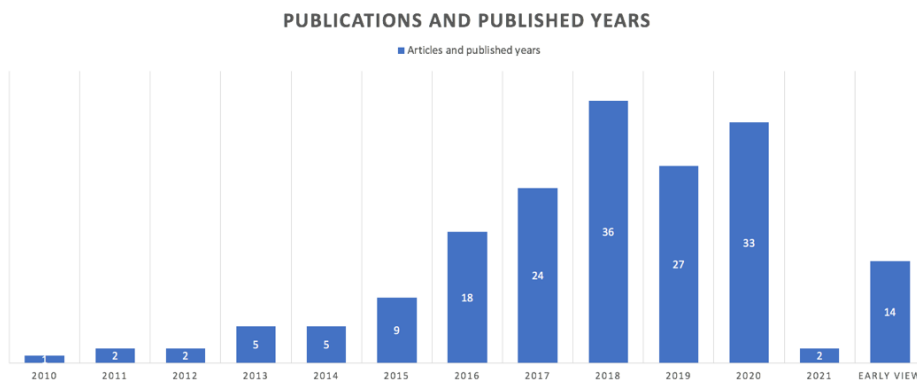
Figure 2. Publications on HR analytics per year

4.2. Co-occurred

580 different keywords were used to classify studies in the sample. Figure 3 shows 33 terms "referred to as keywords" that are used with each other at least three times. The size of the nodes in the map shows how often each word is used. The length of the edge between two nodes "words" indicates the strength of their relationship. The first two keywords in the ranking are "human resource management" and "hr analytics". These words are expected results due to the nature of the research.

The other most used words are "workforce analytics", "big data", "people analytics", "machine learning" concepts as shown in Table 1. Concepts strongly related to HR analytics are: HR metrics, HR strategy, HRIS, people analytics, talent analytics and workforce analytics concepts. The relationships obtained show that the concept of HR analytics is used together with the concepts of strategy, artificial intelligence, big data, employee turnover.

Table 1. Co-occurred keywords

R	K	O	TLS	R	K	O	TLS
1	Human resource management	24	37	9	Business analytics	5	12
2	HR analytics	21	34	10	Human resource analytics	7	11
3	Workforce analytics	14	29	11	Talent management	5	11
4	Big data	19	28	12	HRIS	3	11
5	People analytics	13	24	13	Analytics	11	10
6	Machine learning	9	17	14	Human resources management	6	10
7	Data analytics	8	14	15	Talent analytics	3	10
8	Artificial intelligence	5	12	16	Recruitment	6	9

R: Rank, K: Keyword, O: Occurrence, TLS: Total link strength

Figure 3. Mapping of co-occurred keywords of publications on HR analytics

The most published areas are management, information systems, psychology and artificial intelligence. HR analytics is a process that covers data flow related to other departments. It may involve processes such as adopting different management style, decision making and reporting. Issues with the management of human resources are closely related to management and psychology. The topics covered under the title of industrial / organizational psychology in recent years include many HR projects and processes such as recruitment, orientation, learning organization. Therefore, HR

Analytics is closely related to psychology. The analytics process includes data and the methods used in the analytical process. These processes include some algorithmic technical processes that the engineering field is interested in and seem to attract the attention of these fields as well. The fact that psychology comes after the field of management in the fields of publications can be explained by the successful results of statistical methods in the evaluation of studies on attitudes and tendencies of employees. Organizational behavior issues such as intention to stay at work, teamwork harmony, general performance, work participation are suitable topics to work with data and mining techniques. The fact that industrial relations and mathematical methods are among other subsequent fields supports this view. Since HR analytics is a process that requires competency, educational activities that improve the competencies of employees are important. Studies in the field of educational research shows that there is an emphasis on competence-building. It is noteworthy that the number of these studies is small. The lack of educational research on HR analytics indicates that this HR analytics technical tasks may be outsourced or performed by a technical staff.

4.3. Citation-documents

Document citation networks provide insights into links between commonly cited documents. Citation analysis refers to researchers citing a publication as a reference. Referring to a research expresses the importance of that research. It can be concluded that the more frequently a research is cited, the more it will contribute to the development of the research area (Ramos and Ruiz, 2008). Identifying the most cited publications among the examined publications and determining the relationship of these publications with others, reveals an important determination for the researchers who are studying or will study in the field of HR analytics. Figure 4 reveals the most cited publications and by which publications they were cited.
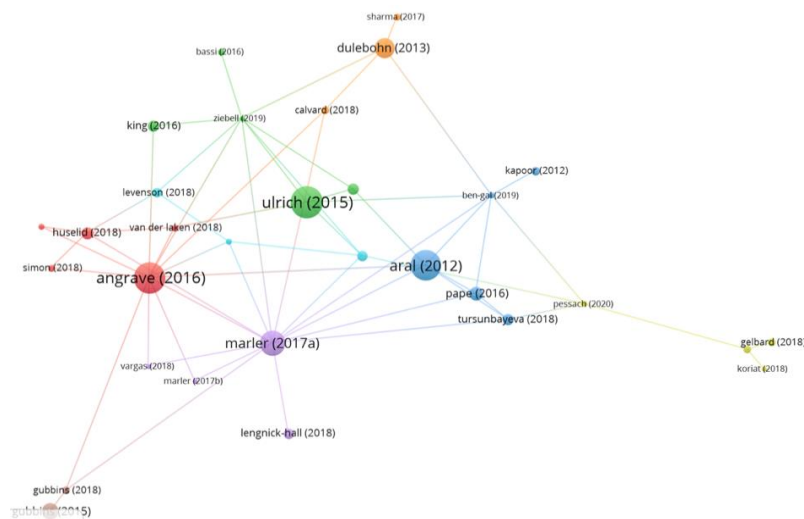
Figure 4. Mapping of most cited publications on HR analytics

The most cited publications are presented in Table 2 according to the number of connections. The most cited studies are the following; Ulrich and Dulebohn (2015), Angrave et al., (2016), Aral et al. (2012), Marler and Boudreau (2017), De Mauro et al. (2018). The links in Table 2 expresses the connection or relationship between two studies. Among the most cited studies, the most related studies are as follows; Marler and Boudreau (2017), Angrave et al. (2016), Ziebell et al., (2019), Ben-gal (2019), Aral et al. (2012). The majority of the most cited publications are article type publications. The research methods discussed in the publications were reflected and used in the keywords. Out of the 32 publications in Table 2, 13 adopt the qualitive research method and 13 adopt the quantitive

research method, except for those whose search method cannot be determined. Among the quantitative methods, data and text mining, algorithm-based analysis techniques and statistical techniques were used. Among the qualitative methods, conceptual framework definitions are remarkable. The articles that received the most citations and had the most links with other articles were written in the type of "Literature Review" and adopted the qualitative research method. In recent years, the most cited articles have included technology-related and analytical process keywords and basic concepts related to HR in a balanced and combined manner. These publications adopt quantitative methods. This shows us that regardless of the method useed, HR-related concepts are the main element and the publications are not method-oriented. The majority of articles that do not use quantitive methods use technology-related keywords. These studies, which examine the new concepts used in the field of HR analytics in a theoretical framework, are valuable in that they are cited many times, explain the connection between related concepts and are based on a certain cumulative knowledge.

Table 2. Most cited publication on HR analytics

D	C	L	T	Research Method
Marler 2017	49	14	Review	Empirical (integrative synthesis)
Angrave 2016	73	12	Article	İnterview with HR professionals, literature view
Ziebell 2019	3	9	Review	Literature Review
Ben-gal 2019	4	7	Review	Literature review, Content analysis
Aral 2012	71	6	Article	Empirical
McIver 2018	11	5	Article	Multiple iteration process in concert to support decisions
Huselid 2018	15	5	Editorial Material	-
Ulrich 2015	79	5	Article	Overview of current and future for HR
Pessach 2020	4	4	Article	Comparing various interpretable and non-interpretable models (AUC measures)
Hamilton 2020	4	4	Article	Examining challenges implementing big data analytics in HR
Tursunbayeva 2018	12	4	Review	Quasi-systematic scoping review
Pape 2016	18	4	Article	Empirical (operational research methods)
Dulebohn 2013	34	4	Article	Framework for HR decision-making
Calvard 2018	7	3	Article	Review
Gubbins 2018	7	3	Editorial Material	-
Levenson 2018	9	3	Article	Review
van der Laken 2018	6	3	Article	General linear models (GLMs), Optimal Matching Analysis (OMA)
Levenson 2017	7	3	Review	Conceptual review

van den Heuvel 2017	13	3	Article	Qualitative, practitioners group, concept analysis
Vargas 2018	3	2	Article	Empirical, Partial least squares (PLS)
Wang 2018	4	2	Article	Longitudinal multivariate quantitative analysis
Simon 2018	6	2	Article	Case study, quantitative analysis
King 2016	13	2	Article	Review
Pejic-Bach 2020	12	1	Article	Analytical approach, data extraction, machine-learning analysis
Gelbard 2018	7	1	Article	Sentiment analysis, text mining
De Mauro 2018	43	1	Article	Web scraping, expert judgment, topic modeling algorithm
Koriat 2018	3	1	Article	Inferential statistics and data mining techniques
Lengnick-Hall 2018	11	1	Book Chapter	-
Sharma 2017	5	1	Article	Conceptual framework
Bassi 2016	5	1	Editorial Material	-
Gubbins 2015	24	1	Editorial Material	-
Kapoor 2012	8	1	Article	Review

D: Document, C: Citations, L: Links, T: Type of publication

4.4. Bibliographic coupling-documents

Bibliographic coupling refers to the number of common references cited by publications. Common references in all of the studies in the field of HR analytics are included in Figure 5. Document-based bibliographic analysis is based on the criteria that each source should be referenced in at least three publications. Table 3 shows the most cited studies, their connections with other publications, authors, year of study and how many pages the study consists of. In 80 of the reviewed studies, Ulrich and Dulebohn (2015), 74 of them Angrave et al. (2016) and Aral et al. (2012), in the 50 of them Marler and Boudreau (2017) were shown as a reference.

Table 3. Information about examined publications

C	TLS	Author/s	Year	NP
79	11	Ulrich, D; Dulebohn, JH	2015	17
73	66	Angrave, D; Charlwood, A; Kirkpatrick, I; Lawrence, M; Stuart, M	2016	11
71	3	Aral, S; Brynjolfsson, E; Wu, L	2012	19
49	114	Marler, JH; Boudreau, JW	2017	24
43	17	De Mauro, A; Greco, M; Grimaldi, M; Ritala, P	2018	11
34	14	Dulebohn, JH; Johnson, RD	2013	13
24	9	Gubbins, C; Rousseau, DM	2015	17
18	40	Pape, T	2016	12
15	48	Huselid, MA	2018	6
12	46	Tursunbayeva, A; Di Lauro, S; Pagliari, C	2018	24
13	44	Van den Heuvel, S; Bondarouk, T	2017	22
13	29	King, KG	2016	9
12	8	Pejic-Bach, M; Bertoncel, T; Mesko, M; Krstic, Z	2020	16
11	42	McIver, D; Lengnick-Hall, ML; Lengnick-Hall, CA	2018	11
11	24	Lengnick-Hall, ML; Neely, AR; Stone, CB	2018	30
9	83	Levenson, A	2018	16
8	0	Kapoor, B; Sherif, J	2012	13
7	60	Levenson, A; Fink, A	2017	12
7	53	Calvard, TS; Jeske, D	2018	6
7	51	Gubbins, C; Harney, B; van der Werff, L; Rousseau, DM	2018	10
7	31	Gelbard, R; Ramon-Gonen, R; Carmeli, A; Bittmann, RM; Talyansky, R	2018	15
6	64	Simon, C; Ferreiro, E	2018	13
6	48	Van der Laken, P; Bakk, Z; Giagkoulas, V; van Leeuwen, L; Bongenaar, E	2018	10
5	41	Sharma, A; Sharma, T	2017	14
4	87	Ben-Gal, HC	2019	20
4	71	Wang, L; Cotton, R	2018	20

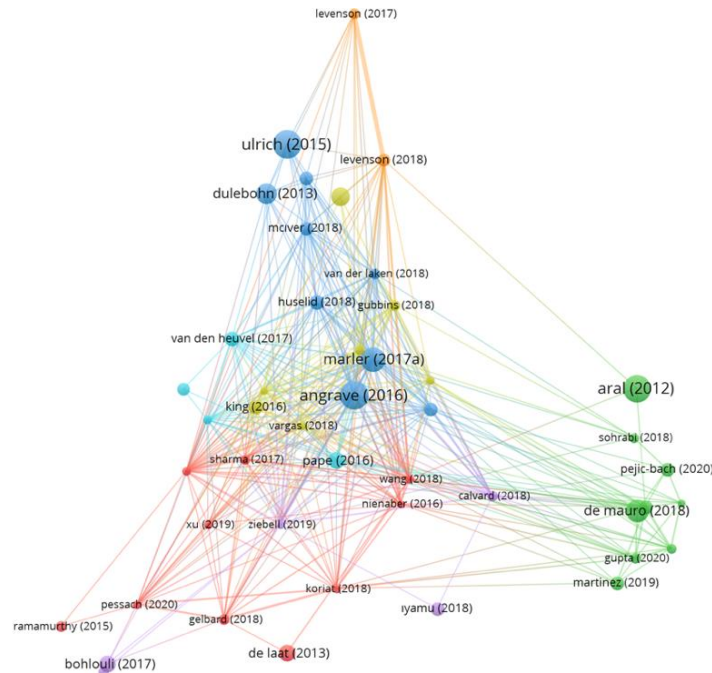| 4	37	Hamilton, RH; Sodeman, WA	2020	11
4	27	Pessach, D; Singer, G; Avrahami, D; Ben-Gal, HC; Shmueli, E; Ben-Gal, I	2020	18
3	67	Ziebell, RC; Albors-Garrigos, J; Schoeneberg, KP; Marin, MRP	2019	27
3	58	Vargas, R; Yurova, YV; Ruppel, CP; Tworoger, LC; Greenwood, R	2018	22
3	37	Koriat, N; Gelbard, R	2018	24

C: Citation, TLS: Total Link Strength, NP: Number of page

Figure 5. Mapping of bibliographic coupling of publications on HR analytics

The number of authors of the publications; 30 with one author, 64 with two authors, 32 with three authors, 30 with four authors, 11 with five authors, 8 with six authors, 2 with seven authors and 1 with twelve authors. The number of authors of the publications in the last two years and the number of authors of the publications made between the years 2012-2015, when the HR Analytics literature started to develop, are given in Table 4. The distribution of authors shows that in the first years, mostly single-author publications were made, and the number of collaborations was not high. In recent years, the number of single-authored studies has decreased and the number of multi-authored studies has increased considerably. The number of authors of the most cited studies is two or more. Author collaborations of the most cited studies are from different fields. In particular, De Mauro et al., written in 2018, is a joint synthesis of the engineering field and the management field. This table shows that HR Analytics should expand its boundaries beyond the field of human resources and cooperate with the engineering field, which deals specifically with technical issues and software, and the profiles of the studies are moving in that direction.

Table 4. Number of authors of early stage publications and the last two years publications of HR Analytics literature

	2010-2015	2020	2021	Most Cited Publications and Authors Study Field			
1 author	4	1	2	Ulrich 2015	79	2 authors	Business, Human Resources and Labor Relations
2 authors	7	9	5	Angrave 2016	73	5 authors	Management, Business and Economics, Data Analytics, Strategic HR Analytics Consultant, Business
3 authors	1	7	4	Aral 2012	71	3 authors	Business, Management, Management
4 authors	1	10	5	Marler 2017	49	2 authors	Management, Management and Organization
5 authors	-	3		De Mauro 2018	43	4 authors	Enterprise Engineering, Civil and Mechanical Engineering, Business and Management
6 authors	1	2					
7 authors		1					
12 authors	1						

4.5. Co-citation – cited references

Citing publications in the same field together is used to search similar publications. Co-citation analysis is used to analyze and understand the intellectual structure of a discipline. When the same reference pairs are cited together in publications on a subject, research clusters are formed (Surwase et al., 2011). Co-citation analysis is a suitable method for mapping the research area as a whole. Figure 6 shows a map of co-cited publications. As a result of the analysis, the resources that are linked are cited at least three times together. 197 sources are shown in five clusters. The publications that lead these clusters are the following; Barney (1991), Marler and Fisher (2013), Davenport et al. (2010), Angrave et al. (2016), Marler and Boudreau (2017).
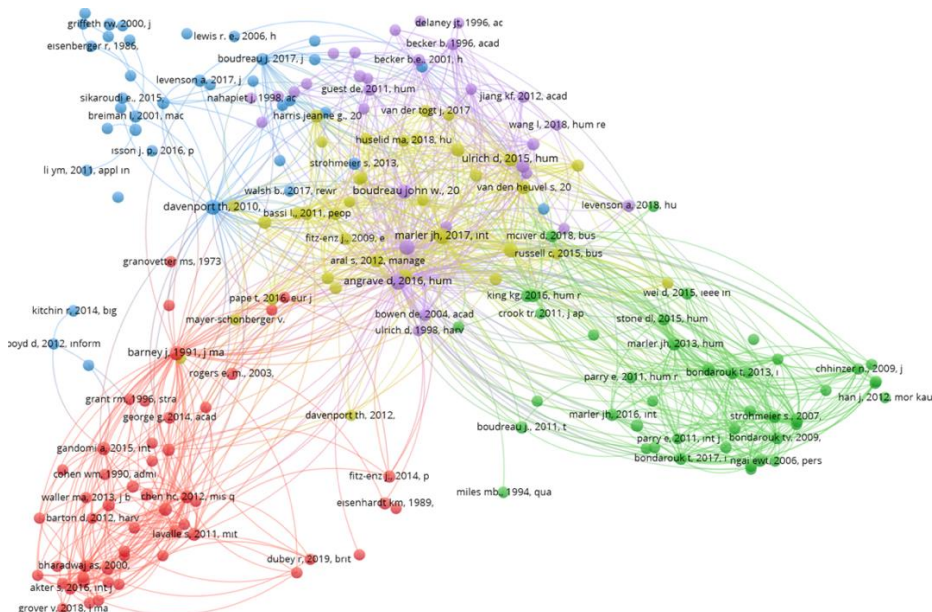
Figure 6. Mapping of references based co-citation of publications on HR analytics

4.6. Co-citation – cited sources

Cited sources are interesting to evaluate the co-citations of the journals, the selection of journals and the collection of journals that serve publication-oriented researchers on a particular subject. Journal co-citation networks reveal the macro structure of the scientific discipline through the analysis of journal titles. The evaluation of the co-citation analysis of HR analytics publications in terms of the published source is presented in Table 5. 3820 cited sources were analyzed. Human Resource Management, Academy of Management Journal, The International Journal of Human Resource Management, Journal of Cleaner Production, Academy of Management Review journals are cited by publications on HR analytics and have the most links. While it is seen that journals publishing about management and human resources are closely linked to each other, the link of Journal of Cleaner Production is far from others since it publishes mostly about cleaner production, environmental, and sustainability research and practice. It is an indication that HR analytics is interested in sustainability and related issues as well as the management dimension and technology dimension. The most cited countries were explained in the citation-countries section. The countries of the journals cited by the publications are summarized in Table 5. The most cited publications were USA, UK and Italy. However, when we look at the countries where the cited journals are published, Netherlands seems to be dominant besides the USA and UK.

Table 5. Journals of co-cited publications on HR analytics

Journals	C	TLS	Ct	Journals	C	TLS	Ct
Human Resource Management	117	5066	USA	Resources, Conservation **and** Recycling - Journal	21	2018	Nethe rl.
Academy of Management Journal	146	4819	USA	Organization Science	51	2016	USA
The International Journal of Human Resource Management	145	4419	UK	International Journal of Information Management	79	1973	UK
Journal of Cleaner Production	80	4391	UK	Strategic Management Journal	48	1933	UK
Academy of Management Review	107	3586	USA	Journal of Business Research	57	1930	USA
Journal of Management	104	3121	USA	MIT Sloan Management Review	43	1491	USA
Journal of Applied Psychology	108	2711	USA	Management Science	47	1417	USA
Harvard Business Review	98	2637	USA	Technological Forecasting and Social Change	26	1363	USA
Human Resource Management Review	81	2562	Nethe rl.	Administrative Science Quarterly	34	1307	USA
MIS Quarterly	84	2509	USA	British Journal of Management	33	1271	UK

International Journal of Production Economics	48	2251	Nethe rl.	People and Strategy	47	1117	USA
International Journal of Production Research	36	2198	UK	Organizational Dynamics	38	1110	UK
Human Resource Management Journal	75	2030	USA	The Journal of Organizational Effectiveness: People and Performance	41	1099	UK

C: Citation, TLS: Total Link Strength, Ct: Country

5. Discussion

The results of this study are consistent with previous research (Rasmussen and Ulrich, 2015; Marler and Boudreau, 2017) and show that research interest in HR analytics has increased. While earlier studies on HR analytics mostly emphasize technical analytical competencies, the studies conducted in recent years deal with the subject with a wider perspective and application examples. The keywords discussed in the reviewed articles include not only analytical but also concepts that are closely related to human resources such as talent, recruitment, employee turnover. Machine learning in particular, artificial intelligence, algorithm, and internet of things are also frequently used keywords. Although the keyword of strategy is not used as often as other keywords, it is included in the publications. As the most cited article, Ulrich and Dulebohn (2015) highlighted the changes in HR and raised the question of whether the HR journey will continue or not, issues related to HR in all aspects, such as HR stakeholders, targets and investments for HR activities, were discussed. It is seen that the study is a guide in terms of comprehensively covering the path that HR has covered up to now. Barney (1991), is the most used reference in the reviewed articles, and the reason behind that can be understood from the study of Marler and Boudreau (2017), who explained this by asking the question: "Why does HR analytics work?". Barney introduced the resource based view in 1991. For human capital changes and strategic outcomes, testable hypotheses, and rigorous research questions, frameworks such as the resource-based view, linking data and decisions, can offer attractive future opportunities for research. Analytics is a complex process with its data collection, analysis, interpretation, reporting, expertise and technical aspects, and it is definitely a team work. It is unlikely that any individual will have all the skills required to design and implement an effective workforce analysis system (Huselid et al., 2018). There are many studies focused on the competencies that people who will perform HR analytics should have. (Ulrich et al., 2017; Andersen, 2017; van der Togt and Rasmussen, 2017; McIver et al., 2018; Minbaeva, 2018; McCartney et al., 2020). Perhaps it would be better to decide first how to do HR analytics and how to create this team process. People who will apply HR analytics must have analytical competence (Rasmussen and Ulrich, 2015; Marler and Boudreau, 2017). While training HR employees in analytical skills seems like a logical solution, it is difficult in practice. There may also be external staff transfer to the HR department (Marler and Boudreau, 2017). IT personnel competent in analytical issues can be evaluated as an option. While building the analytical competence side, we shouldn't deprive the non-technical HR competency side. In this case, Fernandez and Gallardo-Gallardo (2020), focused on the question of which team members with different competencies should be included in HR analytics teams. McIver et al. (2018) and Minbaeva (2018) highlighted that HR analytics have a strategic structure and state how the team responsible for HR analytics should coordinate with other business analytics teams within the organization since data science, strategic decision making and business concepts are now intertwined and cannot be separated from each other with clear lines. Perhaps, another option to focus on is that educational institutions that train experts in the field of business or human resources should include courses such as statistics, analytics, information systems and analytical processes in their curriculum.

Andersen (2017) and McIver et al. (2018) stated that many of the interview participants were extremely ambitious to find all the necessary competencies in one person. Hence, it is necessary to bring together HR analytics teams of complementary roles to acquire the necessary knowledge skills and competencies and turn workforce data into actionable insights. HR academics and researchers can focus on the productivity-enhancing role of data scientists and examine how an organization can attract and retain high-performance data scientists and motivate them to serve the interests of the company (Kim et al., 2021).

Studies that affect the successful implementation of HR analytics emphasize the importance of organizational capabilities (Minbaeva, 2018), organizational design and culture (Levenson, 2018). Technologies used in HR analytics must be suitable for the structure of the organization. Digital HRM technologies will not fully deliver the desired performance unless the organization has a solid system foundation. The positive effects of HRM digitization and HRM system maturity on company performance are evident (Zhou et al., 2021). Firms that focus on learning and information sharing can bring great benefits in the digital age (Tortorella et al., 2020). Digital readiness requires leveraging data analytics and building information and decision support systems. Education and skill development also requires investment in human resources. The analytical process such as data collection, storage, analysis and interpretation should be associated with the supply chain. All of these requirements require an infrastructure (Pirola et al., 2019).

Studies show that regardless of the type of data used, the quality of the data is very important. All studies agree that HR analytics results depend on the quality of the raw material. Therefore, data quality is one of the most important requirements for HR analytics to be successful (Minbaeva, 2018; Fernandez and Gallardo-Gallardo, 2020). Verma et al., (2020) concluded that big data quality affects big data-driven human resource practices and human resource service quality. Human resource service quality also affects innovation competence through its mediation effect. Other studies investigating the quality of big data (King, 2016; De Mauro et al., 2018) prove that big data quality affects innovation competence and big data-driven human resource practices. There are other studies that prove the relationship between big data quality and HR service quality (Iqbal et al., 2018). According to Garcia-Arroyo and Osca (2019), big data quality has a promising future in the HR function of SMEs within the scope of strategic management.

While the e-HRM model works on the human resources information system, the current HR analytical data is very large and uncertain in size. Through IoT-based applications, it is possible to make a new design and data analytics for e-HRM activities such as e-Recruitment, e-Selection, e-Performance, e-Compensation, and e-Learning. Applications based on data science and machine learning techniques are method-intensive and do not provide a prediction for HR. The authors stated that they will apply new analytical techniques to measure the effectiveness and usability of the e-HRM model and continue to study it (Nasar et al., 2020). There are studies that provide application-based solutions for practitioners. There are studies that can predict business participation and offer solutions with machine learning methods for personnel selection. Choi and Choi (2020) measure the personnel profile and which features participate in business with a generalized linear model (GLM).

Due to innovations such as the Internet of Things (IoT) and digitalization, tremendous employee data is created simultaneously. Examples of this data include performance and compensation data, online testing and learning data, business planning data, economic and commercial data, geolocation data, and biological and demographic data. Therefore, big data has the potential to benefit HR departments by improving employment decisions (Gobble, 2017). By modeling performance indicators, it is possible to apply a data mining technique that determines digital

footprints with e-mail analysis and predicts real-time trends (Gelbard et al., 2018). Another study linking HR analytics and economic data provides a perspective to benefit the field of strategic HRM with the people analytics and discusses insider econometrics and the longitudinal analysis approach (Larsson and Edwards, 2021). This perspective considers people analytics a business application and says that people analytics focus on empirical analysis that measures employee performance. Some studies on HR analytics mention the lack of empirical analytical applications (Kremer, 2018; Tursunbayeva et al., 2018). Providing a multi-criteria problem solution with a mathematical model for the sustainable supply chain need, Yassine and Singh (2020) provided an analytical solution to the personnel assignment problem by including the human factor in the model. Integrating HR applications into the supply chain function helps make more effective decisions.

The analyzed studies provide examples not only from the business world but also from human resources activities in the academic environment. Employment turnover estimation can be made with an empirical example of how research performance data can be related or predictive to hiring decisions in the context of the university (Ryan, 2020). HR recruiters and training providers are looking for solutions to meet the supply and demand in the job market more effectively with various approaches such as web scraping of job postings posted online (De Mauro et al., 2018), time series modeling and system dynamics simulation (Safarishahrbijari, 2018). A study that examines the comments of employees on social media about their employers according to the expressions of optimism and partnership tries to measure brand loyalty. Content analysis method was used in the study. It offers different strategies to human resources and marketing managers and sheds new light on how they interact with brands (Pitt et al., 2018). For the analytical process, it is recommended to use external data from the market other than internal data of the organization (Malisetty et al., 2017). In the digital age, employees as stakeholders of the business, express their opinions on social media. In HR studies conducted in recent years, it is seen that employees' attitudes and discourses in social media or blog structures other than business practices are examined. Chittiprolu et al., (2020) treated employees as internal consumers and analyzed their feedback on Glassdoor platform through text mining methods with R.

McCartney et al. (2020) revealed a competency model in their research conducted through interviews with HR analytics experts. It is observed from their research that HR analysts are inadequate with the following competencies; business intelligence, HR knowledge deficiency, data analysis, statistics, reporting and storytelling. It is seen that these analysts, who went through the HR training and certification process, interpret their lack of these competencies as "HR training does not teach these skills". McCartney et al., (2020) conducted content analysis of job postings to identify competencies critical to the role of HR analysts, and the results were: technical knowledge, consulting, data fluency and analysis, storytelling and communication and HR and business intelligence. The mainly required qualifications in job postings; knowing about technical knowledge, HRIS, database, Microsoft Excel knowledge, Tableau and Power BI business intelligence tools, data integrity and maintaining data quality.

Examining the barriers to the adoption of HR analytics, Fernandez and Gallardo-Gallardo (2020) divided the barriers into 4 categories: (i) data and models, (ii) software and technology, (iii) people, and (iv) management. Trying to make sense of why the adoption of HR analytics is so delayed with the planned behavior theory (TPB), Vargas et al. (2018) examined the information and decision process. Since HR analytics is a decision-making process, an interruption in the process at any point can lead to early or accelerated decision making. If this decision is made for reasons such as ignorance or weak self-efficacy, it may cause a decision against the business and the process not to be continued. In addition, lack of resources, lack of supportive norms or attitude towards innovation may be other

reasons for the inadequacy. Organizations that want to facilitate the adoption of HR analytics can take action to remove barriers to the individual's decision (Vargas et al., 2018).

Boudreau (2017) expressed the complexity of models and methods for doing analytics. As said, researchers who can apply complex models focus only on the statistical part of the models used for analysis, without deepening their strategic aspects (Fernandez and Gallardo-Gallardo, 2020). This means that these publications using complex models cannot provide a clear link between their solutions and their impact on business results. As a suggestion for the practice and theory gap, an agile workforce analytics process is proposed and explained in five main elements: (1) prioritizing problems, (2) integrating deductive and inductive approaches, (3) preparing and validating data, (4) implementing multiple methods together and supporting decisions; and (5) transforming insight into action to improve business results (McIver et al., 2018).

6. Conclusions

This study presented a bibliometric analysis of studies in the HR Analytics literature since 2010. In line with previous research, the study results show that research interest in HR analytics has increased in recent years. Although the technical aspects of HR analytics literature such as data collection and analyzing data are emphasized in the early years of the development period, the studies conducted in the last five years emphasize the concepts of strategy and talent in a more HR-focused analytics window. Experiencing technological developments, the changes in the topics discussed in the HR analytics literature and the change in the key concepts used, are parallel. The answer to the question of what awaits HR analytics, which is greatly affected by the developments in technology, can be found by following these developments closely. The point to note here is that although both statistical and technical analytical methods are used and these techniques renew themselves rapidly, they are ultimately a tool and the theoretical knowledge and experience of HR experts will always be needed. The criticism of studies focusing on technical analysis because they do not have HR insight and studies with HR insight are also weak in terms of technical analysis, shows that a balance must be established between these two elements. Otherwise, responses to key HR issues might come from elsewhere in the organization, which could lead to questioning the existence of HR departments especially in smaller organization.

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It is a fact that it is not possible to do HR analytics without quality data. Studies focusing on data quality show that first of all, it is necessary to have a clean, reliable, valid and integrated database. This will require IT departments to be included in the process. In particular, recruitment data, compensation data, performance data, learning / development data and workforce planning data will be of key importance in this process. It is very important that this data is easily accessible at all times. It is an obvious result that one should have an HR insight in order to understand the results obtained at the end of the analytical process. Having an HR insight means being close to employees, being aware of employee issues and the trends that are likely to develop within the company. Sometimes the words of a single employee can give the necessary insight to make sense of the data that comes out at the end of large analyzes. Studies mainly focus on the competencies of HR professionals related to HR analytics and establishing a competence model. As an analytical process, it requires certain stages. Execution of this process is a team work. Obtaining, preparing and storing big data is a technical process. Data analysis is a separate technical process that requires statistical and mathematical competencies. The interpretation of the findings obtained as a result of the analysis and their reporting to the senior management requires both technical competence and HR expertise and experience. As a result, we agree with the studies that say that a team should be formed for HR analytics.

It does not seem possible to find the answers sought in the analysis processes only with HR data. Studies that demonstrate this conduct research on employees' social media accounts, platforms where online comments are posted, websites with job postings, and supply chain data. Data sources fed by HR will not be sufficient after a while. Research conducted in recent years also shows that there are now studies on personality analysis of candidates, up to their social media accounts, during the recruitment process. Camera and image processing techniques may be needed, and the behavior and movements of the employees in working conditions can be examined. Perhaps one step further could be studies on diversifying or deepening HR applications that can be carried out by obtaining external data from companies providing external data services. Henceforth we should focus on what we cannot produce rather than what we produce. In addition, some ethical problems arise from the measurement of employees' attitudes and behaviors with technologies. Even though HR analytics have contributions such as value creation, positive outputs and competitive advantage, employees' privacy, security and confidentiality should not be neglected in this process. The literature seems to neglect the issue of ethics.

All these evaluations emphasize some functions of HR. The emphasis that HR analytics requires teamwork brings up the importance of selection and placement of people with the appropriate competence for HR analytics teams. HR should select and place suitably qualified individuals to perform each different role. Utilizing HR analytics techniques allows to identify labor market supply and demand, improve employment decisions and identify personnel profiles. Creating the necessary technological infrastructure for HR analytics and planning its processes are among the functions of HR. Even if the necessary infrastructure is established and all facilities are provided, there may be some motivational problems in front of the adoption of HR analytics systems. HR should motivate employees in this regard and ensure that analytical systems are designed as appropriate systems that motivate employees, rather than just for the benefit of the business. It should work on the orientation and integration of human resources, and the involvement and retention of high-performance data scientists in HR analytics teams to be formed. Adoption of methods that encourage participation in work should be supported. Analytical solutions should be used in personnel assignment problems. It should reduce the current human resource losses by making employment turnover forecasts. It should guide the human resources to have analytical competencies and provide necessary educational and developmental opportunities.

Limitations

As with all researches, this research has some limitations. In order to provide data for this study, the publications scanned in the Web of Science database were evaluated. A search was made in the database with the keyword "human resource analytics" and a selection was made among the obtained articles in which the abstracts were evaluated according to whether the study is related to human resources or not. Undoubtedly, the literature includes HR analytics studies before the year 2010-2021, on which this study was based. Not all of these studies may be scanned in the Web of Science database. The scope of the research has been evaluated within this limitation.

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