USE OF BIG DATA IN HUMAN RESOURCE MANAGEMENT TO STRENGTHEN HUMAN CAPITAL MANAGEMENT?

Ayoub KATFI
Laboratoire LERSG, Université Mohammed V, Maroc
(*ayoub.katfi@um5r.ac.ma*)

Oumaima EL MNOUER
Laboratoire LERSG, Université Mohammed V, Maroc
(*oumaima.elmnouer@um5r.ac.ma*)

Sabrina GHALLAL
Laboratoire LAREQUOI, Université Paris-Saclay, France
(*sabrina.ghallal@yahoo.com*)

Hamza KATFI
Laboratoire LERSG, Université Mohammed V, Maroc
(*hamza.katfi@um5r.ac.ma*)

Fetta BOUDRICHE
Laboratoire LAREQUOI, Université Paris-Saclay, France
(*fetta.boudriche@gmail.com*)

Pr. Thierry COME
Laboratoire LAREQUOI, Université Paris-Saclay, France
(*thierry.come@uvsq.fr*)

Abstract:
HR Big Data represents an innovative approach to managing large-scale employee-related data, offering significant opportunities for Human Resource Management (HRM). It enables companies to better understand their employees, make more informed decisions, and predict HR-related risks and opportunities. This new approach allows the processing of large volumes of data and the identification of relevant correlations for businesses, particularly in the HR field. However, the challenge lies in identifying relevant data and using it wisely to solve specific HR problems. Although widely regarded as a revolution in management press, academic research on HR Big Data remains limited, largely due to the difficulty of collecting and analyzing massive data sets. This article aims to increase the visibility and understanding of the potential contributions of HR Big Data to Human Resource Management from both a scientific and managerial perspective. The study seeks to propose an exhaustive classification of the HR Big Data literature, complemented by a comprehensive bibliography and a prospective research agenda. To achieve this, a systematic literature review methodology was adopted, based on a database of articles and books published in prestigious journals between 2010 and 2018. The results of this analysis reveal the main advances in HR analytics research. Major findings, as well as gaps in the existing literature, are also highlighted. This study has the potential to inspire new research directions.

Introduction

The evolution of data storage has been marked by widespread adoption across various fields, ranging from academic purposes to government, private, and corporate sectors within companies, societies, and organizations. This transformation has accelerated over time, evolving from storing information in books and hard drives to the emergence of online storage solutions. This rapid technological advancement has transformed the world into a global machine, driven by computers and mobile devices, generating astronomical amounts of data daily from various sources such as digital photos, videos, and social media platforms (Katfi A., El Mnouer O., et al. (2022)).

The diversity of data formats reflects the plurality of sources, presenting companies and organizations with the challenge not only to store this data effectively but also to harness it in order to extract meaningful value. The use of Big Data emerges as a strategic response to this growing need, offering the possibility to transform these vast datasets into actionable insights. This data exploitation capability provides companies with innovative opportunities, thereby enhancing internal decision-making. Indeed, in-depth data analysis using Big Data becomes an essential lever for generating crucial information that can optimize organizational performance and drive innovation. Therefore, the management and effective utilization of data are no longer merely a logistical necessity but have become a major strategic asset in an ever-evolving economic landscape.

Big Data is emerging as an unprecedented source of value creation in the information age, promising significant productivity gains when the data used is aligned with the specific aspects being explored (Nesvijevskaia, 2019). The ability to manage and interpret this data has become an essential tool, enabling each actor to better understand the specific context of their company and industry (Ferréol, 2014).

Historically, data analysis was primarily associated with fields requiring calculations and numbers, such as finance and banking. However, this approach has evolved, and today, data analysis extends to areas once considered far removed from quantification. Marketing, for instance, now utilizes Big Data to predict consumer behavior and improve companies' strategic positioning.

A new frontier is also emerging in the field of human resources, where Big Data is beginning to convince Human Resource Management (HRM) of its utility as a data science. This innovative approach offers solutions to the complex needs of human

resources, representing a significant advancement in how companies approach the management of their human capital. Indeed, Big Data is positioned as a cutting-edge tool, capable of providing precise answers to the specific challenges of the HR field, marking a major shift in how companies perceive and optimize their human capital.

Initially, the role of human resources was primarily focused on managing individual employee records within the company. The advent of HR information systems transformed these records into digital data. The digitization of data paved the way for increased connectivity between different data points, thus creating actionable insights. Analyzing this information now provides new perspectives on employees, becoming a powerful lever for decision-making in human resource management (Silva, 2018).

This digital revolution has given rise to an emerging phenomenon within human resource management, known as HR Big Data. Essentially, HR Big Data represents an innovative approach and methodology for managing large sets of employee-related data. The use of advanced data processing and algorithms now enables a deeper understanding of employees' needs and motivations. A diverse range of HR applications and services leverage these capabilities to provide relevant insights to companies (Silva, 2018).

HR Big Data introduces a new perspective in human resource management by offering the ability to process massive volumes of data and uncover meaningful correlations between them. This wealth of information represents a major strategic opportunity for the HR function, enabling precise responses to organizational challenges. However, the critical challenge lies in the ability to identify which data to use and how to effectively leverage it to address specific HR issues. Thus, HR Big Data ushers in a new era in human capital management, where mastery of data analysis becomes a key skill in shaping the future of HR practices.

HR Big Data has been heralded in management press as a true innovation, even a "revolution." However, despite its pervasive presence in all aspects of professional life, academic work dedicated to this subject remains limited. The speed at which Big Data has evolved has not allowed scholars and researchers enough time to conduct comprehensive studies and fully understand the composition and potential of Big Data (Katfi A., El Mnouer O., et al. (2022)).

This gap in fundamental knowledge within the academic field highlights the need for thorough exploration. The present article aims to shed light on often overlooked

dimensions of Big Data. At a time when digital transformation is becoming predominant in the HR function, characterized by a multitude of technological solutions and digital practices, it is essential to challenge traditional approaches to human resource management.

The objective of this research is to systematize previous academic contributions and clarify the innovations of Big Data, highlighting its implications and challenges for Human Resource Management (HRM). The central question this paper seeks to address is the following: What is the contribution of HR Big Data to human resource management? By tackling this issue, this research aims to enhance our understanding of the role of Big Data in the field of human resources, shedding light on potential pathways for a more strategic and innovative use of these massive datasets in the contemporary professional context.

The approach of this study begins with an exploration of the various definitions attributed to the concept of Big Data in specialized literature. This preliminary step aims to shed light on the multiple facets and nuances that characterize this crucial component of digital transformation. Indeed, the semantic and conceptual richness associated with Big Data provides fertile ground for a deeper understanding of its influence on professional practices.

Subsequently, the focus will shift to the specific contribution of HR Big Data to human resource management, engaging in a detailed analysis of its implications and various uses within the HR field. This investigation will explore the different ways in which Big Data is transforming traditional HR management practices, highlighting the opportunities it offers as well as the challenges it presents to professionals in the sector.

Considering the true revolution that Big Data represents in the landscape of human resource management, this research aims to shed significant light on the complex nature of this convergence between massive data and HR practices, by systematizing existing knowledge and exploring new perspectives.

1. Literature Review

1.1. Big Data: Origins and the Search for Definitions

The essence of Big Data takes on different meanings depending on the context of its application, reflecting the diversity of communities interested in it. The attempt to define this term proves challenging due to the multitude of interpretations surrounding it.

Numerous researchers and academics have proposed approaches to highlight the ambiguous aspects that characterize the concept of Big Data. Before presenting the various definitions found in the literature, it is relevant to explore the origin of the term, which dates back to the late 1990s. Two NASA scientists, Michael Cox and David Ellsworth, introduced it to describe the challenges associated with managing and visualizing databases that exceeded the capacity of the computer systems at the time.

Big Data has its roots in data science, also known as "Data Science." This discipline, merging technology, analytical algorithms, and the exploration of data stored in companies' data warehouses, aims to solve complex problems.

The emergence of Big Data has accelerated with the advent of the Internet of Things (IoT), driven by an explosion of data. This growth can be attributed to the proliferation of digital tools that are constantly connected to the Internet, such as smartphones, tablets, sensors, and mobile chips. These connected devices collect massive amounts of data daily, revealing actionable insights about individual, social, and collective activities.

The increasing abundance of connected devices equipped with sensors provides companies with a considerable wealth of information. This data pool offers the possibility to create new business models, improve operational processes, and reduce costs and risks (Chui et al. (2010)).

Big Data has thus emerged as a major phenomenon, initially fueled by the data surge due to the advent of social networks and the proliferation of mobile phones. Gradually, it extended its influence to all sectors of society, representing a significant transformation in how we understand and utilize data (Mayer-Schönberger and Cukier, (2014), Menger and Paye (2017)).

The definition of Big Data varies depending on the perspectives of researchers and practitioners. According to Ghasemaghaei et al. (2015), Big Data is defined as the application of tools or processes aimed at extracting large-scale data at low cost, enabling the extraction of meaningful insights to improve organizational performance.

Lamba and Dubey (2015) view Big Data as the use of various analytical methods to derive useful information from vast datasets, offering descriptive, predictive, and prescriptive actionable results.

In a similar vein, Storhaye (2016) defines Big Data as the use of massive amounts of data from multiple and heterogeneous sources (internal and external databases, etc.).

This approach enables the construction of models, usually behavioral, whose analysis allows for the anticipation of behaviors or the prediction of probabilities, thus evoking the concept of "predictive models."

According to Jeble et al. (2018), Big Data is an emerging field where various computing, technical, and statistical algorithms are employed to extract insights and patterns from vast datasets. Barker and Ward (2013) define Big Data as the storage and analysis of massive and/or complex datasets using techniques such as NoSQL and Machine Learning.

Big Data relies on various statistical techniques, notably data mining, to analyze data. These techniques aim to create formulas or algorithms that best replicate these data patterns. Based on the use of automated algorithms, Big Data adopts an inductive approach to anticipate future trends and propose alternative scenarios to solve organizational problems. In short, this diversity of definitions reflects the complexity and richness of Big Data as a cross-disciplinary phenomenon, shaping the evolution of organizational practices and strategies.

1.2. Characteristics and Specificities of Big Data

Gartner (2001) laid the foundation for the conceptualization of Big Data by introducing three key concepts: Volume, Velocity, and Variety. This early definition stated that Big Data refers to information characterized by its large volume, speed, and diversity, requiring innovative and cost-effective approaches to information processing to enhance understanding and decision-making.

Gartner's report emphasized three crucial variables: the increasing volume of data (Volume), the diversity of data formats from various sources (Variety), and the dynamic nature of data requiring frequent updates (Velocity). Later, two additional dimensions were added—Veracity (data quality) and Value—completing the "5 Vs" of Big Data.

Further evolution was contributed by Saggi and Jain (2018), who extended the "5 Vs" to "7 Vs." They included Valence (representing the interconnection between data) and Variability (describing the dynamic and rapidly evolving nature of data).

These two added dimensions highlight the growing complexity of data in a context where interconnectivity and dynamics have become key elements of Big Data analysis.

Over time, the conceptualization of the "Vs" of Big Data has continued to evolve. Various researchers have proposed new "V" terms tailored to different applications and

areas of Big Data intervention. A recent study conducted by S. Dhamodhar-avadhani et al. (2018) identified more than 54 "V" characteristics, such as Visual, Virality, Volatility, and Visualization.

This diversity of dimensions reflects the richness and complexity of Big Data, demonstrating that the concept's definition evolves as new facets and requirements emerge in the ever-expanding field of massive data.

Figure 1: *The Evolution of the V's*
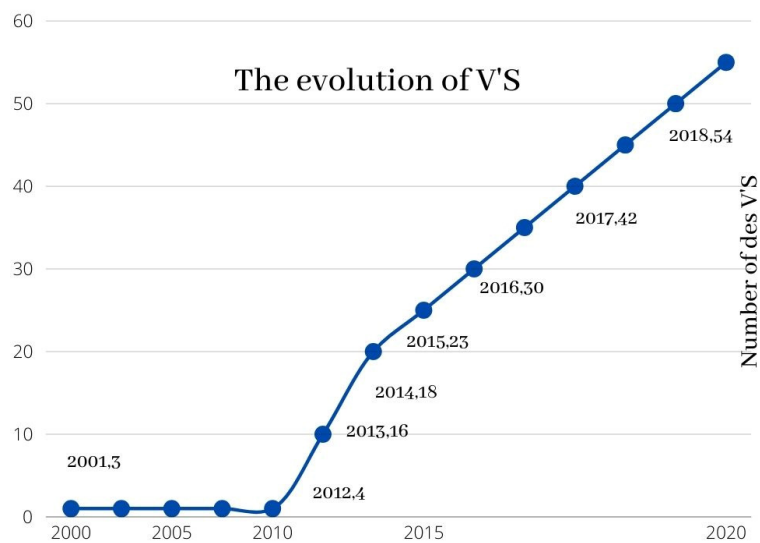
Other research has explored Big Data by focusing on its non-technical aspects. Indeed, Mayer-Schönberger and Cukier (2014) demonstrated that Big Data is not only characterized by its previously mentioned attributes (volume, variety, velocity, value), but also by the methods and techniques used to leverage it.

Traditional scientific methods typically start with a hypothesis about causal relationships between the variables being studied. These hypotheses are then empirically tested using rigorously collected data specifically for this purpose.

In contrast, Big Data research methods often begin with data collected in a less selective manner, without a prior hypothesis. This data is then analyzed to identify patterns or correlations (which do not necessarily imply causality) (Katfi A., El Mnouer O., et al. (2022)).

Thus, the traditional scientific method is hypothesis-based, while Big Data relies on an empirical approach, observing data without preconceived notions (Katfi A., El Mnouer O., et al. (2022)).

Boyd and Crawford (2012) define Big Data as a cultural, technical, and scientific phenomenon based on three elements:

- Technology : This component focuses on improving the accuracy of algorithms used to interconnect, collect, and analyze enormous volumes of data, and increasing computational power.

- Analysis : This refers to the ability to represent data from large datasets to identify trends and formulate relevant statements concerning economic, social, legal, and technical issues.

- Mythology : It is the belief that large datasets provide a superior form of intelligence and knowledge that can generate previously impossible insights, with an aura of truth, objectivity, and clarity.

This definition highlights the various facets of Big Data, emphasizing its essential role and purpose—analyzing vast datasets that require specific technologies, tools, and processes to yield results. This approach is often influenced by the idea that a multitude of data expands the scope of knowledge. Therefore, we can conclude that Big Data is a cultural phenomenon that merges science and technology.

2. Methodology

The literature review focuses on synthesizing academic resources, including research articles and books, that examine HR Big Data, with particular emphasis on the determinants influencing its effective application in organizational contexts. This review was conducted using academic databases, notably Scopus and Google Scholar, and employed search terms such as "HR Big Data."

The research revealed that there are numerous references, books, and reports addressing the concept of HR Big Data. As a result, it may not be perceived as a highly prioritized area of interest for management researchers, leading to a predominance of non-empirical articles. The majority of the articles cited in this literature review are non-empirical in nature.

However, this non-empirical literature has contributed to the development of existing definitions of HR Big Data and has enhanced our understanding of the subject under study. Furthermore, the literature review covers the contribution of HR Big Data to human resource management, which is an iterative process involving the collection, analysis, and use of data to improve decision-making in the HR field. Lastly, the key findings related to the subject under study are discussed.

3. What Are the Differences Between the Quantification Tools Used in HR?

Big Data is often intertwined with other tools used to quantify human resources. This section aims to highlight the distinctions between the various tools dedicated to HR measurement. HR reporting, traditionally focused on retrospective analysis through dashboards and social reports, was once considered a key tool for making informed decisions about the future.

However, as the field of HR quantification has evolved, HR managers are questioning the effectiveness of HR reporting in solving issues and dysfunctions related to human capital management. This re-evaluation has led to the emergence of HR analytics.

Unlike HR reporting, which is focused on describing the past, HR analytics positions itself as a decision-making tool, adopting an approach that could be described as an HR audit. HR analytics seeks to understand and analyze, rather than simply inform and communicate. This discipline aims to go beyond the descriptive nature of phenomena by exploring underlying causes. While HR reporting relies on descriptive statistics, HR analytics employs explanatory statistics using methods such as regression, factor analysis, and predictive statistics.

Some researchers view HR analytics as a natural evolution of HR reporting. Although these two approaches differ in their methodologies, they are not mutually exclusive, as they share a common quantitative foundation. The use of HR reporting remains relevant for providing a historical perspective, while HR analytics emerges as a more advanced solution capable of offering in-depth analytical insights to inform strategic decisions in human resource management.

In the ongoing evolution of HR measurement, an emerging trend is gaining momentum: HR Big Data, which is beginning to surpass HR analytics in terms of recognition, although the two are often confused. However, significant distinctions exist between these two approaches, defining distinct directions. HR Big Data stands out for its predominant use of unstructured data, often external to the company, whereas HR analytics primarily focuses on structured, frequently internal data.

This disparity leads to substantially different approaches, particularly in terms of the statistical tools used, emphasizing data of varied natures and quantities (Cercle, 2017).

It is important to note that behind the term Big Data, it is not merely a data analysis technique but rather an exploratory and inductive approach.

This method goes beyond the mastery of statistical analysis techniques, requiring

extensive experience in the relevant domain (Storhaye, 2016).

Indeed, HR Big Data relies on the collection and exploration of massive volumes of varied data, often sourced externally to the company. This approach requires a deep understanding of the application context, going beyond simple statistical processing to incorporate a broader dimension of business knowledge. Thus, while HR Big Data and HR analytics share the field of HR quantification, their methodological specificities and skill requirements highlight the emergence of a new dimension in HR management measurement.

Table 1: The Differences Between Quantification Tools Used in HR

	HR Reporting	**HR Analytics**	**HR Big Data**
Primary Objective	- Inform - Communicate	- Understand - Analyze	- Analyze - Solve
Final Goal	Describe the HR issue	Identify the cause of the HR issue	Solve the HR issue, prevent HR risks
Data Usage Level	Descriptive analysis	Explanatory, predictive analysis	Predictive, prescriptive analysis
Data Utilized	Mostly internal data	Mostly structured internal data	Structured and unstructured data
Statistical Tools	Descriptive statistics (mean, median, flat sorting, cross-tabs)	Descriptive and predictive econometric modeling (regression, factor analysis)	Predictive modeling, decision trees, machine learning aggregations, neural networks, data mining, inferential statistics
Approach	Represent reality, study each phenomenon in isolation	Relate data and study the links between phenomena (seeking causality between variables)	Forecast using predictive models (seeking correlation between variables), model scenarios and their impact on business results
Type of Approach	Indicator-based operational approach	Hypothesis-based approach	Data-based approach
Actors and Managers	HR professionals	Economists, statisticians	Data scientists
Beneficiaries	Managers	Executives	Executives
Levels of Intervention	Target the company's operational and tactical operations	Target strategic operations	Target strategic operations

4. The Contribution of Big Data in the Context of Human Resource Management

4.1. The Positioning of Big Data in the Field of Management Sciences

A growing number of research fields are incorporating Big Data phenomena into their investigations. Genomics, epidemiology, astronomy, as well as education and history, are adopting Big Data technology. The use of these vast datasets, particularly in the

social sciences and humanities, holds the potential to fundamentally transform research, provided that appropriate tools tailored to these specific fields are adopted (Manovich, 2012).

Big Data finds its place in the approach of Evidence-Based Management (EBM), a method aimed at making management decisions supported by scientific foundations and tangible evidence. Initially applied by marketing departments to continuously optimize customer outcomes, organizational capabilities, and business performance, this approach has expanded to other company functions and, more recently, to human resources management. The goal is to bring more rationality to decisions made by managers and HR professionals, replacing decisions often based on intuition.

Big Data has infused new dynamism into the HR function, making it more credible and reliable than before. This need for relevance in decision-making stems from companies' constant pursuit of growth drivers, where human resources represent a crucial source of information. The sustainable integration of Big Data into HR management practices thus becomes a major issue for optimizing human capital management and contributing significantly to organizational growth.

4.2. Big Data and Human Resource Management

The emergence of the association between Big Data and human resources has led to a new term, commonly known as HR Big Data. For the HR function to fully benefit from all the advantages promised by the digital world, it must meet several key conditions, starting with fostering a data-driven culture, which it still clearly lacks. Analytics and Big Data offer a wide range of opportunities for the HR function (Storhaye, 2016). The diagram below outlines the stages of developing a "Data" culture within a company, specifically within the HR function.

Figure 2: *Steps to Becoming a "Data-Oriented" HR Manager*
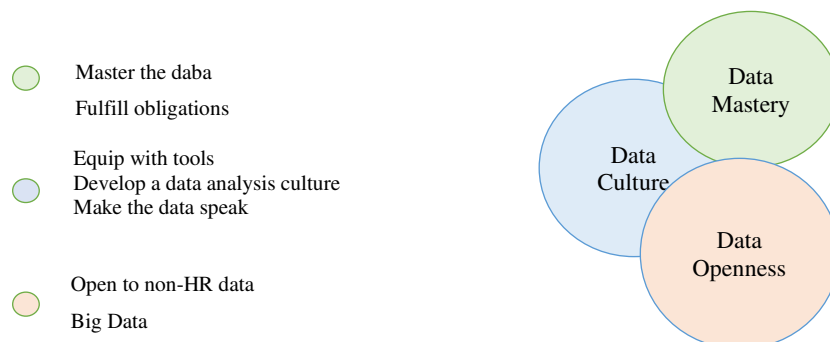
The establishment of a data-driven culture within the HR function is based on several steps, as outlined by Storhaye in 2016:

- **Meeting reporting obligations**: Placing significant importance on complying with HR reporting standards, with a particular focus on the core data required to meet the minimum legal and internal reporting requirements of a Human Resources Department (HRD). This involves a deep understanding of how this data is constructed and its usefulness beyond mere compliance.

- **Starting with the data**: Implementing processes to capture data, ensuring the availability of the tools, knowledge, and experience to make it actionable, maintaining a data-centric Human Resource Information System (HRIS), and mastering analytical tools.

- **Expanding the scope**: Analyzing internal data using semantic analysis techniques or data from smartphone use, workplace sensors, or connected devices. Cross-referencing HR data with data from other domains, for instance, establishing links between customer satisfaction and the internal company climate. Systematically leveraging the information employees share on the internet, especially through social networks.

By adopting these steps, the HR function can gradually establish a culture where the intelligent use of data becomes an integrated practice. This approach goes beyond mere reporting obligations to encompass proactive data use in decision-making, allowing HR to play a strategic role in optimizing organizational performance.

Once a data analysis culture is integrated within the HR function, HR practitioners can move beyond basic descriptive statistics and engage in explanatory methods. This approach primarily aims to highlight relationships between variables, using techniques already proven in other professional fields, such as marketing. By combining these traditional approaches with the benefits offered by Big Data, HR Directors (HRDs) have access to a significant potential for information and communication, even with the usual data from an HR department (Storhaye, 2016).

The promise of HR Big Data lies in its ability to quickly provide relevant information, simplify data access, and contribute to the development of new knowledge beneficial to the management of human factors within the organization (Cercle, 2017).

By cross-referencing internal company data with unstructured external data, such as data from social networks, this approach holds dual importance. On one hand, it improves the profitability of HR decisions, demonstrating their effectiveness and positioning them as crucial elements in major organizational decisions. On the other hand, it aims to enhance the company's overall performance by optimizing aspects such as recruitment, internal mobility, and training, using tools that recommend job profiles, facilitate employees' career development, and refine candidate selection through Big Data algorithms (Levy, 2020).

At the core of HR Big Data is a modeling logic, particularly within a so-called "predictive" approach. This approach relies on the in-depth analysis of large datasets to identify predictive models for anticipating future trends (Storhaye, 2016).

The effectiveness of Big Data lies in its ability to process vast amounts of data using statistics to identify significant variables, a crucial step in building a predictive model. Once these variables are identified and their potential correlations explored, actions can be taken to address observed dysfunctions. Furthermore, Big Data provides the ability to predict the potential impact of one or more variables on final outcomes (Cercle, 2017). Thus, the combination of Big Data and HR represents a significant advance in optimizing decision-making processes and proactively managing human capital within organizations. Big Data is triggering a true revolution within organizations, with a particularly significant impact in the field of management sciences. While finance has always faced the challenge of obtaining large volumes of reliable data, this is now a common concern for all business functions, including human resources management. Organizations are currently collecting a wealth of data in hopes of anticipating answers to various challenges, particularly those related to HR management and leadership (Brillet & Gavoille, 2017).

Big Data is positioning itself as a key player in many HR-related professions, bringing greater reliability and legitimacy to the decisions made. It offers the possibility of significant time savings by automating certain recurring and labor-intensive activities through the adoption of algorithms. This automation frees up resources, allowing HR professionals to dedicate more time to priority issues in their field. This transformation is poised to revolutionize the way human resources approach their work.

The table below provides an illustration of some of the areas where Big Data can be applied in different HR professions, demonstrating the diversity of potential

applications of this technology in talent management, recruitment, training, performance evaluation, and other crucial aspects of human resource management.

Table 2: The Scope of HR Big Data Intervention within the HR Function

human resources professions	The areas of intervention of HR Big Data
	The algorithm can "predict" who will be the best candidate for a given position. Prospect new profiles and skills; Save time in sorting through applications by initially filtering candidates whose skills, values, or profiles match the company's needs.
Employee onboarding	Data analysis plays a major role in determining the best onboarding programs based on the profiles of the recruits and the positions they will hold.
Talent retention	Through the use of predictive retention models to anticipate which talents are likely to leave the company, when they will do so, and why they will make that decision.
Training	Suggest "personalized" training programs to employees, taking into account their past training history and the training needs to be fulfilled for each employee.
areer management: mobility, promotion	Propose suitable profiles for internal mobility or promotion by taking into account acquired experience, seniority, and so on, using Big Data algorithms.

5. Discussion and Results

Most articles on HR Big Data are based on theories and abstract concepts, providing little empirical evidence regarding its practical implementation and application. Current research is dominated by qualitative case studies that rely on existing management frameworks at a very general level. This means that the results of these studies are often difficult to generalize to other contexts.

As a result, there is limited consensus on the effectiveness of HR Big Data. Some researchers believe that it is a promising innovation with the potential to improve organizational performance, while others are more skeptical.

To contribute to the development of HR Big Data, academic researchers need to conduct rigorous scientific studies that examine the impact of this approach on concrete variables such as productivity, employee satisfaction, and profitability. These studies must be conducted in various organizational contexts to ensure generalizability.

Conclusion

The field of Big Data applied to human resources (HR) is currently characterized by a predominance of theories and abstract concepts, with a notable lack of empirical evidence on its practical implementation. The research largely relies on qualitative case studies, thus limiting the generalization of the results to other contexts. This lack of consensus on the effectiveness of HR Big Data reflects divergent opinions among researchers, with some viewing this approach as a promising innovation capable of improving organizational performance, while others remain more skeptical.

To make a significant contribution to the development of HR Big Data, it is imperative that academic researchers undertake rigorous scientific studies. These studies should focus on examining the concrete impact of this approach on specific HR variables, such as employee satisfaction and profitability.

Additionally, the diversity of organizational contexts in which these studies are conducted is crucial to ensure the generalizability of the results. By encouraging a more empirical and diverse approach, researchers can further shed light on the effectiveness of Big Data in the field of human resources.

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