

Bibliometric Analysis of the Financial Supply Chain in the Palm Oil Industry

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ABSTRACT

The palm oil industry plays a vital role in global agribusiness, with its financial supply chain increasingly recognized as a critical determinant of operational efficiency, sustainability, and inclusivity. This study conducts a bibliometric analysis to systematically map the academic literature on financial mechanisms within the palm oil supply chain. Using data from the Scopus database and visualization tools such as VOSviewer, the research identifies key themes, influential authors, institutional collaborations, and country-level networks from 2000 to 2025. Findings reveal that central concepts like palm oil, sustainable development, and biomass dominate the discourse, while emerging topics such as smallholder financing, deforestation, and green investment reflect shifting priorities toward sustainability and inclusive finance. Malaysia and Indonesia lead in research output, with strong global collaborations involving institutions in the United Kingdom, the United States, and the Netherlands. This study contributes to the theoretical understanding of the financial supply chain as a multidimensional construct influenced by environmental, economic, and social factors. It also offers practical insights for policymakers, financial institutions, and industry stakeholders aiming to align financial innovation with sustainable palm oil development.

Keywords: *Palm Oil, Financial Supply Chain, Supply Chain Finance, Sustainable Development, Bibliometric Analysis*

1. INTRODUCTION

The palm oil industry has long stood as a cornerstone of the global agribusiness sector, particularly in Southeast Asia where Indonesia and Malaysia contribute nearly 85% of the world's palm oil supply [1]. As the demand for palm oil in food, cosmetics, and bioenergy continues to escalate, the efficiency and transparency of its supply chain have become central to maintaining competitiveness and ensuring sustainability. Within this context, the financial supply chain encompassing the flow of capital, credit terms, and risk-sharing mechanisms plays a pivotal role in enabling upstream and downstream actors to function cohesively (Hofmann & Kotzab, 2010). However, while the operational dimensions of palm oil supply chains are extensively studied, financial linkages remain under-explored, despite their critical influence on liquidity, investment decisions, and overall supply chain resilience [2], [3].

The financial supply chain (FSC) refers to the network of financial processes and stakeholders that facilitate trade, including procurement financing, inventory funding, credit management, and payment terms across the value chain [4], [5]. In capital-intensive sectors such as palm oil, where harvest cycles, global price volatility, and stakeholder fragmentation are common, the FSC becomes increasingly complex. Producers, processors, traders, and exporters each interact with banks, cooperatives, government credit schemes, and private investors, often under asymmetric information conditions. Misalignments in financial flows can lead to cash flow disruptions, bottlenecks, and heightened risk exposure, especially for smallholder farmers, who constitute over 40% of palm oil producers globally [6].

In recent years, the intersection of supply chain finance (SCF) and sustainability goals has garnered scholarly and practical attention. Green financing, ESG-linked credit instruments, and inclusive banking models are emerging as strategic tools to balance economic returns with

environmental and social governance in palm oil ecosystems [7]. As multinational buyers enforce stricter sustainability and traceability criteria, downstream firms are also pressured to reassess their financing strategies. For example, buyer-initiated reverse factoring, supplier credit arrangements, and blockchain-based smart contracts are being explored to mitigate payment delays and incentivize compliance with certification schemes such as RSPO (Roundtable on Sustainable Palm Oil) and ISPO (Indonesian Sustainable Palm Oil). These shifts further emphasize the importance of understanding the structural, temporal, and relational dynamics of FSCs within the palm oil context [8].

Despite the relevance of these developments, scholarly inquiry into the financial dimension of palm oil supply chains remains fragmented. Literature on palm oil supply chains has traditionally focused on logistical coordination, environmental concerns, and policy frameworks, while studies examining financing patterns, cost of capital, trade credit terms, and the role of financial institutions remain scattered across disciplines [9]. Moreover, cross-country comparisons are limited, and there is a lack of cumulative knowledge regarding thematic clusters, dominant publication trends, and intellectual networks shaping this field. A structured and systematic mapping of this knowledge base is therefore critical to identify trends, gaps, and future research directions.

Bibliometric analysis serves as a powerful methodological approach to address this need. By applying quantitative techniques to scientific publication metadata, including citation networks, co-authorship structures, keyword co-occurrence, and journal influence, bibliometric studies reveal the intellectual landscape of a research domain [10]. For a multidisciplinary topic like financial supply chain in the palm oil industry, which spans supply chain management, finance, sustainability, and agribusiness, bibliometric tools such as VOSviewer can provide actionable insights into publication hotspots, collaboration patterns, and knowledge evolution. This not only supports scholars in navigating the field but also guides practitioners and policymakers in aligning research with practice.

Although the financial supply chain plays a crucial role in sustaining the competitiveness and inclusivity of the palm oil industry, current academic literature remains fragmented, under-integrated, and lacks a consolidated view of how financing mechanisms are studied and evolve within this sector. There is a pressing need to systematically map and synthesize the global scientific output related to this theme, identify key knowledge contributors, reveal emerging clusters of research, and detect critical gaps, particularly in relation to smallholder financing, ESG integration, and technological innovation in financial intermediation. This study aims to conduct a bibliometric analysis of the financial supply chain in the palm oil industry to identify the most influential authors, institutions, journals, and thematic clusters that have shaped this research domain.

2. METHODS

This study adopts a bibliometric analysis approach to systematically map the scientific literature on the financial supply chain (FSC) in the palm oil industry. Bibliometric analysis enables researchers to quantify patterns in academic publications, identify influential contributors, detect thematic clusters, and trace the intellectual structure of a field over time [10]. This method is especially useful for multidisciplinary topics, such as FSC in palm oil, which intersect domains including supply chain finance, agribusiness, sustainability, and development economics. The analytical framework in this study comprises performance analysis (e.g., citation counts, productivity) and science mapping (e.g., co-authorship, co-citation, and keyword co-occurrence networks), providing both macro- and micro-level insights into the evolution of the research area.

The data source for this study is the Scopus database, which was selected due to its comprehensive coverage of peer-reviewed literature across disciplines and its compatibility with bibliometric tools. A structured query was designed using keywords such as “financial supply chain”, “supply chain finance”, “palm oil”, “agribusiness finance”, and “smallholder financing”. Boolean operators and wildcard symbols were used to refine the search, ensuring a balance between specificity and breadth. The inclusion criteria encompassed journal articles, reviews, and conference papers published between 2000 and 2025, written in English, and directly related to palm oil and financial flows. After applying the selection filters and removing duplicates, the final dataset comprised documents suitable for analysis.

The exported metadata was then analyzed using **VOSviewer**, a widely used bibliometric visualization software. The tool enabled the generation of co-authorship maps (to identify collaboration networks among researchers and institutions), keyword co-occurrence maps (to detect dominant research themes), and citation networks (to identify influential articles and publication outlets). Clustering algorithms embedded in VOSviewer helped classify research streams, while temporal analysis provided insights into the evolution of topics such as ESG financing, blockchain applications in FSC, and smallholder credit mechanisms over time.

3. RESULTS AND DISCUSSION

3.1 Network Visualization

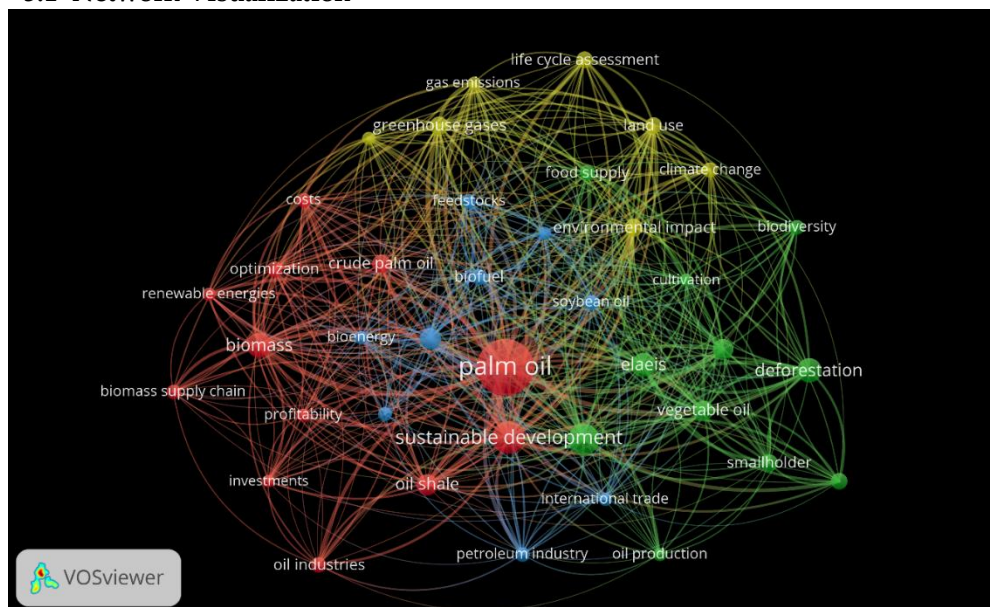


Figure 1. Network Visualization

Source: Data Analysis Result, 2025

In Figure 1, the visualization places “palm oil” at the center of the bibliometric landscape, indicating its role as the dominant keyword and thematic anchor. Its centrality and large node size reflect the volume of research and keyword co-occurrence surrounding palm oil in both environmental and economic contexts. The proximity of “sustainable development” and “crude palm oil” to the core term signifies how these themes are frequently discussed in conjunction with palm oil, specially in relation to production practices, economic growth, and policy reforms that intersect with environmental stewardship and value chain management. Surrounding the core, several distinct clusters emerge, each color-coded to represent a specific research stream. The red cluster, for instance, highlights economic and energy-related terms such as “biomass,” “bioenergy,” “investments,” “profitability,” and “optimization.” This suggests a strong scholarly focus on the economic utility of palm oil byproducts and their integration into the renewable energy sector. The presence of terms like “biomass supply chain” and “oil industries” also signals growing interest in

financial linkages and efficiency strategies within upstream and downstream palm oil value chains, touching directly on financial supply chain management concerns.

Moving toward the green cluster, keywords such as “deforestation,” “biodiversity,” “smallholder,” “cultivation,” and “vegetable oil” dominate the thematic space. This group clearly represents the environmental and socio-political dimensions of palm oil production, especially regarding land use changes and the roles of smallholder farmers. Notably, “smallholder” emerges as a crucial node, reinforcing its significance in discussions related to financing models, inclusion mechanisms, and challenges in ensuring sustainable practices across fragmented producer groups. These insights directly inform the financial supply chain narrative, especially in relation to credit access and risk-sharing for small-scale actors. The yellow cluster appears to be anchored around climate-related concepts such as “greenhouse gases,” “gas emissions,” “climate change,” and “life cycle assessment.” This indicates a rich body of literature examining the environmental impact of palm oil from a carbon footprint and sustainability accounting perspective. These studies often intersect with financial mechanisms through green finance instruments, carbon trading, and ESG all of which are part of the broader financial supply chain discourse. The integration of life cycle assessment into supply chain financing decisions further highlights the convergence of environmental metrics with credit and investment evaluation processes.

The blue cluster shows a concentration around technical and cross-sectoral terms like “biofuel,” “feedstocks,” “soybean oil,” and “international trade.” This cluster reflects the integration of palm oil into global commodity systems and comparative studies with alternative oils. Here, the financial supply chain intersects with global trade finance, regulatory compliance, and logistics funding, emphasizing the need for responsive financing instruments that can adapt to international market dynamics. The node “international trade” reinforces the transnational nature of financial flows and underscores the complexity of managing liquidity, hedging risks, and financing operations across borders in the palm oil industry.

3.2 Overlay Visualization

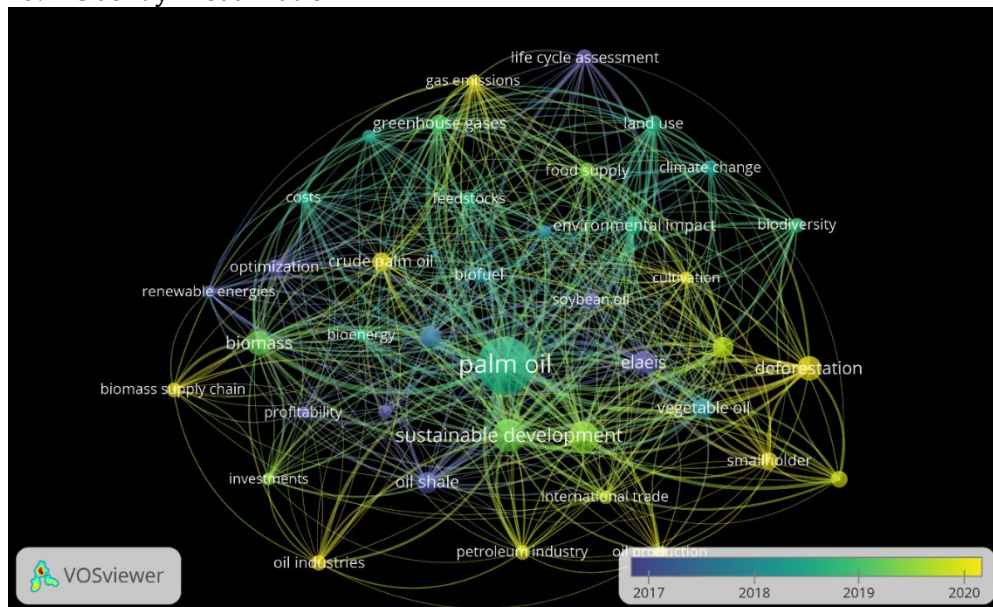


Figure 2. Overlay Visualization
Source: Data Analysis Result, 2025

The second figure reveals the temporal evolution of research themes in the palm oil literature from 2017 to 2020. The color gradient (ranging from purple (older keywords) to yellow (newer keywords)) indicates when specific terms became more prominent in the academic discourse. The central terms, such as “palm oil” and “sustainable development,” appear in a light green hue,

suggesting they have been consistently studied throughout the period. These central nodes function as thematic anchors around which newer and older concepts revolve, demonstrating their sustained relevance in discussions about the palm oil industry and its supply chains. Interestingly, newer research directions (marked in yellow) are concentrated around keywords like “deforestation,” “smallholder,” “biomass supply chain,” “vegetable oil,” and “optimization.” This implies a shift in scholarly attention toward inclusive economic participation and environmental externalities, particularly in how smallholders are integrated into the financial value chain and how land-use impacts such as deforestation are being evaluated financially. Additionally, the emergence of terms like “optimization” and “costs” in yellow reflects a growing interest in the efficiency and financing mechanisms embedded in the palm oil supply network, possibly in response to global pressure for sustainability and financial transparency.

On the other hand, older terms (in purple and blue) such as “oil industries,” “crude palm oil,” “oil shale,” and “petroleum industry” indicate past emphases on the fossil fuel comparison and broader industrial narratives. These topics were more dominant in earlier phases of the literature, reflecting a time when palm oil research was more aligned with traditional energy transitions and biofuel substitution. As the field matures, the literature has evolved toward multi-dimensional sustainability themes, integrating environmental impact assessments, ESG financing, and smallholder inclusion, all of which are critical to understanding the current state of the financial supply chain in the palm oil industry.

3.3 Citation Analysis

Table 1. The Most Impactful Literatures

Citations	Authors and year	Title
659	[11]	Properties of various plants and animals feedstocks for biodiesel production
443	[12]	The Relationship Between Sustainable Supply Chain Management, Stakeholder Pressure and Corporate Sustainability Performance
333	[13]	Transparency and sustainability in global commodity supply chains
268	[14]	Massive soybean expansion in South America since 2000 and implications for conservation
248	[15]	Trading forests: Land-use change and carbon emissions embodied in production and exports of forest-risk commodities
242	[16]	Shifting patterns of oil palm driven deforestation in Indonesia and implications for zero-deforestation commitments
239	[17]	Obesity, the metabolic syndrome, and type 2 diabetes in developing countries: Role of dietary fats and oils
224	[18]	Oil palm in the 2020s and beyond: challenges and solutions
214	[19]	Nutritional and physiological role of medium-chain triglycerides and medium-chain fatty acids in piglets.
210	[20]	Oil palm economic performance in Malaysia and r&d progress in 2017

Source: Scopus, 2025

3.4 Density Visualization

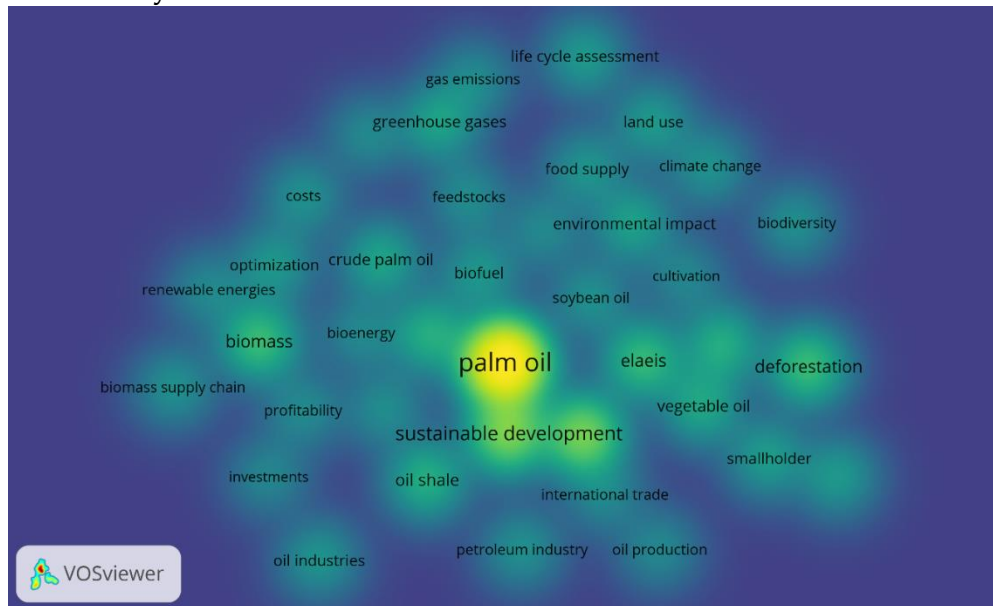


Figure 3. Density Visualization

Source: Data Analysis Result, 2025

Figure 3 provides a heatmap-style overview of keyword prominence in the academic literature, with yellow areas representing high-frequency and high-relevance terms, and blue-to-green areas indicating lower occurrence or peripheral themes. At the heart of the visualization is the term “palm oil,” radiating in bright yellow, which confirms its centrality as the core subject of discourse. Surrounding it, “sustainable development” also appears in a bright gradient, reflecting the consistent scholarly linkage between palm oil and broader goals such as environmental sustainability, economic equity, and ethical sourcing. This confirms the industry’s tight integration with discussions on sustainable practices and supply chain accountability. Moving outward from the core, terms like “biomass,” “crude palm oil,” “bioenergy,” “deforestation,” and “environmental impact” occupy medium-density zones (light green), signifying their substantial, but slightly less central role in the literature. These keywords reflect critical topics such as energy transition, land use change, and ecological consequences, which all influence how the financial supply chain is constructed and managed. On the periphery, blue areas containing terms like “smallholder,” “investments,” “oil shale,” and “petroleum industry” suggest emerging or context-specific interests that may not yet be deeply integrated into the mainstream discourse.

3.5 Co-Authorship Network

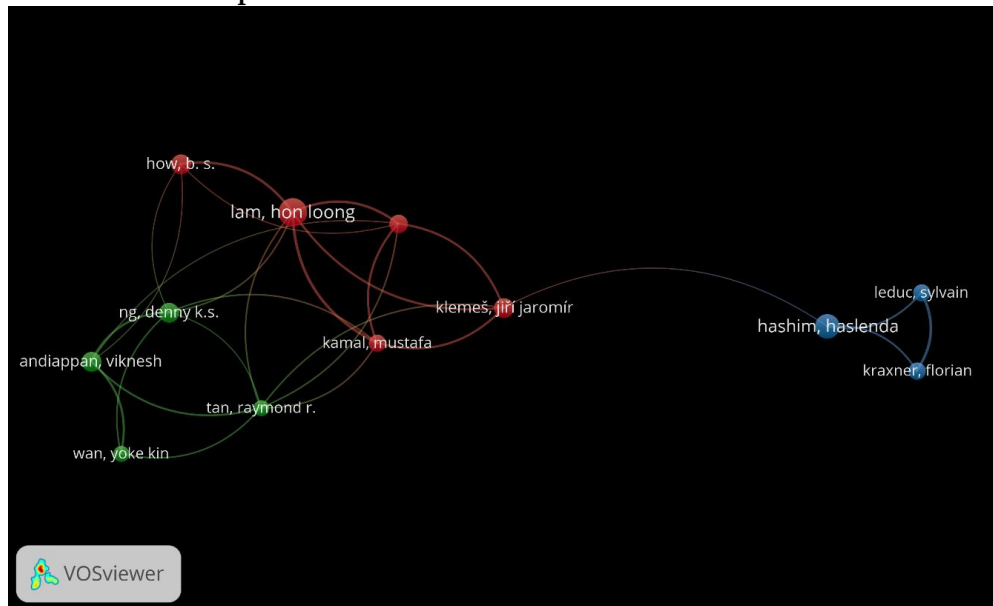


Figure 4. Author Visualization

Source: Data Analysis Result, 2025

Figure 4 reveals distinct clusters of collaborative researchers in the field of palm oil and financial supply chain-related studies. The most central figure in the red cluster is Lam, Hon Loong, who connects strongly with prominent authors like Klemes, Jiří Jaromír, Kamal, Mustafa, and How, B. S., indicating a dense and well-established collaboration network focused likely on optimization, bioenergy, or supply chain efficiency themes. The green cluster, led by Andiappan, Viknesh and Ng, Denny K. S., suggests another active research group, possibly with a regional or methodological focus, working closely with Tan, Raymond R. and Wan, Yoke Kin. On the periphery, the blue cluster consisting of Hashim, Haslenda, Leduc, Sylvain, and Kraxner, Florian shows a smaller but tightly connected group that may be working on sustainability, carbon emissions, or land-use-related finance topics.

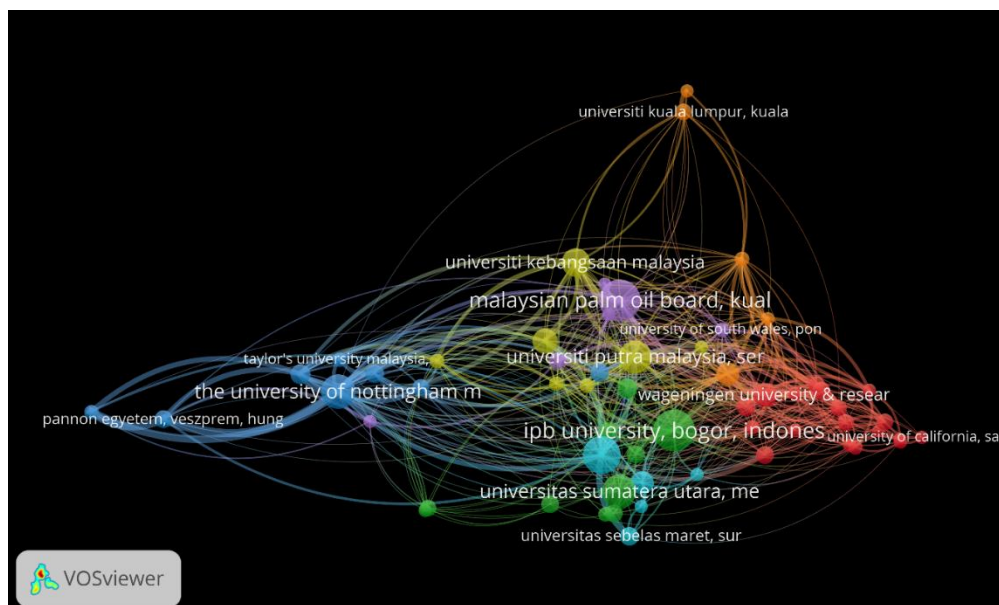


Figure 5. Affiliation Visualization

Source: Data Analysis Result, 2025

Figure 5 highlights a vibrant and internationally collaborative research ecosystem centered around the palm oil industry and its financial or sustainability dimensions. At the core of the network is the Malaysian Palm Oil Board (MPOB), which serves as a pivotal node linking major Malaysian universities such as Universiti Putra Malaysia, Universiti Kebangsaan Malaysia, and Universiti Kuala Lumpur, all seen in closely connected yellow and orange clusters. This underscores Malaysia's dominant role in palm oil research. On the other side, IPB University (Bogor, Indonesia), Universitas Sumatera Utara, and Universitas Sebelas Maret form a strong Indonesian cluster, reflecting the country's growing academic contribution. Notably, international institutions like The University of Nottingham Malaysia, Wageningen University & Research (Netherlands), and Pannon Egyetem (Hungary) also appear well-integrated, suggesting robust global academic linkages. The dense web of interconnections between institutions shows cross-border collaborations, yet the presence of distinct clusters also hints at regional research specializations.

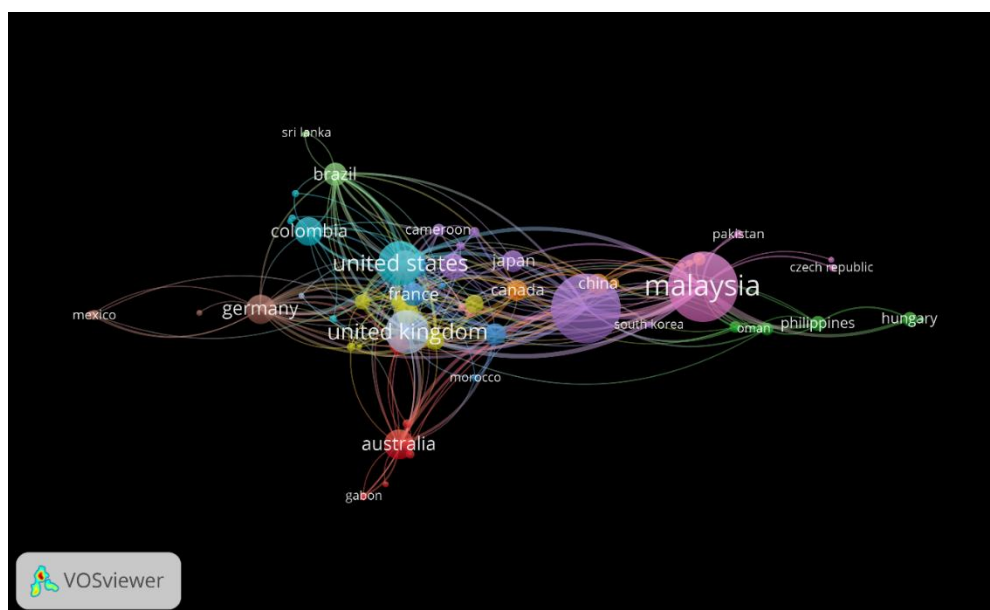


Figure 6. Country Visualization

Source: Data Analysis Result, 2025

Figure 6 illustrates a highly interconnected global research landscape on palm oil and its financial or sustainability dimensions, with Malaysia emerging as the most dominant contributor, indicated by its large node and dense web of linkages. Malaysia's centrality is unsurprising given its status as one of the world's top palm oil producers, and it is closely connected with countries such as China, South Korea, United States, United Kingdom, and Australia, reflecting its broad international research ties. The United States, United Kingdom, and Germany also appear as significant nodes, indicating strong research output and collaboration, particularly within Western academic circles. Meanwhile, countries like Brazil, Colombia, and Philippines show growing involvement, possibly reflecting expanding interest in palm oil economics and sustainable agriculture in the Global South.

Practical Implication

This study offers several practical insights for policymakers, financial institutions, and stakeholders in the palm oil supply chain. By mapping the intellectual landscape of financial supply chain literature in the palm oil industry, it becomes evident that topics such as smallholder inclusion, deforestation finance, and green investment instruments are emerging as key concerns. For government agencies, the findings highlight the need to develop integrated financial mechanisms to

support sustainable practices along the supply chain. For financial institutions and banks, this study points to the increasing academic interest in supply chain finance tools (e.g., factoring, reverse factoring, and inventory financing) as leverage points to manage liquidity risk and enhance supplier-buyer coordination. Palm oil producers and exporters can use this knowledge to identify trends in sustainable finance and adopt practices aligned with global certification schemes and market expectations. In short, this bibliometric analysis provides a roadmap for aligning financial innovation with operational efficiency and environmental responsibility in palm oil ecosystems.

Theoretical Contribution

This study contributes theoretically by consolidating a fragmented body of knowledge at the intersection of supply chain finance, sustainability, and agribusiness. By employing bibliometric techniques, the research identifies dominant thematic clusters such as bioenergy financing, smallholder support, and sustainable supply chain governance and clarifies how these themes evolve over time and across institutional or geographical boundaries. In doing so, the study advances the theoretical understanding of the financial supply chain as not merely a capital flow mechanism but as a complex system shaped by environmental pressures, global trade dynamics, and inclusive development goals. The study also highlights how certain concepts (e.g., “sustainable development,” “biomass,” “optimization,” “deforestation”) serve as intellectual bridges between different research communities, thus enriching the interdisciplinary dialogue. Furthermore, it positions bibliometric mapping as a valid analytical lens to explore emerging paradigms in green finance and agri-based financial architecture, extending its relevance to both operations management and development studies.

Limitation

While this bibliometric study provides a comprehensive overview of the intellectual structure surrounding the financial supply chain in the palm oil sector, several limitations should be acknowledged. First, the analysis relies exclusively on data from the Scopus database, which, although extensive, may omit relevant literature indexed in other databases such as Web of Science, Google Scholar, or regional repositories, particularly those in Bahasa Indonesia or Malay. Second, the use of keyword-based search queries may result in the exclusion of studies that employ different terminologies or focus implicitly on financial dynamics without explicitly labeling them as such. Third, bibliometric analysis emphasizes quantitative citation patterns, which may not fully capture the depth, quality, or methodological richness of individual studies. Lastly, while the visualizations provide structural insights, they do not substitute for in-depth qualitative review and critical discourse analysis, which would be required to explore nuanced narratives and theoretical frameworks in greater detail. Future research could address these limitations by integrating systematic literature reviews or content analysis to enrich the interpretative value of the findings.

CONCLUSION

This study provides a comprehensive bibliometric analysis of the scholarly landscape surrounding the financial supply chain in the palm oil industry, revealing key trends, influential contributors, thematic clusters, and international collaboration patterns. By leveraging tools like VOSviewer and data from the Scopus database, the study highlights the central role of concepts such as palm oil, sustainable development, biomass, and smallholder financing, while also identifying emerging research directions in green finance, optimization, and environmental impact. Malaysia and Indonesia emerge as dominant research hubs, supported by a growing global network of institutions and countries actively engaged in palm oil research. The findings underscore the increasing integration of financial mechanisms with sustainability goals, offering a foundational knowledge base for academics, policymakers, and industry practitioners.

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