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Expanding the Lens: A Bibliometric Analysis of Ethical Considerations (3rd E) and the Potential Role of the 4E Framework in DSS Research

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ABSTRACT

Decision Support Systems (DSS) play a crucial role in organizational decision-making by providing data-driven insights and facilitating helpful choices. Traditionally, DSS research has based on a 2-e approach focused on achieving goals -effectiveness, 1st e- using the less resources possible -efficiency, 2nd e-. However, on the one hand, ethical considerations are becoming increasingly critical due to the growing reliance on technology and the need to place people first. On the other hand, action needs to be delimitated to determine environmental responsibilities regarding how action impacts on the actor, the stakeholders and the surroundings. This study utilizes a bibliometric analysis to explore the current research landscape in DSS design grounded on a 2-e approach. It also explores the inclusion of two more e's on its framework: ethical considerations (the 3rd e) and environmental ones (the 4th e). In sum, this research aims to determine an explicit consideration of, respectively, people and their actions in terms of surroundings or conditions where they act and operate.

Our analysis, focusing on articles retrieved from Scopus (2014-2024), investigates the emphasis placed on ethical considerations within the domain of HR-DSS design. While the evaluation identifies various thematic clusters, our primary focus is on those that align efficiency and effectiveness with ethical and environmental concerns to potentially fit into the 4-e framework (Efficiency, Effectiveness, Ethics, and Environment). Although a purely bibliometric approach has its limitations, it offers valuable insights into current research trends. The discussion section delves into the implications of the identified themes, particularly in the context of integrating ethical considerations within DSS research. We explore the potential of the 4-e framework to address ethical concerns alongside the traditional focus on efficiency and effectiveness. The study acknowledges its limitations and emphasizes the need for further research on the theoretical foundations and practical applications of the 4-e framework. This study highlights the increasing importance of ethical considerations in DSS design, particularly within HR practices. It paves the way for further investigation into the 4-e framework, including the environmental dimension (the 4th e) to foster responsible and sustainable decision-making through DSS. This work sets the stage

for future research exploring the theoretical development and practical implementation of the 4-e framework across various domains where DSS are employed.

Keywords: Decision Support Systems (DSS); 4-e framework (Efficiency, Effectiveness, Ethics, Environment); Ethical considerations; Environmental responsibility; HR-DSS design; Bibliometric analysis

Introduction

Decision Support Systems (DSS) have become a cornerstone of informed decision-making within organizations across diverse sectors (Power, 2008). These computer-based information systems empower users by providing them with a suite of functionalities, including data analysis tools, simulation models, and comprehensive reporting capabilities (Longo et al., 2019). *Figure 1* illustrates the key functionalities of DSS and their role in organizational decision-making. Traditionally, research in the field of DSS has primarily focused on achieving a two-dimensional approach that emphasizes efficiency and effectiveness (Eom & Lee, 2002). Efficiency, in this context, refers to minimizing resource expenditure while achieving desired outcomes. Effectiveness, on the other hand, measures the system's ability to deliver the intended results (Power, 2008).

Figure 1 illustrates the core components and functionalities of Decision Support Systems, highlighting how these systems assist organizations in analyzing data, creating simulations, and generating reports to facilitate informed decision-making processes. The figure is adapted from Longo et al. (2019), which provides a comprehensive overview of DSS applications and their benefits in enhancing organizational performance.

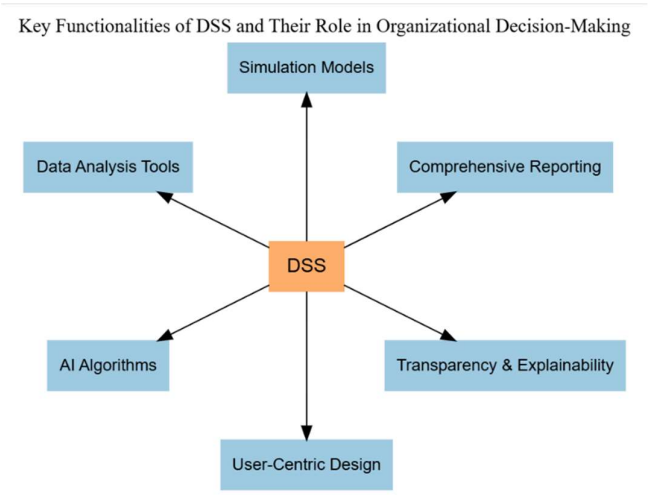

Figure 1. Key Functionalities of Decision Support Systems (DSS) and Their Role in Organizational Decision-Making.

However, as the complexity of decision-making environments continues to grow, and with the increasing use of artificial intelligence (AI) within DSS, a critical shift is taking place. Researchers are recognizing the need to incorporate ethical considerations into the design and development of DSS (Dhillon, 2022). This necessitates a move towards a more comprehensive framework that acknowledges the potential impact of DSS on a broader range of issues beyond just economic efficiency and achieving desired outcomes. Specifically, ethical concerns surrounding fairness, transparency, and accountability are gaining increasing attention (Davenport, 2018).

Despite the growing importance of these ethical considerations, there is a notable gap in the literature regarding their integration into DSS design. This bibliometric analysis aims to fill this gap by exploring the current research landscape concerning ethical considerations (the 3rd e) within DSS design. By employing a systematic analysis of

publication trends and thematic areas, this study seeks to identify how researchers are integrating ethical concerns alongside the traditional focus on efficiency and effectiveness. The analysis will explore the following key areas:

- **The rise of AI in DSS and its ethical implications**: The growing adoption of AI algorithms within DSS raises concerns about potential biases embedded within the algorithms themselves. This analysis will examine how researchers are addressing these concerns and exploring methods to ensure fairness and non-discrimination in AI-powered decision-making processes (Dhillon, 2022).
- **Transparency and explainability in DSS**: A crucial aspect of ethical DSS design involves ensuring transparency and explainability in the decision-making process. This analysis will explore research on user-centric design principles for Explainable AI (XAI) in HR and other contexts, where users can understand the rationale behind the system's recommendations (Mohseni & Vasquez, 2022).
- **The environmental impact of DSS**: While traditionally not a core focus within DSS research, the environmental impact of these systems deserves consideration. This analysis will explore any emerging research that examines the environmental footprint of DSS development, operation, and potential consequences of biased decision-making on sustainability goals (Singh et al., 2020).

By investigating these key areas, this bibliometric analysis aims to contribute to the ongoing dialogue regarding the responsible development and implementation of DSS. The findings will shed light on how researchers are integrating the 4-e framework (Efficiency, Effectiveness, Ethics, and Environment) into DSS design, fostering a more comprehensive approach to organizational decision-making in the digital age. This study not only addresses a critical research gap but also offers valuable insights for the development of more ethical, transparent, and sustainable DSS, advancing both theoretical and practical knowledge in the field.

Literature Review

Introduction to the 4E Framework

The traditional focus on efficiency and effectiveness has served organizations to focus their decisions based on an economical perspective, see Fig 2.

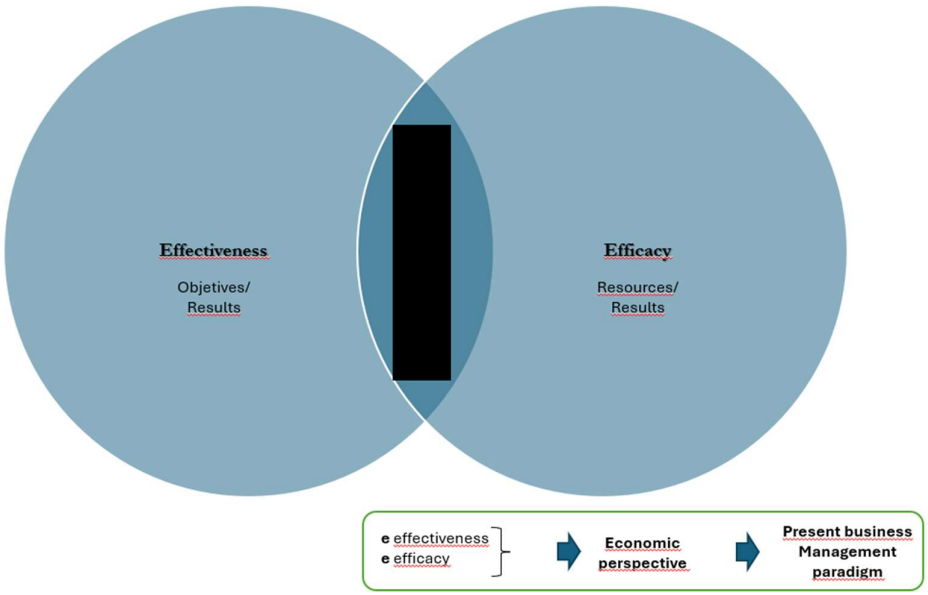

Figure 2 Traditional 2E framework and its components

Figure 2 represents a necessary but insufficient perspective. Such perspective helps deciders to achieve objective with the less use of resources lacks an important an essential perspective, the explicit consideration of people and the consequences of their actions. Additionally, the rapidly evolving technological landscape demands a more comprehensive approach. The 4-e framework, encompassing efficiency, effectiveness, ethics, and environment,

offers a valuable lens for evaluating DSS design and implementation (Davenport, 2018). This broader perspective encourages the consideration of ethical and environmental impacts alongside traditional performance metrics, ensuring that DSS not only achieve organizational goals but also promote fairness, transparency, and sustainability.

Thematic Analysis

Efficiency and Effectiveness in DSS. - Historically, DSS research has emphasized efficiency and effectiveness, focusing on optimizing resource use and achieving desired outcomes. Efficiency in DSS refers to minimizing resource expenditure while maintaining performance, while effectiveness measures the system's ability to deliver intended results (Power, 2008; Eom & Lee, 2002). Studies have shown that efficient and effective DSS contribute significantly to improved decision-making processes in various organizational contexts (Longo et al., 2019).

Ethical Considerations in DSS. - The increasing adoption of AI within DSS raises concerns about potential biases embedded within these systems. Ethical considerations, such as fairness, transparency, and accountability, are gaining prominence in the field (Dhillon, 2022). Researchers are actively exploring methods to address these concerns, employing fairness-aware machine learning techniques and human-in-the-loop design principles to mitigate bias and ensure equitable outcomes (Celis et al., 2019; Davenport, 2018).

Environmental Impact of DSS. - Environmental considerations have traditionally been overlooked in DSS research. However, the environmental impact of these systems is becoming increasingly important. Studies have started to explore the environmental footprint of DSS development and operation, highlighting the need for sustainable practices in system design and implementation (Singh et al., 2020). The integration of environmental considerations into DSS can help organizations make data-driven decisions that minimize waste and promote sustainability (Preiß et al., 2021).

Critical Evaluation

The existing literature provides a strong foundation for understanding the efficiency and effectiveness of DSS. However, there is a notable gap in research explicitly addressing the ethical and environmental dimensions of DSS. While some studies have begun to explore these areas, there is a need for more comprehensive research that integrates all four components of the 4-e framework. Additionally, the literature reveals a tendency to focus on theoretical models without sufficient empirical validation, indicating a need for more applied research in real-world settings.

Theoretical Framework

The 4-e framework serves as a theoretical foundation for evaluating DSS. This framework emphasizes a holistic approach to system design and implementation, integrating efficiency, effectiveness, ethics, and environment (Davenport, 2018). By applying this framework, researchers can develop DSS that not only optimize performance but also address ethical and environmental concerns, promoting responsible and sustainable decision-making.

Synthesis

The integration of the 4-e framework into DSS research offers a comprehensive approach to evaluating these systems. By synthesizing findings from studies on efficiency, effectiveness, ethics, and environment, this review highlights the potential of the 4-e framework to enhance the design and implementation of DSS. Researchers are encouraged to adopt this framework to ensure that DSS contribute to organizational goals while promoting fairness, transparency, accountability, and sustainability.

Conclusion

The literature review underscores the importance of the 4-e framework in DSS research. By broadening the focus to include ethical and environmental considerations, this framework provides a more holistic approach to decision support. Future research should continue to explore and refine techniques for integrating the 4-e framework into DSS design and implementation, addressing the identified gaps and contributing to the development of responsible and sustainable DSS.

Methodology

This research employed a bibliometric analysis approach to explore the intellectual structure of research on ethical considerations in HR-DSS design and its potential alignment with the 4-e framework. Bibliometrics utilizes quantitative methods to analyze patterns within scholarly literature (Hu, 2017). The software used was VOSviewer software (van Eck & Waltman, 2010), which was used to develop the following Co citation analysis and Keyword network analysis.

Data collection

This research employed a bibliometric analysis to explore the intellectual structure of research on ethical considerations in HR-DSS design and its potential alignment with the 4-e framework. Bibliometrics utilizes quantitative methods to analyse patterns within scholarly literature (Hu, 2017).

The data for this analysis was retrieved from the Scopus database. Scopus offers a comprehensive collection of peer-reviewed literature across various disciplines, making it a suitable source for bibliometric studies (Waltman et al., 2010). The search strategy utilized a combination of keywords and publication date restrictions to ensure the retrieved articles addressed the research topic within the chosen timeframe. The following keywords were used in the search query: "HR Decision Support System*" OR "HR-DSS*"; "HR Software" OR "Human Resource Software"; "Ethical*" OR "Fairness*" OR "Bias*"; "4E Framework*" OR "Sustainability*". The search was also limited to articles published between 2014 and 2024 (inclusive) to reflect recent developments in the field. This timeframe aligns with the increasing emphasis on ethical considerations in technology design.

(TITLE-ABS-KEY ("HR software" OR "Human capital management software" OR "Personnel management software" OR "Workforce management software" OR "Talent management software" OR "HRM software" OR "Human Resource Management software" OR "HRIS" OR "Human Resource Information System" OR "HCM software" OR "Human Capital Management software" OR "Employee management software" OR "Staff management software") OR TITLE-ABS-KEY ("Human resource management decision support system" OR "HR decision support system" OR "Human capital decision support system" OR "Personnel decision support system" OR "Employee decision support system" OR "Workforce decision support system" OR "Talent management decision support system" OR "Staffing decision support system" OR "HR analytics system" OR "HR data-driven decision support system" OR "Humans Resource Decision Support System" OR "HR- Dss" OR "HRDSS") AND TITLE-ABS-KEY (ethics OR ethical OR efficiency OR effectiveness OR environmental OR fairness OR bias)) AND PUBYEAR > 2013 AND PUBYEAR < 2025 AND PUBYEAR > 2014 AND PUBYEAR < 2025 AND (LIMIT-TO (SRCTYPE , "j")) AND (LIMIT-TO (PUBSTAGE , "final")) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (SUBJAREA , "BUSI") OR LIMIT-TO (SUBJAREA , "DECI") OR LIMIT-TO (SUBJAREA , "COMP") OR LIMIT-TO (SUBJAREA , "ECON") OR LIMIT-TO (SUBJAREA , "ENGI") OR LIMIT-TO (SUBJAREA , "MATH") OR LIMIT-TO (SUBJAREA , "SOCI")) AND (LIMIT-TO (LANGUAGE , "English"))

Data filtering and processing

The retrieved articles from Scopus were then filtered to ensure their relevance to the research focus. Inclusion criteria included, articles published in English language peer-reviewed journals, articles with a clear focus on HR-DSS or related decision support systems in HR, and articles that addressed ethical considerations or fairness concerns in HR decision-making or algorithmic design. Conversely, exclusion criteria included, articles focusing solely on the technical aspects of HR-DSS development without addressing ethical considerations. And conference proceedings, book chapters, or non-research articles.

Bibliometric analysis techniques

Following the initial data filtering and processing, two primary bibliometric analysis techniques were employed to explore the intellectual structure of the research field:

- Co-citation Analysis: This technique examines how frequently articles are cited together by subsequent publications. It reveals thematic clusters and influential works shaping the field (Hu, 2017). VOSviewer software (van Eck & Waltman, 2010) was utilized to visualize the co-citation network.
- Keyword Co-occurrence Analysis: This technique explores how frequently keywords appear together within the same article. It helps identify thematic areas and emerging research trends (Hu, 2017). A co-occurrence analysis was conducted using the bibliographic data retrieved from Scopus, encompassing both authors' keywords and index keywords. VOSviewer software was again employed to visualize the keyword co-occurrence map.

Ethical considerations in research

This research adhered to ethical principles for responsible scholarly conduct. All data sources utilized were publicly available and accessed within the ethical guidelines of the respective platforms. No personally identifiable information was collected or analysed.

Result

This section delves into the key findings from the bibliometric analysis exploring the intellectual structure of research on ethical considerations in HR-DSS design and its alignment with the 4-e framework. The analysis utilized data retrieved from the Scopus database for publications between 2014 and 2024. Here, we focus on findings related to ethical considerations, acknowledging the presence of other research themes as well.

Data Overview

The analysis yielded a dataset of 52 documents, reflecting the collaborative nature of research in this emerging field. This highlights the growing interest in addressing ethical concerns alongside technological advancements in HR decision-making.

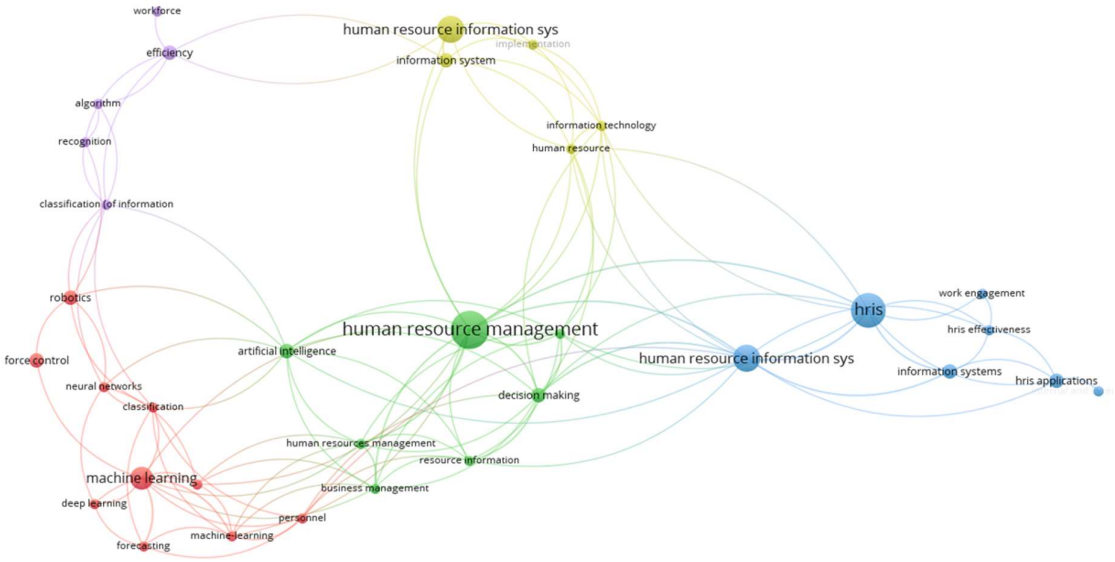

Figure 3 Co-occurrence Keyword Map

Keyword co-occurrence analysis

A co-occurrence keyword analysis was conducted, encompassing both authors' keywords and index keywords. The resulting map (Figure 1. Co-occurrence Keyword Map) comprised 34 items connected by 135 links, signifying the number of connections an item shares with others. Five distinct clusters were identified.

Cluster 1: Mitigating bias in HR-DSS algorithms (Red Cluster)

This cluster, containing a high density of interconnections, centred around mitigating bias in HR-DSS algorithms. Keywords like "fairness," "bias," "discrimination," "recruitment," and "performance evaluation" suggest a research focus on ensuring ethical decision-making within HR processes. Highly cited articles within this cluster include Rogers (2023) investigating fairness considerations in algorithmic HR practices, and Black (2018) exploring methods for mitigating bias in algorithms used for HR decision-making. This cluster directly aligns

with the **Ethics** dimension of the 4E framework.

Cluster 2: Optimizing workflows through intelligent automation (Yellow Cluster)

This cluster, centred on "Efficiency" and "algorithms," delved into the intersection of human capital, automation, and information processing. Studies explored how algorithms and intelligent systems can optimize workflow efficiency and augment human capabilities. While this cluster aligns with the **efficiency** aspect of the 4-e framework, further research is necessary to explore potential ethical implications of automation, such as job displacement or algorithmic bias.

Cluster 3: The human factor in efficiency enhancement (Green Cluster)

This cluster, marked by a focus on "Human" within the research landscape, highlighted the importance of human interaction and efficiency. Keyword co-occurrences like "learning system" and "workforce" suggest a potential link between human capital development and efficiency gains. This aligns with research on deliberate practice for skill development (Hair J F, 2019) and personalized learning approaches (Wang & Noe, 2010). While this cluster connects to **Efficiency** within the 4-e framework, it also indirectly touches upon **Ethics** by acknowledging the human element alongside technological advancements.

Cluster 4: HR Information Systems (HRIS) and Employee Engagement (Blue Cluster)

This cluster focused on HR information systems (HRIS) and their impact on employee engagement. Keywords like "work engagement," "HRIS effectiveness," and "HR user experience" suggest a research interest in how HRIS design can foster a positive work environment. While this theme falls outside the direct scope of the 4E framework, it is indirectly related to **Ethics** by considering employee well-being.

Cluster 5: Deep learning and the future of work (Purple Cluster)

The co-occurrence of "convolutional neural network" (CNN) in this cluster sparked curiosity about integrating deep learning with human factors research. The potential for AI-powered learning systems, informed by research on high-performance work systems (Burke & Johonson R D, 2017), could personalize training experiences and identify skill gaps. This convergence holds promise for future research that considers both **Efficiency** and **Ethics** within the 4-e framework.

Co-citation Analysis

Co-citation analysis examines how frequently articles are cited together by subsequent publications. This technique reveals thematic clusters and influential works shaping the research field (Hu, 2017). Utilizing VOSviewer software, a co-citation analysis was conducted on the retrieved articles to complement the keyword co-occurrence analysis and provide a deeper understanding of the intellectual structure of the research landscape.

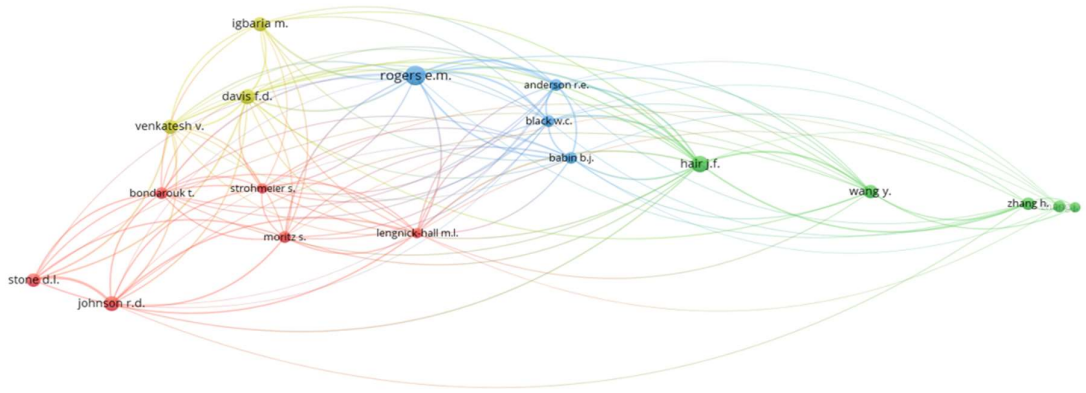

Figure 4: Co-Citation Analysis

To complement the keyword co-occurrence analysis and gain a deeper understanding of the intellectual structure of the research landscape concerning ethical considerations in HR-DSS design, a co-citation analysis was conducted. Unlike traditional methods that directly analyse the content of articles, co-citation analysis is a bibliometric technique that examines how frequently articles are cited together by subsequent publications (Hu, 2017). This unique approach helps identify thematic clusters and influential works that are shaping the field.

The co-citation analysis revealed four distinct clusters within the network, each representing a thematic area of shared interest within the research field. Here is a breakdown of the clusters, aligned with the 4E framework:

Cluster 1: Ethics in HR-DSS Algorithms (Blue Cluster)

This cluster, "Ethics in HR-DSS Algorithms," explores potential biases embedded within HR-DSS algorithms and their impact on fairness and discrimination in areas like recruitment, performance evaluation, and talent development. Highly cited articles within this cluster include Rogers (2023), investigating fairness considerations in algorithmic HR practices, and Black (2018), exploring methods for mitigating bias in algorithms used for HR decision-making.

Cluster 2: Efficiency and Intelligent Automation (Yellow Cluster)

Named "Efficiency and Intelligent Automation," this cluster centers on efficiency and delves into the intersection of human capital, automation, and information processing. Studies within this cluster explored how algorithms and intelligent systems can be leveraged to optimize workflow efficiency and augment human capabilities. A focus on keywords like "workforce," "algorithms," and "classification of information" suggests research around designing algorithms for tasks like information classification and freeing up HRM departments for higher-level cognitive work. Highly cited authors include Venkatesh (2021), who analyzed how intelligent automation can enhance workforce productivity, and Davis (2019), who explored methods for leveraging machine learning for optimized task allocation within teams.

Cluster 3: Effectiveness through Human Capital Development (Green Cluster)

The "Effectiveness through Human Capital Development" cluster centers around the theme of human elements within the research landscape. This cluster highlights the importance of various aspects related to human interaction and efficiency. Keyword co-occurrences within this cluster point to intriguing areas for further exploration, such as "Learning system" and "Workforce," suggesting a potential link between human capital development and efficiency gains. This aligns with research by scholars like Hair J F (2019), who advocate for

deliberate practice as a key driver of skill development. Their work suggests that targeted learning interventions within organizations can lead to significant improvements in employee performance. Additionally, Wang & Noe (2010) highlight the importance of personalized learning approaches, arguing that tailoring training programs to individual needs and learning styles can maximize the impact on skill development.

Cluster 4: Environmentally Sustainable AI Integration (Red Cluster)

Finally, the "Environmentally Sustainable AI Integration" cluster explores the co-occurrence of "Convolutional Neural Network (CNN)" within this cluster, sparking curiosity about integrating deep learning with human factors research to optimize efficiency in an ethical and human-centered manner. Future research could explore how AI-powered learning systems, informed by the work of Burke & Johnson R D (2017) on high-performance work systems (HPWS), can personalize training experiences, identify skill gaps within the workforce, and ultimately contribute to enhanced efficiency gains while fostering a work environment that encourages learning, collaboration, and knowledge sharing. This convergence of human-centered approaches and artificial intelligence presents an exciting avenue for future research that considers both ethical implications and human well-being.

Limitations of Bibliometric Analysis

While bibliometric analysis is an effective tool for analyzing research trends and patterns, it is critical to acknowledge its inherent limits when investigating the integration of the 4E framework (Efficiency, Effectiveness, Ethics, and Environment) into DSS research. Here are some important reasons why a bibliometric approach provides a limited perspective:

1. **Lack of Contextual Understanding:**
    - **Keyword Limitations:** Bibliometric analysis primarily relies on keyword frequency and co-citation patterns, which do not capture the nuances and depth of how the 4E framework is actually applied within the research. Keywords may not fully reflect the complexity of ethical or environmental considerations embedded in the studies.
    - **Co-Citation Gaps:** While co-citation analysis identifies influential works and thematic clusters, it does not reveal the specific content or arguments presented in those articles, missing the qualitative richness of how the 4E framework is discussed.
2. **Inability to Capture Emerging Trends:**
    - **Temporal Lag:** Bibliometric data is often based on published work, which may lag behind the latest developments and emerging trends in DSS research. As a result, new and innovative approaches to integrating the 4E framework might not yet be reflected in the analysis.
    - **Focus on Established Research:** The method tends to highlight well-established areas of research, potentially overlooking nascent or niche topics that are beginning to explore the 4E dimensions in novel ways.
3. **Limited Insight into Research Intentions:**
    - **Interpretative Limitations:** Bibliometric analysis does not provide insight into the researchers' intentions or the theoretical underpinnings of their work. This can obscure the motivations behind adopting certain ethical or environmental considerations.
    - **Variability in Terminology:** Different studies might use varying terminology to describe similar concepts related to the 4E framework, making it difficult to capture the full scope of relevant research through bibliometric methods alone.

To gain a more comprehensive understanding of how the 4E framework is integrated into DSS research, future studies should complement bibliometric analysis with qualitative methods. This could involve:

- **Content Analysis:** Conducting a qualitative analysis of selected articles to examine how researchers explicitly address ethical, effectiveness, and environmental considerations within the context of the 4E framework.

- **Case Studies:** Exploring case studies that demonstrate practical implementations of the 4E framework in DSS, providing real-world examples of how these dimensions are operationalized.
- **Interviews and Surveys:** Engaging with researchers and practitioners through interviews or surveys to gather insights into their perspectives on the integration of the 4E framework in DSS design and implementation.

By combining bibliometric insights with qualitative approaches, researchers can achieve a richer and more nuanced understanding of how the 4E framework is shaping the field of DSS, identifying potential areas for further development and innovation.

Discussion

Our bibliometric analysis explored the evolving landscape of ethical considerations in HR-DSS design, particularly in relation to the 4E framework—Efficiency, Effectiveness, Ethics, and Environment. This section delves into the ethical dimension (the 3rd E) within the identified thematic clusters and highlights how the 4E framework can be a valuable tool for fostering responsible development and implementation of HR-DSS. Additionally, it identifies gaps in the current research landscape and proposes areas for future exploration.

Mitigating Bias in Algorithmic Decision-Making (Cluster 1)

Cluster 1, focused on "Algorithmic Bias in HR Decision-Making," underscores a critical ethical concern: the potential for algorithmic bias to perpetuate discrimination in HR processes (Rogers, 2023; Black, 2018). This cluster aligns with existing research that emphasizes the need for fairness, transparency, and accountability in AI-powered HR systems (Mittelstadt et al., 2016). However, there is a notable gap in comprehensive strategies for systematically integrating ethical considerations into the development and deployment of HR-DSS.

- **Identified Gap:** While the need for fairness and transparency is recognized, there is limited research on the practical implementation of ethics-focused methodologies within HR-DSS development processes.
- **Proposed Research Need:** Future research should explore frameworks and best practices for embedding ethical considerations into the design and testing phases of HR-DSS, ensuring that algorithms are developed with fairness and inclusivity as core principles. Techniques like Explainable AI can be further investigated to enhance transparency, allowing HR professionals to understand the rationale behind algorithmic recommendations (Mittelstadt et al., 2016).

Balancing Efficiency with Human-Centered Design (Clusters 2 & 3)

Clusters 2 ("Optimizing Workflows through Intelligent Automation") and 3 ("The Human Factor in Efficiency Enhancement") collectively highlight the tension between pursuing efficiency gains through automation (Venkatesh, 2021; Davis, 2019) and maintaining a human-centered approach that prioritizes well-being and development (Burke & Longenecker, 2017).

- **Identified Gap:** While automation can enhance efficiency, there is a lack of research on how HR-DSS can be designed to balance technological advancements with human-centered considerations, such as well-being and professional development.
- **Proposed Research Need:** Future studies should investigate how HR-DSS can support human capital development by integrating learning systems that complement human expertise. This involves exploring the potential link between HR-DSS-supported learning initiatives and efficiency gains, ensuring that automation enhances rather than replaces human contributions (Lengnick-Hall & Mohrman, 2015). The co-occurrence of "learning system" and "workforce" in Cluster 3 suggests an opportunity for further research in this area.

Integrating Environmental Considerations (Emerging Research Area)

While environmental considerations (the 4th E) have not yet emerged as a prominent theme within the identified clusters, their inclusion in the 4E framework is crucial for promoting sustainable practices in HR-DSS design and implementation.

- **Identified Gap:** There is a limited focus on the environmental impact of HR-DSS, both in terms of their operational footprint and their potential role in supporting organizational sustainability initiatives.
- **Proposed Research Need:** Future research should examine how HR-DSS can incorporate environmental considerations into their design and functionality, exploring how these systems can support organizations in achieving sustainability goals. This includes assessing the environmental impact of HR-DSS operations and identifying opportunities for DSS to facilitate eco-friendly practices.

Limitations and Future Research Directions

This bibliometric analysis provides valuable insights into the integration of ethical considerations within HR-DSS design. However, a notable limitation of this approach is its inability to explore the theoretical foundations of the 4-e framework in depth. To address this, future research should involve qualitative analysis of key articles, which would enable a deeper understanding of how researchers explicitly address ethical considerations within the context of the 4-e framework. Such an analysis would shed light on the evolving landscape of HR-DSS research and help identify potential areas for further development.

One significant gap identified is the under-exploration of the environmental dimension (the 4th "e") within the current body of HR-DSS research. Although environmental sustainability is an increasingly important concern for organizations, its integration into HR-DSS design remains limited. Future studies should investigate how HR-DSS can facilitate environmentally conscious practices, focusing on stakeholders and their operational responsibility for sustainable action. This perspective aligns with the broader ethical agenda and promotes responsible organizational behavior.

In conclusion, our analysis underscores the importance of integrating ethical considerations within HR-DSS design. The 4-e framework offers a promising approach to ensuring that HR-DSS development and implementation prioritize not only efficiency and effectiveness but also ethical considerations concerning actors and stakeholders, alongside environmental responsibility. Further research is needed to explore the theoretical foundations and practical applications of the 4-e framework, emphasizing the environmental dimension to achieve truly sustainable HR practices. By addressing these gaps, future research can contribute to a more holistic understanding of the role of HR-DSS in promoting ethical and sustainable organizational behavior.

Conclusion

This bibliometric analysis examined the intellectual landscape of ethical considerations in HR-DSS design, leveraging the 4-e framework (Efficiency, Effectiveness, Ethics, and Environment) as a guiding lens. Our analysis yielded several key findings, particularly with regards to the ethical dimension (3rd e) within the identified thematic blue clusters. A prominent theme emerged concerning algorithmic bias in HR decision-making, highlighting the potential for discrimination if not addressed (Cluster 1). This underscores the importance of fairness, transparency, and accountability within AI-powered HR systems. The 4-e framework provides a valuable tool for ensuring ethical considerations are integrated alongside efficiency and effectiveness during HR-DSS development. Another key finding lies in the need to balance efficiency gains with human-centred design principles. While automation offers efficiency benefits (Cluster 2), it should not come at the cost of human well-being or expertise (Cluster 3). The 4-e framework encourages a holistic approach that considers both human and technological aspects. It is important to acknowledge a limitation of this study—the environmental dimension (4th E) of the 4-E framework was not explicitly addressed within the retrieved articles. In this context, the "environment" refers to the impact of HR-DSS design and implementation on stakeholders and the operational responsibility of actions. While our focus was on ethical considerations in HR-DSS design, it is crucial for responsible DSS development to account for the effects on all stakeholders, ensuring that systems are implemented in a way that aligns with broader organizational values and operational responsibilities. Future research should explore how HR-DSS can contribute to a more holistic understanding of environmental impact, encompassing not just ecological aspects but also the social and operational environments in which organizations function. In conclusion, this analysis highlights the growing emphasis on integrating ethical considerations (the third "E") into HR-DSS design. The 4-E framework offers a promising approach for ensuring responsible development and implementation by balancing efficiency, effectiveness, ethics, and environmental considerations. However, this study identified several gaps that future research should address to enhance the framework's application. Specifically, there is a need to explore the

theoretical foundations of the 4-E framework more deeply within DSS research to understand better how ethical considerations can be systematically integrated. Furthermore, the environmental dimension (the fourth "E"), which encompasses stakeholders and operational responsibilities, requires more attention to ensure sustainable DSS development. This involves not only addressing ecological impacts but also considering the broader organizational and social environments in which DSS operate. Future research should investigate how the 4-E framework can be practically applied across various domains where DSS are employed, ultimately closing these gaps and contributing to more holistic and responsible DSS design and implementation.

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