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Frugal Innovation: a Bibliometric Study of the Conceptual Foundations and Future Research Directions

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ABSTRACT

Frugal innovation is gaining traction in resource-limited settings, emphasizing sustainability. This paper uses bibliometric analysis to explore trends and gaps in frugal innovation research. Further publications were identified from the Scopus database using the Publish or Perish tool for the period 2014-2024. Data is processed using RStudio and VOSviewer to reveal key themes, influential scholars, research institutions, and network maps. It highlights the growing scholarly interest in frugal innovation and its alignment with sustainability goals, stressing the need for further exploration of its principles and impacts. The study aims to advance understanding and to guide future research. Additionally, integrating sustainability and environmental considerations in product development, alongside frugal innovation, can drive economic and social sustainable development. Organizational capabilities like Big Data are vital for achieving sustainability outcomes, and frugal innovation positively impacts a firm's financial and environmental performance. Strengthening organizational capabilities is key to leveraging frugal innovation for sustainability.

Keyword: frugal innovation; sustainability; organizational capabilities

INTRODUCTION

Frugal innovation has drawn increasing attention as an effective strategy, especially in resource-limited environments, with an emphasis on sustainability (Pineda-Escobar, 2023). Although the concept itself is not entirely new, with historical examples of necessity-driven innovations, it has become more prominent in the early 21st century. This shift reflects a move towards more resource-efficient solutions in innovation paradigms (Le Bas, 2023c). The interplay between frugality and sustainability is a major area of interest, calling for a clearer definition of frugal innovation, a global research perspective, and an evaluation of its impact throughout the product life cycle (Le Bas, 2023b). Frugal innovation is marked by significant cost reductions, simplified core functionalities, and enhanced performance levels, pointing to a new direction in technological change that prioritizes inclusivity and environmental efficiency (Khan, 2023).

The bibliometric analysis of frugal innovation reveals several pivotal findings. First, it underscores the escalating international interest and scientific output in the domain, highlighting a discernible trend towards examining business sustainability and consumer

behavior within the framework of frugal innovation (Dima et al., 2022). Second, the analysis identifies frugal innovation as a promising approach for fostering sustainable development from economic and social perspectives, despite the presence of both positive and negative impacts across economic, social, and ecological dimensions (STÖBER et al., 2022a). Furthermore, the study emphasizes the critical role of collaboration in achieving sustainability outcomes through frugal innovation, noting that the types of actors involved and their motivations significantly influence the potential impact on economic, environmental, and social sustainability (De Marchi et al., 2022).

Recent bibliometric analyses highlight the increasing scholarly attention toward frugal innovation, emphasizing its potential alignment with sustainability goals (Mbabil Dok-Yen et al., 2023). Frugal innovation is recognized as a promising approach to addressing sustainability challenges, particularly in resource-constrained environments (STÖBER et al., 2022a). The concept of frugal innovation is evolving, with a focus on the economic, social, and ecological dimensions of sustainability (Le Bas, 2023c). Scholars emphasize the need for a clear definition of frugal innovation, a global research perspective, and an assessment of its impact throughout the product life cycle to enhance its sustainability characteristics (Le Bas, 2023a). Moreover, the relationship between frugality and sustainability is being explored, positioning frugal innovation as an emerging technological paradigm with the potential to significantly contribute to environmental sustainability. However, these analyses also identify potential gaps in the literature. Given the nascent stage of the field, there is a need for further exploration of its fundamental principles and long-term impacts. Additionally, integrating insights from other disciplines that address frugality and simplicity could enhance the understanding of frugal innovation.

This research utilizing bibliometric analysis can address these gaps by mapping the landscape of existing studies, identifying key themes, influential scholars, and prominent research institutions. It can also unveil emerging trends by exploring new directions and underexplored aspects of frugal innovation research and identifying potential research gaps where further investigation is required to deepen our understanding of frugal innovation. By employing bibliometric analysis, this research has the potential to significantly advance our comprehension of frugal innovation and guide future research endeavors in this critical field.

METHODS

This research employs a bibliometric approach to analyze the landscape of frugal innovation research. Scopus, a comprehensive citation database for peer-reviewed literature (Shestakova et al., 2023), will be utilized using the Publish or Perish (PoP) software (Moosa, 2018). The search strategy involves developing a search string that combines terms related to "frugal innovation". To focus on recent and impactful research, PoP filters within the Scopus database will limit the publication date to 2014-2024 and include document types such as articles and reviews, or specific subject areas such as engineering, business, and economics. Data organized in a research information system (RIS) format was collected and imported into Mendeley. From the Scopus database, 200 valid data entries were retrieved for further analysis. After applying multiple selection criteria, including scope, keywords, and alignment, 191 suitable articles were identified to achieve the study's objectives.

Data analysis will be conducted using RStudio, beginning with data cleaning and preprocessing to remove irrelevant information, standardize text formats, and correct errors (Aria & Cuccurullo, 2017). Using R packages such as bibliometric analyses will be performed, including co-citation analysis to explore thematic connections, author co-occurrence analysis to identify potential research collaborations, and keyword analysis to pinpoint key research areas. Network visualization with VOSviewer will create network maps where nodes represent articles, keywords, or authors, and edges represent their relationships, with node size and color indicating factors like publication frequency or centrality within the network ("Network Visualization," 2023a).

RESULT AND DISCUSSION

This section explains how the searched publications were distributed according to annual scientific production, most relevant sources, total citation per year. This section also presents a comprehensive bibliographic analysis, which includes network visualization, overlay visualization, and density visualization. All the results presented in this section were obtained from the Scopus by using PoP filtered analysis options, that were applied on the entire document corpus extracted using the search string mentioned in the previous section.

An analysis of the keyword "frugal innovation" was conducted, examining publication trends across 200 research articles from 2014 to 2024. The annual distribution of publications is as follows: 2014 (11 articles), 2015 (3 articles), 2016 (18 articles), 2017 (18articles), 2018 (29 articles), 2019 (12 articles), 2020 (29 articles), 2021 (31 articles), 2022 (32 articles), 2023 (14 articles), and 2024 (3 articles). Figure 1 illustrates the publication trend over this ten-year period.

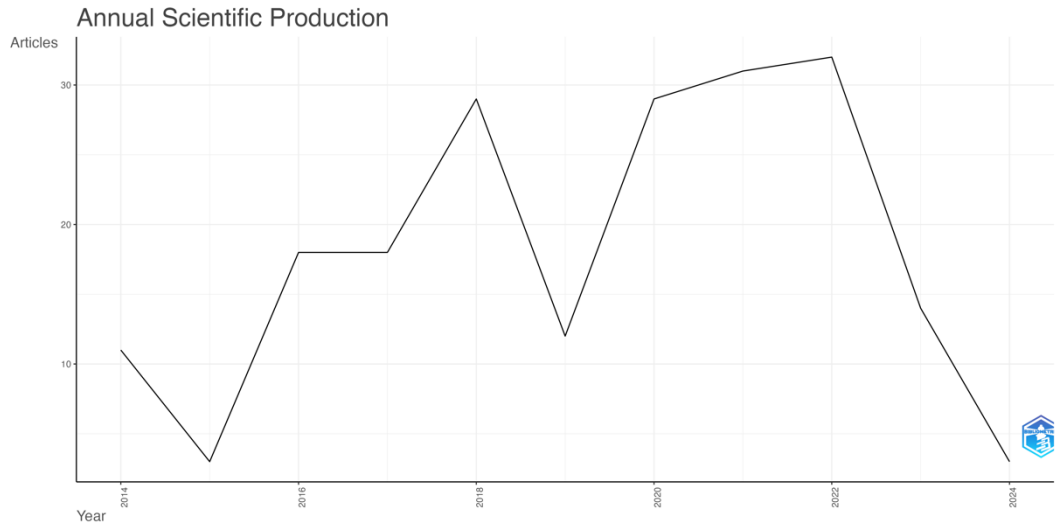

Figure 1. Annual Scientific Production
Source: Results of data analysis using Biblioshiny, R Studio

Figure 2 depicts the cumulative occurrences of publications from different sources related to the field of study from 2014 to 2024. The y-axis represents the cumulative

occurrences (or the number of publications), while the x-axis represents the years. Each line on the graph corresponds to a different source, identified by different colors and labeled at the bottom of the graph. The European Journal of Development Research (Red) saw a rapid increase in publications starting around 2017, reaching a plateau from 2019 to 2020, and then again in 2021, with a slight increase afterward. In contrast, IEEE Transactions on Engineering Management (Blue) demonstrated steady growth from around 2015, with a noticeable increase in publications around 2017, continuing to rise consistently until plateauing in 2022. The International Journal of Technology Management (Green) exhibited a gradual increase in publications starting around 2016, with a more significant rise around 2019, continuing to grow steadily afterward. Similarly, the Journal of Cleaner Production (Purple) had a gradual increase starting around 2015, with a more significant rise around 2018, then showing a consistent upward trend until plateauing in 2022. Sustainability (Switzerland) (Pink) showed a steady increase starting around 2017, with a noticeable rise around 2019, continuing to grow steadily through to 2022, and then maintaining a steady pace. Technology in Society (Brown) showed a gradual increase starting around 2018, with a significant rise around 2020, followed by a steady growth trend. Finally, Technovation (Yellow) showed a steady increase starting around 2017, with a significant rise around 2019, continuing to grow steadily afterward.

The graph illustrates how different sources have contributed to the body of literature over time, with most sources showing an upward trend in publications, particularly around the mid to late 2010s and continuing into the early 2020s. This indicates a growing interest and increasing research output in the field covered by these sources.

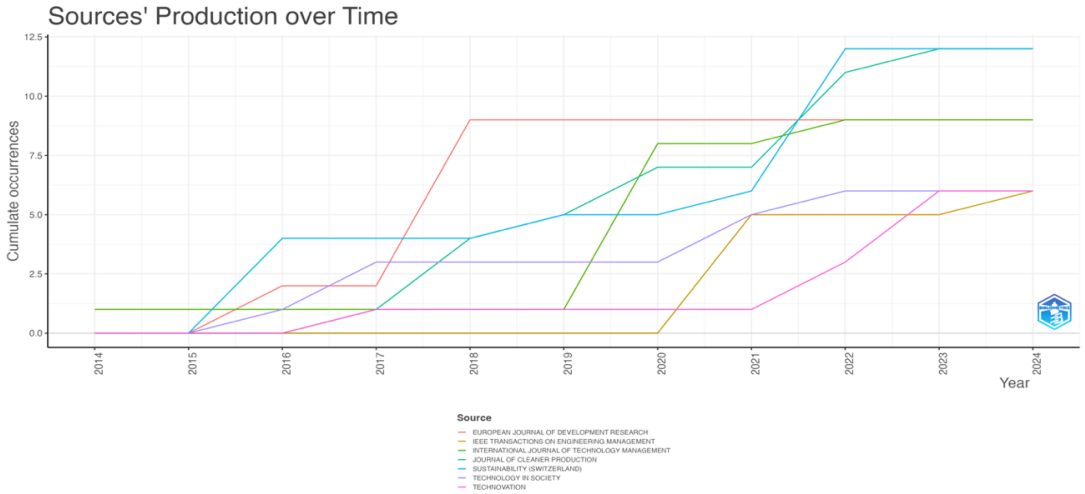

Figure 2. Sources' Production over Time
Source: Results of data analysis using Biblioshiny, R Studio

Figure 3 displays the top-cited documents based on the number of global citations. Each document is represented by a dot on the horizontal axis, which corresponds to the total number of citations received. The document by M.B. Zeschky (2014) is the most cited in "Res. Technol. Manag". It has the highest number of citations at 218, indicating its significant

influence or relevance in its field. Journals such as "J. Clean. Prod." appear multiple times with 198 citations, suggesting that this journal is a key source for highly cited documents in the dataset. The range of citations (from 17 to 218) indicates a varied impact among the listed documents. This chart is useful for identifying influential documents and understanding the impact of various research works within a specific academic context.

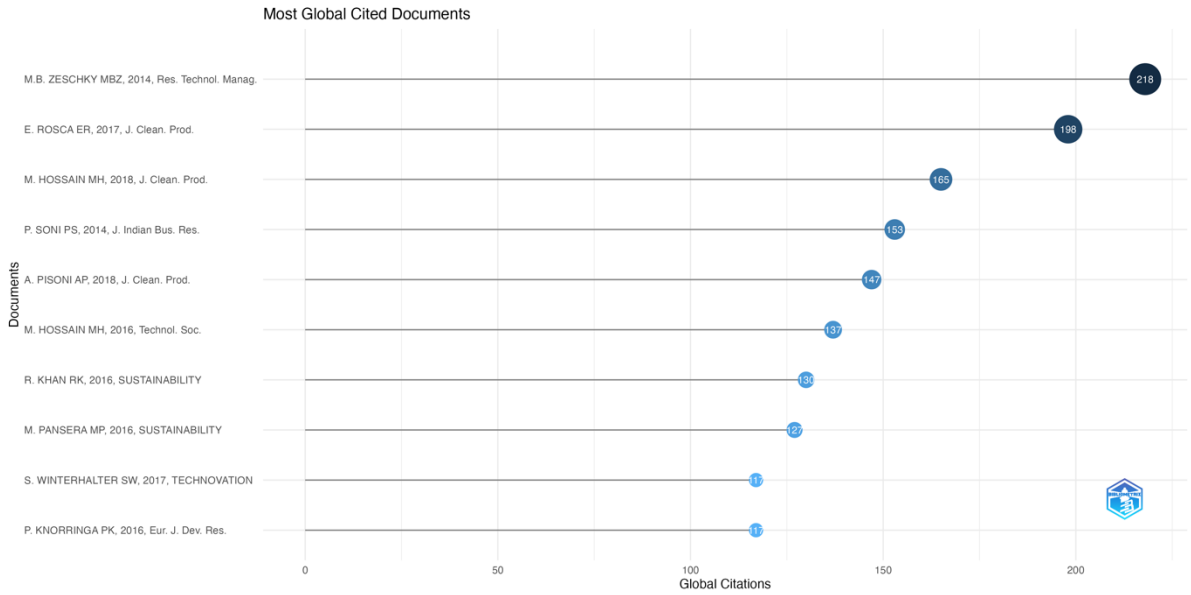

Figure 3. Most Global Cited Documents
Source: Results of data analysis using Biblioshiny, R Studio

The Network Visualization generate three cluster. The blue cluster on the left likely represents terms related to "sustainable development," including "sustainable development goal" and "pyramid." The red cluster in the center focuses on terms such as "product," "process," and "sustainability," indicating a theme around sustainable products and processes. The green cluster on the right includes terms like "firm," "role," and "capability," suggesting a focus on organizational aspects and the roles and capabilities of firms. For example, "sustainable development goal" (blue cluster) is connected to terms like "sustainable development" and "pyramid," indicating a thematic grouping around sustainable development goals. "Product" (red cluster) has many connections to terms like "process," "sustainability," and "use," showing its centrality in discussions about sustainable products. "Role" (green cluster) is linked to terms like "capability," "data," and "effect," pointing to discussions around the roles and capabilities in firms. The network provides an overview of the main themes and the relationships between them within the dataset. It allows researchers to see how different concepts are interconnected and to identify major areas of focus and significant terms within the field. In summary, this visualization helps to map out the intellectual structure of the research domain, showing the prominent themes (clusters) and how various terms (nodes) are interrelated through their co-occurrences (links).

The idea of sustainable development involves various concepts, such as the "sustainable development goal" and "pyramid," which are essential for comprehending and advancing sustainability. The United Nations Sustainable Development Goals (SDGs) significantly influence global sustainability efforts (Lim, 2022). Additionally, the sustainability pyramid presents a hierarchical approach to sustainable consumption and production, prioritizing economic, social, and environmental sustainability to inspire behavioral changes among mainstream consumers (Andersen & Esbjerg, 2020). Grasping these concepts and frameworks is vital for organizations, including multinational corporations, to create strategies that support sustainable development goals and tackle sustainability challenges, particularly in base-of-the-pyramid markets (Lotan Marcus, 2018).

Sustainable product design, process innovation, and the creation of sustainable business models are vital in the current business environment. Integrating sustainability into product development is crucial, with tools like the Sustainable Design Evaluation helping to assess ecological, economic, and social criteria throughout a product's lifecycle (Restu Millaningtyas et al., 2023). Design Thinking is instrumental in developing and innovating sustainable business models, utilizing methods such as workshops, brainstorming, co-creation, and prototyping (Havemo, 2023). Additionally, frameworks that connect Design Thinking with Sustainable Business Models emphasize circular economy models, product-service systems, and user-oriented innovation, underscoring the importance of stakeholder needs analysis and prototyping for sustainable business success (Reichard & Martin, 2023). Incorporating sustainability and environmental considerations into product development processes is also essential, focusing on remanufacturing, recyclability, end-of-life design, and Extended Producer Responsibility to meet sustainable objectives (Kurek et al., 2023).

Furthermore, Frugal innovation emphasizes core functionalities, cost reduction, and sustainable engagement, is recognized as an effective strategy for promoting economic and social sustainable development (STÖBER et al., 2022b). The success of frugal innovation in driving sustainability outcomes depends significantly on the types of actors involved—whether large firms, small firms, or non-firm entities—their motivations, and their collaborations (Dost et al., 2022). Additionally, frugal innovation positively impacts a firm's financial and environmental performance, with proactive orientation further enhancing its environmental benefits (Rossetto et al., 2023). Strengthening these organizational capabilities and roles within firms is essential to leverage frugal innovation for achieving positive sustainability outcomes.

Organizational capabilities like Big Data capability (BDC) (Wang et al., 2023), big data analytics capabilities (Alyahya et al., 2023), and Information Technology capability (ITC) (Awan et al., 2023) are pivotal in influencing sustainability outcomes within firms. These capabilities are associated with enhanced performance in sustainability-oriented innovation (SIP) (Liang et al., 2022), sustainable performance (Lee et al., 2023), and business sustainability through ambidextrous innovation. In summary, harnessing these organizational

capabilities and nurturing a culture driven by data are crucial for firms to attain sustainable outcomes and adeptly respond to market dynamics.

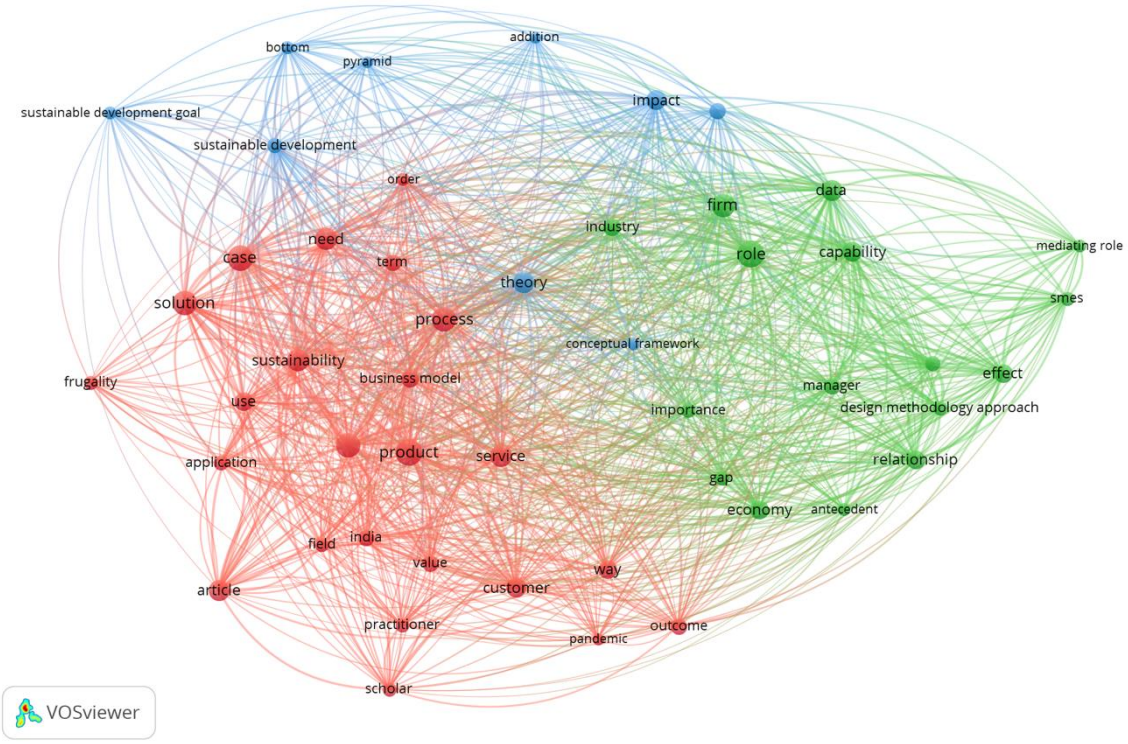

Figure 4. Network Visualization
Source: Results of data analysis using Vos Viewer

The network visualization effectively maps the thematic landscape of sustainable development research, highlighting the temporal evolution of key concepts and illustrating how different areas of study are interconnected ("Network Visualization," 2023b). The color coding offers a valuable perspective on how research focus has shifted over time, with newer topics like "pandemic" and "impact" emerging recently, reflecting contemporary issues and challenges. The color gradient in the visualization provides insights into how recent or old the research on specific terms is. Dark Blue Terms, discussed since 2019, represent foundational concepts like "process" and "product." Green Terms, prominent around 2020, reflect the growing emphasis on "capability" and "data." Yellow Terms, emerging around 2021, capture

newer concerns and focuses, such as the impact on "SMEs" and the effects of the "pandemic."

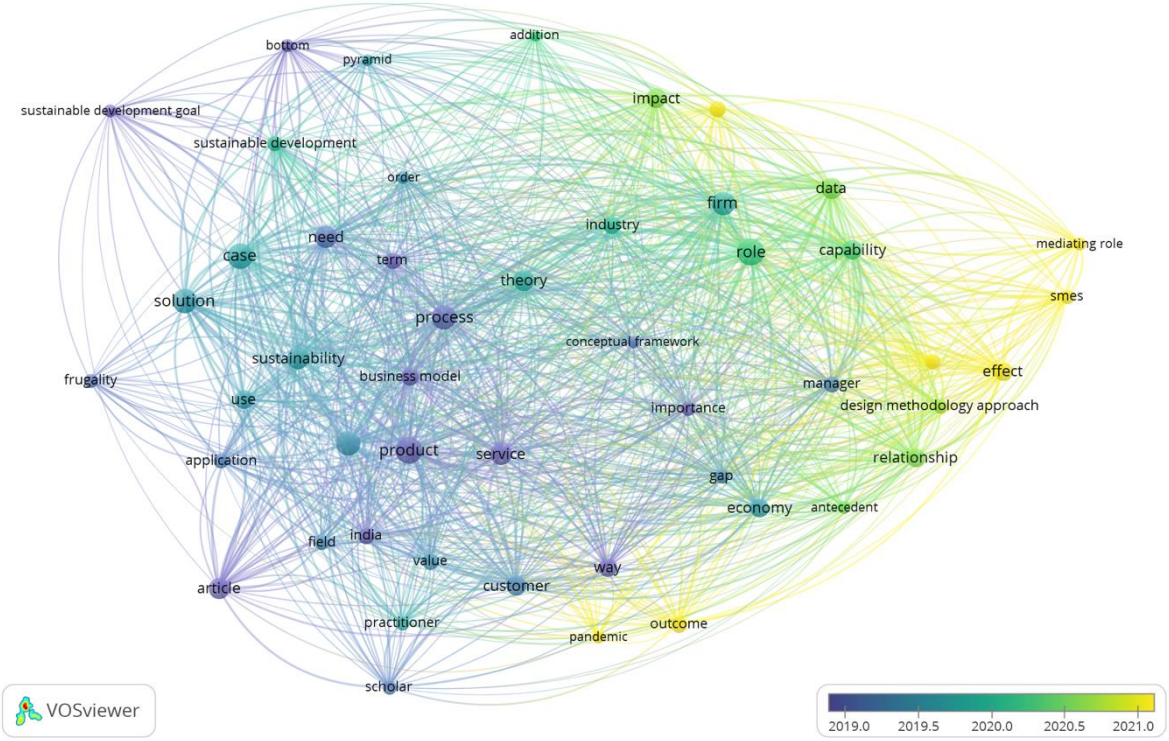

Figure 5. Overlay Visualization
Source: Results of data analysis using Vos Viewer

Network visualization, presented as a heat map, uses VOSviewer to show the density and distribution of terms based on their co-occurrence within a dataset, which is likely drawn from academic publications or articles (“Network Visualization,” 2023b). The heat map highlights areas of high and low term density, providing insights into the focus and intensity of research in different thematic areas. Specifically, the map identifies key research areas: Sustainable Development and Goals (Top Left), Sustainable Products and Processes (Center), Organizational Capabilities and Roles (Top Right), Relationships and Methodologies (Right), and Impact and Outcomes (Center to Right). The heat map visualization provides a clear representation of the density and focus areas within the field of sustainability research, highlighting where the most intense research activities are concentrated and offering insights into how different themes and topics are interconnected. The temporal aspect, though less emphasized in this map, can be inferred by the density and the prominence of terms reflecting ongoing or emerging research trends.

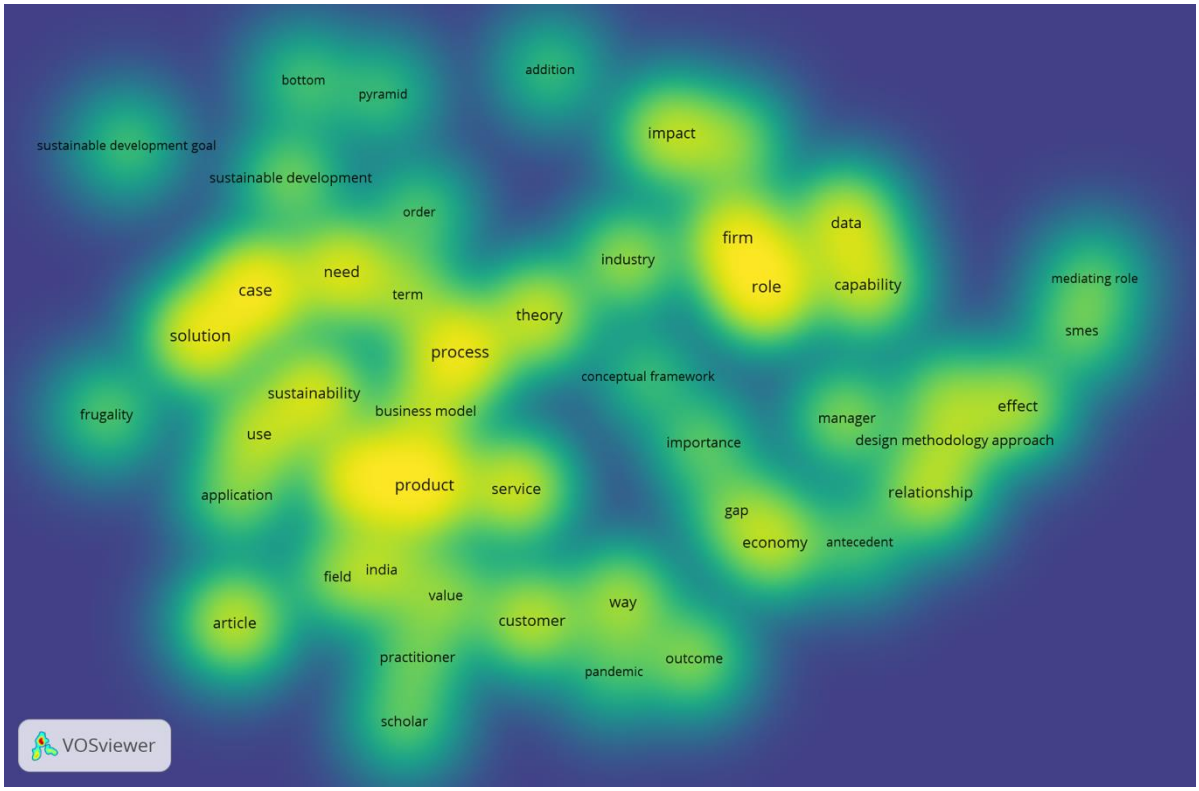

Figure 5. Density Visualization
Source: Results of data analysis using Vos Viewer

CONCLUSIONS

The integration of sustainability and environmental considerations in product development processes, alongside frugal innovation, is shown to be a key driver of economic and social sustainable development. Organizational capabilities, particularly in areas like Big Data and Information Technology, are highlighted as critical for achieving sustainability outcomes. Network and density visualizations provide valuable insights into the thematic landscape and research focus within sustainable development. Frugal innovation is demonstrated to have a positive impact on both a firm's financial performance and its environmental sustainability. The importance of strengthening organizational capabilities and roles is underscored as essential for effectively leveraging frugal innovation for sustainability outcomes. Overall, this article contributes to the understanding of frugal innovation as a growing trend in resource-limited environments, particularly in the context of promoting sustainability. Through bibliometric analysis, it identifies increasing scholarly interest in frugal innovation and its alignment with sustainability goals, emphasizing the need for further exploration of its fundamental principles and long-term impacts. This research serves to guide future studies in the field of frugal innovation, aiming to enhance its application and effectiveness in driving sustainable development.

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